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The 'Healthy Dads, Healthy Kids' community randomized controlled trial: A community-based healthy lifestyle program for fathers and their children[☆]



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ABSTRACT

Objective: To evaluate the effectiveness of the 'Healthy Dads, Healthy Kids' (HDHK) program when delivered by trained facilitators in community settings.

Method: A two-arm randomized controlled trial of 93 overweight/obese fathers (mean [SD] age = 40.3 [5.3] years; BMI = 32.5 [3.8] kg/m²) and their primary school-aged children (n = 132) from the Hunter Region, Australia. In 2010–2011, families were randomized to either: (i) HDHK intervention (n = 48 fathers, n = 72 children) or (ii) wait-list control group. The 7-week intervention included seven sessions and resources (booklets, pedometers). Assessments were held at baseline and 14-weeks with fathers' weight (kg) as the primary outcome. Secondary outcomes for fathers and children included waist, BMI, blood pressure, resting heart rate, physical activity (pedometry), and self-reported dietary intake and sedentary behaviors.

Results: Linear mixed models (intention-to-treat) revealed significant between-group differences for fathers' weight ($P < .001$, $d = 0.24$), with HDHK fathers losing more weight (−3.3 kg; 95%CI, −4.3, −2.4) than control fathers (0.1 kg; 95%CI, −0.9, 1.0). Significant treatment effects ($P < .05$) were also found for fathers' waist ($d = 0.41$), BMI ($d = 0.26$), resting heart rate ($d = 0.59$), energy intake ($d = 0.49$) and physical activity ($d = 0.46$) and for children's physical activity ($d = 0.50$) and adiposity ($d = 0.07$).

Discussion: HDHK significantly improved health outcomes and behaviors in fathers and children, providing evidence for program effectiveness when delivered in a community setting.

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Introduction

Obesity is a serious public health concern and is associated with numerous adverse health consequences (Barr et al., 2006). Internationally, its prevalence is high and increasing (Finucane et al., 2011), especially among men (Australian Bureau of Statistics, 2011). This is

concerning given that, compared to women, men are less likely to perceive themselves as overweight (Lemon et al., 2009), attempt weight loss, or enroll in weight loss programs (French and Jeffery, 1994; Morgan et al., 2011e; Pagoto et al., 2012).

An additional consequence of male obesity is the potential impact overweight and obese fathers may have on their children. Emerging evidence suggests that fathers have a unique and key role in shaping their children's dietary and physical activity behaviors (Freeman et al., 2012; Hall et al., 2011; Wake et al., 2007). For example, a recent longitudinal study of more than 3200 families identified that children with a healthy weight mother were substantially more at risk of becoming obese if their father was overweight (odds ratio 4.18; 95%CI, 1.01–12.33) or obese (odds ratio 14.88; 95%CI, 2.61–84.77) (Freeman et al., 2012). However, the reverse scenario (having an overweight or obese mother with a healthy weight father) was not a significant predictor of childhood obesity. Given that a large proportion of children are not

Abbreviations: HDHK, Healthy Dads, Healthy Kids; BMI, body mass index; LGAs, local government areas; SCT, Social Cognitive Theory; AES, Australian Eating Survey; FFQ, food frequency questionnaire; ACAES, Australian Children and Adolescent Eating Survey; SES, socio-economic status; SEIFA, Socio-Economic Indexes for Areas; LMMS, linear mixed models.

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meeting current diet and physical activity recommendations (Australian Bureau of Statistics, 2013a, 2013b), this provides a clear rationale to explore the efficacy of behavioral interventions that target fathers to improve the health and healthy lifestyle behaviors of both fathers and their children.

Despite this, little is known about how best to engage fathers in lifestyle interventions. Recent systematic reviews have not explored the representation of fathers in parenting interventions for physical activity and nutrition (e.g. Hingle et al., 2010; Marsh et al., in press; O'Connor et al., 2009). As such, researchers have called for greater numbers of fathers in future research (e.g. Patrick et al., 2013; Rodenburg et al., 2013; Sleddens et al., 2011). To the authors' knowledge, we conducted the only published experimental study focusing on physical activity and nutrition that specifically targeted fathers and their children (Morgan et al., 2011b). The *Healthy Dads, Healthy Kids* (HDHK) efficacy trial examined the impact of a lifestyle program targeting overweight or obese fathers to role model and influence their children's physical activity and dietary habits. Children of any weight status were eligible for participation in the study, provided they were in primary school (i.e. typically aged 5–12 years). Relative to the control group, fathers achieved clinically important weight loss and children significantly improved their physical activity levels and dietary intake. Feasibility was established with high levels of recruitment, retention, attendance and satisfaction of participants (Morgan et al., 2011b).

However, these promising efficacy results were obtained from a university-based research study delivered by highly qualified staff in a closely monitored trial. While efficacy is an essential first step to evaluate outcomes under ideal conditions, effectiveness measures the impact of an intervention when implemented in a real-world setting. This represents a more realistic evaluation of the likely intervention effect (Stevens et al., 2007). There is an urgent need to translate obesity prevention and treatment programs with demonstrated efficacy into real-world settings (Green and Glasgow, 2006). Therefore, the aim of the current study was to implement and evaluate the HDHK intervention, when delivered by trained local facilitators in a community setting. This effectiveness study addresses the recent call for more high quality RCTs conducted for child obesity prevention (Waters et al., 2011) and male only weight loss studies (Young et al., 2012).

Methods

Study design

The study was a two-armed randomized controlled trial (RCT). Family units (fathers and their child[ren]) were randomly allocated to one of two groups: the HDHK intervention (treatment) or a wait-list control group. Outcome measures were obtained from all participants at baseline and 14-weeks (post-test). Measurements were taken at an after school setting by trained staff, using the same instruments at each time point. Participants and assessors were blind to group allocation at baseline assessment. The wait-list control group received no information or intervention before attending the follow-up assessments. The following methods for the HDHK community trial have been published in greater detail elsewhere (Morgan et al., 2011d).

Participants

Overweight or obese (BMI between 25 and 40 kg/m²) fathers (aged 18–65 years) with a child attending primary school (i.e., typically aged between 5 and 12 years) were recruited and assessed between 2010 and 2011 in two cohorts from two local government areas (LGAs) (Singleton and Maitland) in the Hunter Region of NSW, Australia with treatment and control groups at each LGA. Of note, these rural LGAs include high rates of mining and shift work-based employment (Australian Bureau of Statistics, 2009), which are linked to increased risks of obesity and associated health complications (Atkinson et al., 2008). Recruitment strategies included school newsletters, school presentations, interactions with parents waiting to pick their children up from school, local media, and fliers distributed through local communities. Fathers were screened for eligibility via telephone. As in the HDHK efficacy

trial, children of any weight status were able to participate in the trial and fathers were required to live with their children (although the criteria did not specify a minimum number of days). Ineligibility criteria included major medical issues (e.g. complications of heart disease), Type 1 diabetes and recent weight loss of ≥ 4.5 kg. Ethics approval was obtained from the Institutional Human Research Ethics Committee. Written informed consent was obtained from the fathers prior to their participation as well as child assent.

The HDHK intervention

The aims of the HDHK intervention were to assist fathers achieve their personal weight loss goals and influence the lifestyle behaviors of their children. Table 1 outlines the content of each session and the resources provided to families. The HDHK intervention involved fathers attending seven consecutive weekly group sessions (90 min each); four sessions were for fathers only, and three practical sessions involved both fathers and their children. Sessions were conducted in local schools from 6.00 to 7.30 pm and both practical and theoretical sessions were delivered by two trained local Physical Education teachers who had completed an 8-hour training course (delivered by PJM). Both facilitators attended all program sessions with the lead facilitator's main role to deliver all learning experiences. The co-facilitator provided a supporting role during all sessions (e.g., equipment provision, management of group-based activities), administrative support prior to sessions (participant weigh-in, attendance sheets and homework compliance) and following sessions (participant feedback questionnaires). The co-facilitator ran the activities for the children at the beginning of each dads-and-kids session while the lead was reviewing the previous session and explaining the current session with the fathers.

The HDHK intervention was based on Social Cognitive Theory (SCT) (Bandura, 1986) and Family Systems Theory (FST) (Golan and Weizman, 2001). The following SCT constructs were operationalized: self-efficacy, goals/intention, outcome expectations, perceived facilitators and barriers to changes, and social support. FST is a theoretical framework that postulates reciprocal relationships among family members; that is, when a parent changes his or her physical activity and dietary behaviors this will be reflected in the child's behavior (Golan et al., 1998). HDHK taught fathers about the importance of spending quality time with their children and used healthy eating and physical activity as the engagement medium. The fathers' physical activity sessions emphasized modeling, co-physical activity that engaged both father and child(ren), reinforcing and providing opportunities for physical activity and overcoming barriers. The four major focus areas of the father/child(ren) practical sessions were (i) fundamental movement skills (Lubans et al., 2010), (ii) rough and tumble play (Fletcher et al., 2011), (iii) health-related fitness (Ortega et al., 2008), and (iv) fun and active household and backyard games.

The program provided a focus on an authoritative parenting style to facilitate better dietary and activity choices for children (Sleddens et al., 2011) and was informed by the dietary program from the HIKCUPS child obesity intervention (Collins et al., 2011; Okely et al., 2010). Sessions on healthy eating for families focused on multiple aspects of parental influence on children's dietary intake and incorporated Satter's 'trust' paradigm (Satter, 1996). The weight loss component of the HDHK intervention was adapted from the SHED-IT program, which is a weight loss program that has been specifically tailored for men and extensively developed and validated in previous qualitative and quantitative research (Morgan et al., 2009, 2011c, 2013).

Outcomes

Assessments were conducted 1–2 weeks before program commencement and following the program. The primary outcome was fathers' body weight at 14-week follow-up. Of note, although the HDHK program ran for seven consecutive weeks, there was no contact with participants during weeks 8–14. A brief description of both primary and secondary outcome measures is described in Table 2; further detail is provided elsewhere (Morgan et al., 2011d).

Sample size and randomization

The sample size for the RCT was based on 80% power to detect a significant weight loss difference between groups of 3 kg, assuming SD = 5 (Morgan et al., 2011a) ($P = .05$, two-sided), therefore a sample size of 50 fathers was required, assuming a 20% attrition rate (Morgan et al., 2011b).

The random allocation sequence was generated using a computer-based random number-producing algorithm. To ensure concealment, the sequence was generated by an independent statistician who did not have any contact

Table 1
The 'Healthy Dads, Healthy Kids' program resources (including session overview) (Hunter Region, Australia, 2010–2011).

Resource	Summary	Detail
Manual for Dads	Handbook for fathers that includes a summary of the information from the face-to-face sessions and additional background information	<ul style="list-style-type: none"> * Session 1: Weight loss fundamentals for men (Dads) * Session 2: Raising children in an inactive world (Dads) * Session 3: Ready to rumble with dad (Dads & Kids) * Session 4: Healthy eating for families - dads matter (Dads) * Session 5: Fun, fitness and fundamental movement skills (Dads & Kids) * Session 6: Sustaining healthy lifestyles (Dads) * Session 7: Weight loss is a journey not a destination (Dads & Kids)
Dad's log book	Log book that dads use as a working document for self-monitoring and completing session worksheets	<ul style="list-style-type: none"> * Monitoring tasks including green slip activities, weekly weight loss and pedometer step count monitoring * Program activities * Homework activities (e.g., Setting goals, monitoring children's small screen time, design a family fitness circuit and monitoring children's food intake)
Kid's hand-book	Includes tasks for children to complete each week with their dads that must be signed off with their dads (space to receive a sticker from facilitators if completed)	<ul style="list-style-type: none"> * Selection of physical activity and healthy eating tasks to choose from each week (e.g., 'Have 3 sock wrestles with dad', 'Play balloon tennis with dad', 'Help dad set up a home fitness circuit', 'Help dad pack a healthy lunch for work', 'Make vege spaghetti with dad' and 'Put some fruit on your dads cereal')
Green slips	Slips are given to fathers at the end of each session to complete home-based tasks	<ul style="list-style-type: none"> * Examples of healthy recipes to cook with dad * Activities are designed to align with the principles presented at the respective session and any activities detailed in the Dad's log book and Kid's handbook (e.g. cooking meals with kids, family fundamental movement skills circuit, rough and tumble games with dad)

with participants and given to the project manager. Fathers (and their children) were stratified by the father's BMI category (overweight [25–29.9 kg/m²], obese class 1 [30–34.9 kg/m²], obese class 2 [35–40 kg/m²]) and randomized, in block lengths of 6, to either the HDHK intervention or a wait-list control group after baseline assessments. A research assistant not involved in assessments completed randomization and the allocation sequence was concealed from participants until after baseline assessments. Information for the two study groups was pre-packed into identical white, opaque envelopes. These envelopes were consecutively numbered within the three stratification categories and ordered according to the randomization schedule. The packing and sequencing of these envelopes were completed by a research assistant who was not involved in enrolment, assessment or allocation of participants.

Data analysis

Analyses were performed using SPSS Statistics 20 (IBM Inc. Armonk, NY). Data are presented as mean (SD) for continuous variables and counts (percentages) for categorical variables. Characteristics of completers versus dropouts were tested using the independent *t* test for continuous variables and the chi-squared (χ^2) test for categorical variables. The significance level was set at .05. Analyses were performed separately for fathers and children and included all randomized participants. Linear mixed models (LMMs) were fitted with an unstructured covariance structure for all primary and secondary outcomes. Differences between means and 95% confidence intervals (CIs) were determined using the LMMs. Means and standard deviations were calculated for all normally distributed variables.

Linear mixed models were used to assess all outcomes (primary and secondary) for the impact of group (Intervention and Control), time (treated as categorical with levels baseline and 14-weeks) and the group-by-time interaction, with these three terms forming the base model. Age, SES, LGA (i.e. program site) and sex (for child models only) were examined as pre-specified covariates to determine if they contributed significantly to the models. If a covariate was significant, two-way interactions with time and treatment were also examined and all significant terms were added to the final model to adjust the results for these effects. Differences of means and 95% CIs were determined using the linear mixed models. Analyses included all randomized participants. Effect sizes were determined using Cohen's *d* (Cohen, 1988) and calculated using mean differences from the mixed model and the pooled standard deviation of the two groups at baseline ($d = (M_1 - M_2) / \sigma_{pooled}$).

Results

Participant flow

Fig. 1 illustrates the flow of participants through the trial. A total of 116 families were recruited, 101 men were eligible; however eight men were not randomized as no consent was received. In total, 93 fathers and 132 children attended baseline assessments and were randomized by family into intervention (*n* = 47) or control groups (*n* = 46). The mean number of children per family was 1.4. One family did not attend any information sessions. Mean attendance rate for the 7 sessions was 71%. In terms of retention, measurements were obtained for 81% of the sample at 14-week follow-up. There was no difference in retention between the HDHK and control groups ($\chi^2 = 2.03$, *df* = 1, *P* = .16). All randomized participants with baseline data were analyzed for all outcomes. There were no significant differences (*P* > .05) in baseline characteristics between those lost to follow-up and those retained for any outcomes.

Baseline data

Fathers' baseline characteristics are presented in Table 3; 28% were considered overweight and 72% obese. Table 4 presents baseline characteristics of the children (55% boys); 23% and 10% were overweight or obese, respectively.

Table 2
Overview of 'Healthy Dads, Healthy Kids' community RCT measures (Hunter Region, Australia, 2010–2011).

Measure	Detail
<i>Physical/biomedical measures</i>	
Weight	• Weight was measured with fathers and children wearing light clothing, without shoes on a digital scale to 0.1 kg (model CH-150kp, A&D Mercury Pty Ltd., Australia).
Height	• Height was measured to 0.1 cm using the stretch stature method and a stadiometer (VR High Speed Counter) (Harpenden/Holtain, Mentone Education Centre, Moorabbin, Victoria).
Body mass index (BMI) and BMI z-score	• BMI was calculated using the standard equation (weight [kg] / height [m] ²). For children, age- and sex-adjusted standardized scores (z-scores) based upon the UK reference (Cole et al., 1995) data and LMS methods (Cole and Pan, 2002) were calculated.
Waist circumference	• Waist circumference was measured with a non-extensible steel tape (KDSF10-02, KDS Corporation, Osaka, Japan). Father: 1) level with the umbilicus and 2) the widest point. • Child(ren): the narrowest point + z-scores (McCarthy et al., 2001).
Blood pressure and resting heart rate	• Systolic and diastolic blood pressure and resting heart rate were measured using a NISSEI/DS-105E digital electronic blood pressure monitor (Nihon Seimitsu Sokki Co. Ltd., Gunma, Japan).
<i>Physical activity and sedentary behaviors</i>	
Physical activity	• Yamax SW200 pedometers (Yamax Corporation, Kumamoto City, Japan) were used and have been validated in children (Eston et al., 1998) and adults (Steeves et al., 2011). Fathers and children wore pedometers for seven consecutive days.
Sedentary behaviors	• For Fathers, using a modified version of the Sitting Questionnaire (Marshall et al., 2010) total sitting time was calculated for a non-work day and a work day. • For the eldest child in the study, the mother completed a modified version of the CLASS, which has been validated in children (Telford et al., 2004). Total sitting time for each of Monday-Friday and Saturday-Sunday was calculated by converting reported values to minutes and summing the 15 domains. An average was then calculated. Small screen recreation time was calculated by summing the three domains TV/Videos, Playstation/Nintendo/Computer games and Computer/Internet.
<i>Dietary behaviors</i>	
Dietary intake	• For fathers, dietary intake was measured using the Australian Eating Survey (AES), a 120-item semi-quantitative Food Frequency Questionnaire (FFQ), which has been validated in adults (Collins et al., in press). Participants were asked the frequency of their consumption of individual food items over the previous three months. • For the eldest child, mothers completed the Australian Child and Adolescent Eating Survey (ACAES) a 120-item semi-quantitative FFQ developed and validated for use with children (Burrows et al., 2009; Watson et al., 2009). Children's energy intake was adjusted relative to body weight and reported as kJ/kg. • At follow-up assessments for both fathers and mothers, they were instructed to report on the previous 3-months dietary intake.
Demographic characteristics	Questionnaire including age and postcode. Socio-economic status (SES) is based on postal code of residence using the Index of Relative Socioeconomic Advantage and Disadvantage from the Australian Bureau of Statistics census-based Socio-Economic Indexes for Areas (SEIFA) (Australian Bureau of Statistics, 2008).

Change in primary outcome

Table 5 shows the mean change in weight for fathers by group. There was a significant intervention effect ($P < .001$; $d = 0.24$) with a mean difference between the two groups of 3.4 kg. There was also a significant difference in percentage weight loss between groups (3.3% vs -0.1%) ($P < .001$). At follow-up, significantly more fathers in the HDHK group (28%) achieved 5% weight loss compared to the control group (0%) ($\chi^2 = 12.5$, $df = 1$, $P < .001$).

Change in secondary outcomes for fathers and children

Significant intervention effects were found for fathers' waist circumference ($P < .001$); BMI ($P < .001$); resting heart rate ($P < .01$); mean steps/day ($P = .04$) and daily energy (kJ/day) intake ($P < .01$) represented by medium effect sizes (range $d = 0.36$ – 0.59). No significant differences between the two groups were found for blood pressure or sitting time variables.

For children (Table 6), there were significant group-by-time differences for BMI, BMI z-score ($P = .05$) and mean steps/day ($P = .01$). There were no significant between group effects for the other secondary outcomes ($P > .05$). Except where noted, these results relate to all children participating in the trial.

Discussion

The primary aim of the current study was to evaluate the effectiveness of the 'Healthy Dads, Healthy Kids' (HDHK) intervention in a community setting delivered by trained facilitators, as a unique approach to reduce obesity prevalence in men and improve lifestyle behaviors in children. To the authors' knowledge, this is the first community RCT to demonstrate the effectiveness of targeting overweight fathers in effecting changes in their own lifestyle behaviors

and those of their children. Significant intervention effects were found for fathers' weight, BMI, waist circumference, resting heart rate, physical activity levels, and dietary intake. For children, intervention effects were found for adiposity and physical activity. Feasibility of the HDHK intervention delivered in a community setting was also established, evidenced by the successful recruitment of fathers and sound retention and attendance rates.

For fathers, the weight loss difference between groups was both statistically and clinically significant (Stevens et al., 2006). For example, in the Diabetes Prevention Program, a between group difference of 3.5 kg was associated with a 39% reduction in the onset of Type 2 diabetes in overweight/obese adults (Knowler et al., 2002). The weight loss findings are also comparable to other male only weight loss studies, although many of these reported with completer analysis only (Young et al., 2012). Other than the HDHK efficacy trial (Morgan et al., 2011b), to our knowledge, no other lifestyle program has targeted fathers exclusively nor tailored a program specifically to them, which makes direct comparisons difficult. Of interest, the mean weight loss difference between groups was almost half that found in the efficacy trial (Morgan et al., 2011b). This disparity demonstrates the expected difference in effect between a closely monitored trial delivered by highly qualified research personnel in a university setting and a community program delivered by trained local facilitators in a community setting (Conn et al., 2011). In addition, the intervention in the current trial had only seven sessions delivered over seven weeks compared to eight sessions over 3 months in the efficacy trial. As a consequence, the duration of the program will be reconsidered for future implementation, as intervention duration has been found to positively predict effectiveness in child obesity prevention interventions involving parents (Niemeier et al., 2012).

Some of the difference between trial results for fathers' weight is likely to be due to the different recruitment strategies employed. In the efficacy trial, fathers were recruited using school newsletters

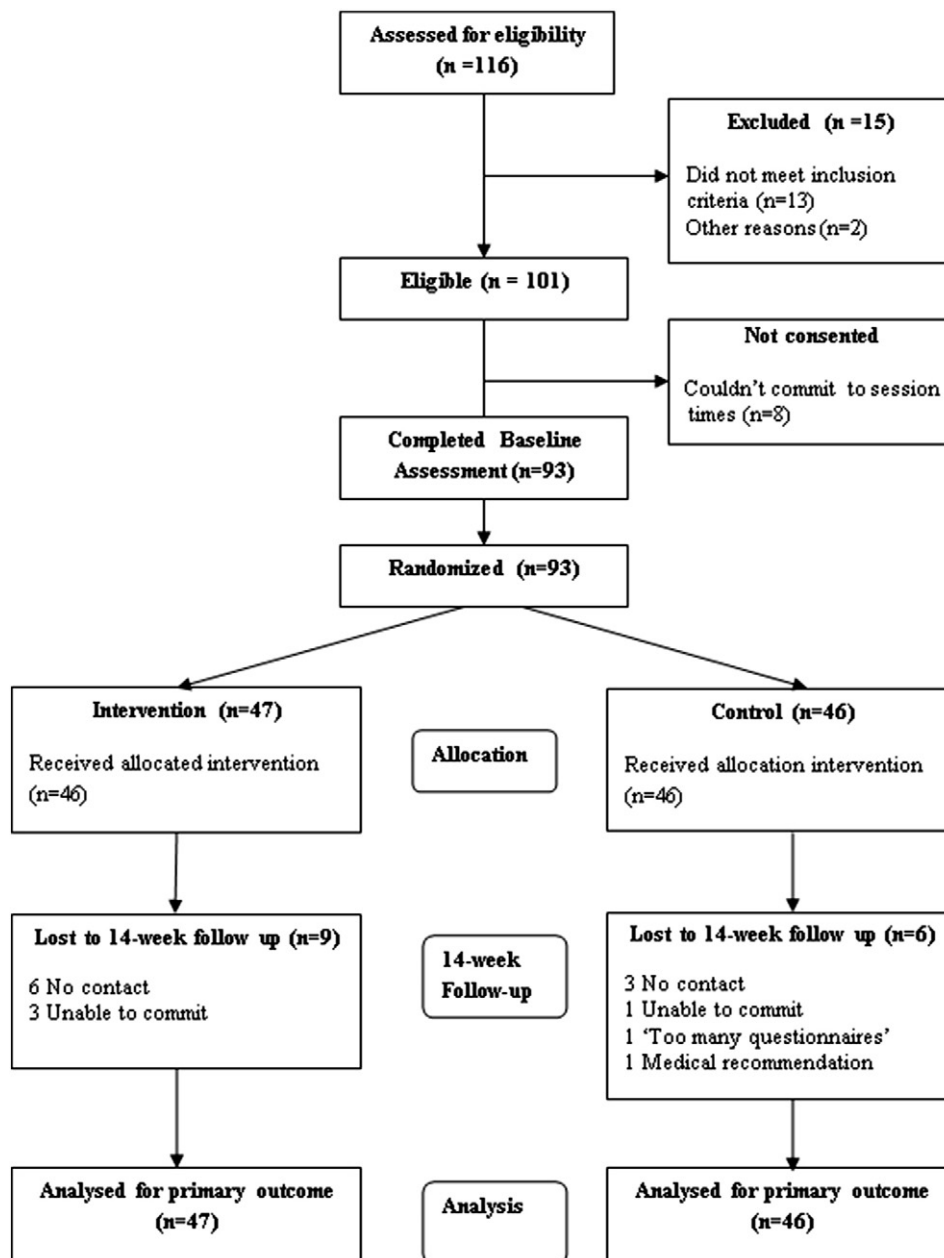


Fig. 1. Participant flow through the trial and analyzed for the primary outcome (Fathers' weight [kg]) (Hunter Region, Australia, 2010–2011).

which promoted the program as an opportunity for fathers to 'lose a few kilos'. In the community trial, key recruitment strategies were school presentations and interactions with parents waiting to pick up their children after school, with the program marketed as an opportunity for dads to spend quality time with their children in fun physical activities. As a result there may have been more fathers highly motivated to lose weight in the efficacy trial, supported by the fact that they were, on average, 4.1 kg heavier at baseline. In comparison, the community trial was conducted in two LGAs that are well above regional and state averages for physical inactivity, inadequate fruit and vegetable intake and obesity (Hunter Medicare Local, 2012). The community trial findings demonstrate that, despite living in these challenging obesity promoting environments, a program tailored to the specific needs of this population can be effective in achieving weight loss and improving health behaviors. There was also a high percentage of mining and shift workers in this study, making this an at-risk population (Australian Bureau of Statistics, 2009) as shift workers are faced with unique behavioral and biological challenges to healthy eating and physical activity (Atkinson

et al., 2008), as well as adding constraints to availability to attend all sessions.

Relative to the control group, fathers in the intervention group significantly improved their physical activity levels, BMI, waist circumference, resting heart rate and dietary intake. Favoring the intervention group, the between-group difference of 1258 steps per day at follow-up is clinically important (Dwyer et al., 2007) and noteworthy, given the previously documented mediating effect of physical activity on weight loss in fathers (Lubans et al., 2012). A recent systematic review of physical activity interventions in men (George et al., 2012) reported that almost half of the studies did not significantly improve physical activity levels, although many did not use objective measures. The HDHK intervention was designed to appeal to men and targeted self-efficacy, goal setting, social support and outcome expectations, aligning with recommendations from the literature to increase physical activity (Bravata et al., 2007; George et al., 2012).

There was also a significant intervention effect for fathers for a reduction in total daily kJ intake with a mean difference between groups

Table 3

Baseline characteristics of fathers randomized to the HDHK intervention and control group (Hunter Region, Australia, 2010–2011).

Characteristics	Control (n = 45)		HDHK program (n = 48)		Total (N = 93)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Age (years)	40.9	5.6	39.8	5.0	40.3	5.3
Weight (kg)	100.5	14.1	103.0	14.1	101.8	14.1
Height (m)	1.76	0.05	1.78	0.07	1.77	0.06
BMI (kg/m ²)	32.3	3.9	32.6	3.7	32.5	3.8
Waist [Umb] (cm)	109.0	9.9	110.4	10.8	109.7	10.3
Waist [widest] (cm)	106.4	9.8	107.4	10.3	106.9	10.0
Systolic blood pressure (mm Hg)	129	13	128	11	129	12
Diastolic blood pressure (mm Hg)	83	8	83	10	83	9
Resting heart rate (BPM)	72	11	75	11	73	11
Physical activity (steps/day) ^a	7272	2436	7167	3058	7219	2751
Daily energy intake (kJ/day) ^b	10578	3698	11367	4274	10981	4000
Sitting time (min)						
Work day ^c	573	264	534	255	552	258
Non-work day ^d	430	165	467	238	450	207
	n	%	n	%	n	%
BMI category						
Overweight	13	29%	13	27%	26	28%
Obese I	22	49%	23	48%	45	48%
Obese II	10	22%	12	25%	93	24%
SES ^e						
1–2 (lowest)	0	0%	0	0%	0	0%
3–4	1	2%	2	4%	3	3%
5–6	16	36%	17	35%	33	36%
7–8	28	62%	29	61%	57	61%
9–10 (highest)	0	0%	0	0%	0	0%

Abbreviations: HDHK = Healthy Dads, Healthy Kids; BMI = body mass index; SES = socioeconomic status; Umb = umbilicus measurement; BPM = beats per minute; kJ = kilojoules.

^a n = 79 (40 intervention; 39 control);^b n = 88 (45 intervention; 43 control);^c n = 90 (47 intervention; 43 control);^d n = 89 (47 intervention; 42 control).^e Socioeconomic status based on the SEIFA Index of Relative Socio-economic Advantage and Disadvantage (Australian Bureau of Statistics, 2008).

of approximately 2000 kJ/day, sufficient to induce weight loss. A recent review of nutrition interventions in men identified mixed findings, highlighted the uncertainty around strategies to improve dietary intake in men, and the paucity of high quality studies (Taylor et al., 2013). Our findings are encouraging and support the potential for gender-tailored approaches in programs to achieve dietary changes in men, as shown in other studies (Morgan et al., 2012, 2013).

The innovative aspect of the HDHK intervention was that fathers and children were both targeted as agents of behavior change in their families. The overall improvements in fathers' health outcomes and behaviors may be explained by the additional motivation and encouragement to role model healthy lifestyles and create healthy home environments for their children. For example, the program motivated fathers to engage in physical activity with their children and involve them in healthy eating opportunities. In turn, the children were encouraged to prompt and encourage their fathers to adopt healthier behaviors. This reciprocal reinforcement of healthier behaviors between father and child(ren) was targeted in the program and is particularly pertinent when adopting and refining behaviors (Bandura, 1978).

At post-test, a significant between-group intervention effect was observed for children's physical activity, favoring the intervention group. This is very encouraging, given that the evidence for the impact of community interventions successfully increasing physical activity in children has been weak (van Sluijs et al., 2011). While it has been unclear how best to engage parents (O'Connor et al., 2009), our findings highlight the importance of targeting fathers. Although parental modeling of physical activity has been found to be associated with child physical activity (van der Horst et al., 2007), family-based interventions to increase child physical activity have been characterized by poor study quality, inconsistent findings, and the use of self-report measures (O'Connor et al., 2009; van Sluijs et al., 2011). The significant

intervention effect for children indicates the effectiveness of the HDHK intervention approach, which focused on fathers and children spending quality time, at sessions and in home tasks, engaged in fundamental movement activities, rough and tumble play and fun, health-related fitness games, and suggests that these should be key elements of programs targeting physical activity in children.

Despite favorably impacting on energy intake for children in the efficacy trial (Morgan et al., 2011b), measured by daily energy intake relative to body weight, we did not find a significant intervention effect for this variable in the current trial. This may be due to a number of reasons including the challenges of using self-reported measures. Children may have also positively changed other aspects of their eating behavior or reduced portion sizes, which may not have been detected using a semi-quantitative FFQ. The program may also need to make more explicit efforts to engage mothers in the future, given their usually central role in food purchase, preparation and provision (Harnack et al., 1998). It may also be that the dietary messages may need to be strengthened within the facilitator training and during delivery in future programs. There was no difference between groups for sitting or screen time, where the study is likely to have been underpowered. A possible strength of both the FFQ and sitting time measures was they were completed by mothers who were not directly involved in the program, which aimed to reduce reporting bias.

Despite the non-significant difference in energy intake, children in the intervention group significantly improved their weight status, compared to the control, as measured by the mean reduction in BMI and BMI-z score. Although a recent Cochrane review demonstrated that strong evidence exists for efficacious child obesity prevention programs, it noted the need for more rigorous study designs and translational research to embed effective interventions in community settings (Waters et al., 2011). Further, the HDHK findings are important

Table 4
Baseline characteristics of children randomized to the HDHK intervention and control groups (Hunter Region, Australia, 2010–2011).

Characteristics	Control (n = 60)		HDHK program (n = 72)		Total (N = 132)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Age (years)	8.4	2.3	7.9	2.0	8.1	2.1
Weight (kg)	31.8	10.2	31.4	10.4	31.6	10.3
Height (m)	1.32	0.14	1.29	0.13	1.30	0.14
BMI (kg/m ²)	17.9	2.9	18.4	3.1	18.2	3.0
BMI z-score	0.64	1.01	0.94	1.05	0.81	1.04
Waist [narrow] (cm) ^a	60.4	8.0	61.1	7.9	60.7	7.9
Waist z-score ^a	0.89	1.32	1.25	1.38	1.08	1.36
Systolic blood pressure (mm Hg) ^b	98	11	96	12	97	11
Diastolic blood pressure (mm Hg) ^b	61	8	59	9	60	9
Resting heart rate (BPM) ^c	86	15	83	11	84	13
Physical activity (steps/day) ^d	9906	3238	10296	3227	10105	3223
Daily energy intake (kJ/kg/day) ^e	352	141	334	129	342	134
Sitting time (min/day) ^{f,g}	402	137	444	155	425	147
Screen time (min/day) ^{e,f}	157	72	155	79	156	75

	n	%	N	%	n	%
Sex						
Boys	36	60%	37	51%	73	55%
Girls	24	40%	35	49%	59	45%
BMI category						
Underweight	1	2%	0	0	1	1
Healthy weight	43	71%	44	61	87	66
Overweight	12	20%	18	25	30	23
Obese	4	7%	10	14	14	10

Abbreviations: HDHK = Healthy Dads, Healthy Kids; BMI = body mass index; SES = socioeconomic status; UM = umbilicus measurement; BPM = beats per minute; kJ = kilojoules; kg = kilograms; g = grams.

^a N = 131 (71 intervention; 60 control).

^b N = 128 (69 intervention; 59 control).

^c N = 131 (72 intervention; 59 control).

^d N = 104 (53 intervention; 51 control).

^e N = 65 (36 intervention; 29 control).

^f Reported by mothers (for eldest child if more than one child enrolled).

^g n = 63 (35 intervention; 28 control).

given the difficulty in reversing obesity once it is established (Luttikhuis et al., 2009). The BMI and BMI-z results from this trial may be slightly difficult to interpret, given that we did not detect a difference in energy intake and the between-group difference observed for steps (1625 steps/day) may not have been enough to elicit a change in BMI

z-score of this nature. However, it is important to note that measuring dietary intake in children is very difficult (Magarey et al., 2011), and that the dietary results would likely have included a larger component of error than the weight and height results, which are considerably easier to measure with good validity and reliability. In addition, two

Table 5
Changes in outcome variables for fathers by treatment group from baseline to 14 weeks and differences in outcomes among the treatment groups at 14-weeks (ITT analysis) (n = 93) (Hunter Region, Australia, 2010–2011).

Outcome	Treatment group		Mean difference between groups (95% CI) ^b	Group × Time P	Effect size (Cohen's d)
	Control (n = 45)	HDHK program (n = 48)			
Weight (kg)	0.1 (−0.9, 1.0)	−3.3 (−4.3, −2.4)	−3.4 (−4.7, −2.1)	<0.001	0.24
BMI (kg/m ²)	−0.0 (−0.3, 0.3)	−1.1 (−1.4, −0.8)	−1.0 (−1.5, −0.6)	<0.001	0.26
Waist (Umb) (cm) ^c	0.4 (−0.4, 1.3)	−3.3 (−4.2, −2.3)	−3.7 (−4.9, −2.4)	<0.001	0.36
Waist (widest) (cm) ^c	1.9 (0.7, 3.0)	−2.2 (−3.4, −1.1)	−4.1 (−5.7, −2.5)	<0.001	0.41
Systolic blood pressure (mm Hg) ^d	−1 (−5, 3)	−2 (−6, 3)	−1 (−7, 5)	0.72	0.09
Diastolic blood pressure (mm Hg) ^d	1 (−2, 4)	0 (−3, 3)	−1 (−6, 3)	0.58	0.13
Resting heart rate (BPM)	1 (−3, 4)	−6 (−9, −2)	−6 (−11, −2)	<0.01	0.59
Physical activity (mean steps/day) ^e	805 (−39, 1650)	2063 (1209, 2918)	1258 (56, 2459)	0.04	0.46
Daily energy intake (kJ/day) ^f	−234 (−1115, 647)	−2190 (−3108, −1272)	−1956 (−3228, −684)	<0.01	0.49
Sitting time					
Work day (min/day) ^g	5 (−92, 102)	−51 (−158, 55)	−56 (−200, 88)	0.44	0.22
Non-work day (min/day) ^g	−9 (−89, 71)	−68 (−151, 15)	−59 (−174, 59)	0.31	0.29

Abbreviations: ITT = Intention-to-treat; Umb = umbilicus; BMI = body mass index; BPM = beats per minute; kJ = kilojoules.

^a Time differences were calculated as (14 week minus baseline).

^b Between group differences at 14-weeks.

^c Adjusted for age.

^d Adjusted for SES.

^e N = 83 (42 intervention, 41 control).

^f N = 90 (46 intervention, 44 control).

^g N = 91 (47 intervention, 44 control).

Table 6

Changes in outcome variables for children by treatment group from baseline to 14-weeks and differences in outcomes among the treatment groups at 14-week follow-up (ITT analysis) (Hunter Region, Australia, 2010–2011).

Outcome	Treatment group		Mean difference between groups (95% CI)	Group × Time <i>P</i>	Effect Size (Cohen's <i>d</i>)
	Mean change from baseline (95% CI) ^a				
	Control (<i>n</i> = 60)	HDHK program (<i>n</i> = 72)			
BMI ^b	−0.1 (−0.2, 0.1)	−0.3 (−0.4, −0.2)	−0.2 (−0.5, 0.0)	0.02	0.07
BMI z-score	−0.08 (−0.15, −0.01)	−0.18 (−0.26, −0.11)	−0.10 (−0.21, 0.00)	0.05	0.10
Waist circumference [narrow] ^b	0.6 (−0.1, 1.3)	−0.2 (−1.0, 0.5)	−0.8 (−1.9, 0.2)	0.12	0.10
Waist z-score	0.11 (−0.05, 0.28)	−0.06 (−0.23, 0.11)	−0.17 (−0.41, 0.06)	0.15	0.13
Systolic blood pressure (mm Hg) ^{b,c,d}	−2 (−5, 1)	−4 (−7, −2)	−2 (−6, 1)	0.19	0.21
Diastolic blood pressure (mm Hg) ^{b,d}	−1 (−4, 2)	−3 (−6, −1)	−2 (−6, 1)	0.23	0.25
Resting heart rate (BPM) ^b	2 (−1, 5)	0 (−3, 3)	−2 (−6, 2)	0.38	0.15
Physical activity (mean steps/day) ^{e,f}	−157 (−1028, 713)	1468 (631, 2305)	1625 (418, 2832)	0.01	0.50
Daily energy intake (kJ/kg/day) ^{b,g,h,i}	−25 (−59, 10)	10 (−26, 47)	35 (−15, 85)	0.17	0.26
Sitting time (min/day) ^j	17 (−27, 60)	−25 (−71, 22)	−42 (−105, 22)	0.20	0.29
Screen time (min/day) ^{b,f,k}	15 (−6, 37)	4 (−18, 26)	−12 (−42, 19)	0.45	0.16

Abbreviations: ITT = Intention-to-treat; Umb = umbilicus; BMI = body mass index; BPM = beats per minute; kJ = kilojoules; kg = kilograms.

^a Time differences were calculated as (3 month-baseline).

^b Adjusted for age.

^c Adjusted for age × time.

^d Adjusted for LGA.

^e *N* = 109 (56 intervention, 53 control).

^f Adjusted for sex.

^g *N* = 77 (39 intervention, 38 control).

^h Adjusted for SES.

ⁱ Reported by mothers (for eldest child if more than one child enrolled).

^j *N* = 71 (36 intervention, 35 control).

^k *N* = 78 (39 intervention, 39 control).

significant physical activity components of HDHK were rough-and-tumble play and health-related fitness, which include many vigorous intensity non-ambulatory activities and games. As such, the associated energy-expenditure from these activities may not be adequately captured using pedometry.

Internationally, obesity in men and obesity prevention in children are public health priorities (Finucane et al., 2011). A community-based program that can improve health outcomes for men and children simultaneously may be a cost-effective obesity prevention strategy in comparison to separate interventions. Compared to other family-based interventions, the HDHK intervention was less onerous with a lower number of sessions and less face-to-face time than other programs (McLean et al., 2003; Waters et al., 2011). The HDHK community trial also addressed many of the limitations in the literature (Birch and Ventura, 2009; van Sluijs et al., 2011; Waters et al., 2011; Young et al., 2012), and its strengths included: a randomized design, intention-to-treat analysis, theoretically-based framework and use of an objective measure for the primary outcome. There were some study limitations which need to be noted. Use of the FFQ as a dietary assessment tool may be associated with a reporting bias, which would manifest as systematic rather than random error. In addition, the HDHK intervention only involved a 14-week follow-up; longer-term follow-up as well as a cost effectiveness evaluation would provide important additional information. Future research for the HDHK program of work will also examine enablers, barriers and effectiveness of the approaches for recruitment, implementation, evaluation and sustainability in each of the LGAs.

Conclusion

Within the child development literature there is considerable evidence that fathers play a key role in their child's social, academic, cognitive and behavioral development (Lundahl et al., 2008). While there is limited research examining paternal influences on children's lifestyle behaviors, there is consistent evidence that parents influence their child's patterns through their own behaviors, role modeling and

parenting practices (Edwardson and Gorely, 2010; Patrick and Nicklas, 2005). The current HDHK intervention delivered by trained facilitators in a community setting targeting overweight fathers was effective in achieving health improvements in fathers and children.

The translation of efficacious intergenerational obesity prevention programs into evidence-based community programs is a research and public health priority (Green and Glasgow, 2006; Swanson et al., 2011). The findings of this study have demonstrated both the generalizability and effectiveness of the HDHK intervention when implemented by local facilitator in a community setting.

Conflict of interest statement

The authors declare that they have no competing interests.

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Authors' contributions

The study chief investigators PJM, DRL, CEC, RCP, RC, TB, RF and ADO were responsible for identifying the research question, design of the study, obtaining ethics approval, and acquisition of funding and overseeing study implementation. Research assistants MDY, AM, JBC, ATC, KLS and PhD student ABL have contributed to the development of intervention materials, recruiting participants and study

implementation. All authors were responsible for the drafting of this manuscript and have read and approved the final version.

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