Larsen, K. T., Huang, T., Møller, N. C., Andersen, L. B., Sørensen, J. (2017). Cost-effectiveness of a day-camp weight-loss intervention programme for children: Results based on a randomised controlled trial with one-year follow-up. *Scandinavian Journal of Public Health, 45*, 666-674.

Title

Cost-effectiveness of a day-camp weight-loss intervention programme for children: Results based on a randomised controlled trial with one-year follow-up

Authors

Kristian Traberg Larsen (corresponding author)
Centre of Research in Childhood Health (RICH), Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Campusvej 55, 5230 Odense, Denmark.
E-mail: ktlarsen@health.sdu.dk
Telephone number: (+45) 6550 4551

Tao Huang
Department of Physical Education, Shanghai Jiao Tong University, Dongchuan Rd. 800, 200240 Shanghai, China.
E-mail: taohuang1981@hotmail.com

Niels Christian Møller
Centre of Research in Childhood Health (RICH), Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Campusvej 55, 5230 Odense, Denmark.
E-mail: ncmoller@health.sdu.dk

Jan Sørensen
Center for Health Economic Research (COHERE), Department of Public Health, University of Southern Denmark, J. B. Winsløws Vej 9B, 5000 Odense, Denmark.
E-mail: jas@health.sdu.dk

Keywords

Childhood obesity, cost-effectiveness, weight-loss, intervention, physical activity, RCT, Incremental cost-effectiveness ratio

Abstract

Aims: The aim was to analyse cost-effectiveness of an intensive weight-loss intervention for children compared with a low-intense intervention.

Methods: One-hundred fifteen overweight children (mean age 12.0 ± 0.4) were randomised either to the camp group (CG) (N=59) or the standard group (SG) (N=56). Participants of the CG were offered a six-week day-camp weight-loss programme followed by a family-based supportive programme containing four meetings during the succeeding 46 weeks. Participants of the SG were offered weekly two-hour exercise session for six weeks. Changes in body mass index (BMI) and BMI z-score 12 months after inclusion were used to compare the effects of the two interventions. Incremental cost-effectiveness ratios (ICER) were estimated from the perspective of a Danish municipality. To achieve the required number of participants, an additional intervention was initiated one year later.

Results: In comparison with the SG, the CG changed their mean BMI by -1.2 (95% CI -1.8 to -0.5). Compared with the SG children, the CG children changed their BMI z-score by -0.20 (95% CI -0.35 to -0.05). The ICER per decreased BMI point in the CG compared with the SG was DDK 24,928.

Conclusions: Compared to the SG, the CG showed favourable effects after 12 months. However, the CG was more costly. Results observed in the present study can be helpful in guiding decision makers take more informed decisions when choosing different types of interventions.

Trial registration:

ClinicalTrial.gov. Registration number: NCT01574352.
URL: https://clinicaltrials.gov/ct2/show/NCT01574352?term=NCT01574352&rank=1

Introduction

Childhood obesity has several negative health consequences [1-4] and tracks into adulthood [5, 6]. Consequently, it has become a significant economic burden on the health care system [7, 8]. In Denmark, 54% of adults [9] and approximately 17% of children are overweight or obese, and the condition is estimated to cost the Danish Health services DDK 1.5 billion annually [10]. Recent reviews and meta-analyses suggested that the most effective interventions in order to reverse childhood obesity are multi-disciplinary, containing both physical activity, dietary, and behavioural components [11-13]. One of the more promising approaches, taking these components into account, is referred to as *immersive* interventions. These often take place in camp surroundings and have proven to be short-term effective in a number of recent evaluations [14]. Typically, such interventions reduce body mass index (BMI) between 1.2 to 3.3 units during camp sessions lasting three to eight weeks, and they often show larger effects when more time is spend on the camp [15-17]. However, the evaluations of camp-based interventions have been characterised by short-term follow up, non-randomised designs and with highly selected participants [14]. Furthermore, such interventions have rarely been analysed in relation to cost-effectiveness. It is reasonable to assume that an immersive camp-based intervention can be a significant investment given that it requires use of sports facilities and equipment, food serving, camp staff, and overnight stay. We have identified only one study that reported on the cost of a camp-based intervention [18], and it did not consider cost-effectiveness. However, information about the cost-effectiveness of an intervention is particularly relevant for decisions about whether or not a programme should be implemented within the constraint of scarce resources.

The municipality of Odense, Denmark (approximately 250k inhabitants) has since 2005 provided an immersive camp-based weight-loss programme for children at a remote located island with a subsequent 46-week supportive family-based programme. In 2011, a feasibility project was conducted to assess the opportunities for providing the programme as a day-camp. Besides the location and no overnight stays, the content of the day-camp was similar to the original camp content. In 2012 and 2013, the Odense Overweight Intervention Study (OOIS) was conducted to compare the effects of the day-camp with a low-intense standard intervention in a randomised

controlled trial (RCT) design. The predetermined health related effects have recently been published [19]. The trial demonstrated a significant reduction in BMI (1.2 kg/m^2) and BMI z-score (0.20) after one year for children participating in the day-camp compared to those who received a standard intervention [19].

Whether the results are worth the investment from a municipal perspective is still uncertain and requires scrutiny of the costs and whether it could be cost-effective. The aim of this study was to conduct a 12-month cost-effectiveness analysis of the immersive day-camp programme for overweight children with subsequent family-based support compared with a low-intense standard intervention.

Methods

The OOIS study design

We conducted a RCT based economic evaluation of the OOIS from a Danish municipal perspective. This perspective was chosen because municipalities have the responsibility of primary prevention in Denmark and, consequently, are the initiators and funders of such programmes. Gender-stratified concealed block randomization with a ratio of 1:1 was applied to ensure gender balance between the two study groups. The randomisation was performed prior to baseline measurements due to school and parent planning. The study protocol has been published [20], and the study was approved by The Regional Scientific Ethical Committee for Southern Denmark (Approval number: S-20120015), registered with the Danish Data Protection Agency and at ClinicalTrial.gov (Registration number: NCT01574352). To achieve the required number of participants, the intervention was opened for enrolment the consecutive year as well.

Participants

Almost all fifth-grade children (91.3%) from 2012 and 2013 in the municipality of Odense participated in an annual mandatory health examination by the school nurses. If a child exceeded the age and sex-specific BMI cut-off limits for overweight (corresponding to BMI>25 for adults), as described by Cole et al. [21], he/she was invited to participate in the OOIS. All overweight children and parents (or legal guardians) were invited to an informative meeting, and were enrolled after

signing a consent form. Inclusion and exclusion criteria for participants are fully described in the study protocol [20]. Predefined decision rules specify that accepted adherence to the interventions requires an attendance of 85% of the time for the day-camp group and four out of six activity sessions for the standard group [20].

Interventions

Camp Group (CG)

A full description of the intervention programmes is provided in the study protocol [20]. Briefly, the day-camp took place from mid-May to end-June in 2012 and in 2013. Children arrived at the day-camp, centrally placed in Odense, every day for six weeks at 7.00 a.m. and left to stay overnight at home at 8.30 p.m. and were withdrawn from regular school during the day-camp. On a daily basis, children were engaged in a minimum of three hours of structured motivation-enhancing physical activity, one hour of health education, and one hour of school homework. Healthy meals were provided [22] and supervised by the camp instructors, although no diet restrictions was enforced. Of the six instructors employed at the camp, two received the children in the morning, four was present during the day, and three were present after dinner at night. After the day-camp, a 46-weeks supportive family-based programme was implemented. The objective of the family support was to help the families to sustain the healthy lifestyles changes initiated during the day-camp. This included four group meetings with trained school nurses and camp instructors for participating children and at least one of their parents for eight to ten families at a time, and a one-day sports and activity programme for all children.

Standard Group (SG)

The standard intervention consisted of six weekly exercise sessions (two hours duration) for the children, as well as a single health and lifestyle educational session for the parents which were provided by a dietician and physical activity specialist. The standard intervention was delivered at the same time as the day-camp intervention and ended after the six-week period.

Measurements and outcomes

A wide range of physical and body composition measurements were obtained at each data collection, although only a few of these measures were used in this study (more details appear in

the study protocol [20]). The test personnel were blinded for allocation group at all measurements. Measurements were obtained when the participants attended the measurement facilities at the University of Southern Denmark and Odense University Hospital, both in the city of Odense, Denmark. Data were collected during three separate occasions: at baseline, at six weeks (immediately after completion of the six-week programme), and after completion of the family-based programme (52 weeks). In the present study, results from the baseline and one-year follow-up measurements [19] were applied in the cost-effectiveness analysis. In this context the post-camp measurements were found less relevant to include.

Anthropometric measurements

Body weight was measured in underwear using a Soehnle Professional Medical electronic scale (Murrhardt, Germany). Body height was assessed without footwear on a wall mounted stadiometer. Waist circumference was assessed between the lower costal margin and the iliac crest to the nearest 0.5 cm, at the end of a gentle expiration. Pubertal development was assessed according to Tanner by self evaluation and divided in five categories [23]. BMI was calculated as body weight divided by the square of the body height (kg/m^2). BMI z-scores was calculated based on norm data from the International Obesity Task Force [21].

Socio-demographics

Parental socio-economic status, derived from self-reported questionnaires, was classified based on the mother's highest education level and categorised into short, medium, or long according to the International Standard Classification of Occupations from 2008 [24]. Ethnicity was dichotomised into Danish/Non-Danish origin.

Costs

Operating expenses of the day-camp and the standard intervention were collected through inspection of accounts from Odense Municipality. Cost of staff salaries were estimated based on actual working hours and the hourly salary at 2012-price levels in Danish crowns (DKK) as reported by the Municipality of Odense and validated with existing collective agreements. The municipality also reported additional costs related to the interventions, e.g. administrative bonuses for school nurses and payments to dieticians for their participation in the project.

Costs were reported for the actual number of participating children in the two interventions (i.e. 55 children in the CG and 51 children in the SG) during the programme as the interventions had spare capacity due to difficulties in recruiting sufficient participants. Therefore, a complementary cost analysis was performed assuming full participation during the two years (i.e. 80 children enrolled in each programme). This was considered a reasonable assumption if the programme should be implemented into an ordinary municipal setting without being evaluated in a scientific research programme. As the number of participating children only influenced some of the cost (e.g. food expenses), while others were fixed (e.g. costs for facilities), costs dependent on the number of participants from the actual day-camp was multiplied by the respective factors needed to reach 80 children in each intervention group (e.g. 80/55 = 1.45 for the CG).

Cost-effectiveness

The cost-effectiveness was estimated within a one-year time perspective both regarding the effect and intervention costs. The Incremental cost-effectiveness ratio (ICER) was defined as:

$$ICER = \frac{C_1 - C_0}{E_1 - E_0},$$

where the difference between C_1 and C_0 indicate the average incremental cost and the difference between E_1 and E_0 indicate the incremental effect of the CG in comparison with the SG [25]. Changes in BMI and BMI z-score were used as effects.

Statistical analyses

Normal distribution of baseline variables were assessed by Shapiro-Wilk tests. Unpaired t-tests for normal distributed data, Wilcoxon rank-sum tests for non-normal distributed data, and chi-squared tests for categorical data were applied to detect between-group differences at baseline. Measures of difference in change between groups were analysed using linear mixed effects models for repeated measures with the interaction between time and intervention group as the primary effect measure including all three measurements from the effect paper[19]. The first (baseline) and last measurements from these analyses were applied in the cost-effectiveness analyses in the present study. Incremental cost-effectiveness ratios were calculated as described above. As costs were determined as a deterministic cost, analysis of statistical uncertainty was not

possible. Significance level was set at P<0.05. Analyses were performed using Microsoft Excel 2010 (version 14) and Stata version 12.1 SE (StataCorp LP, College Station, TX, USA).

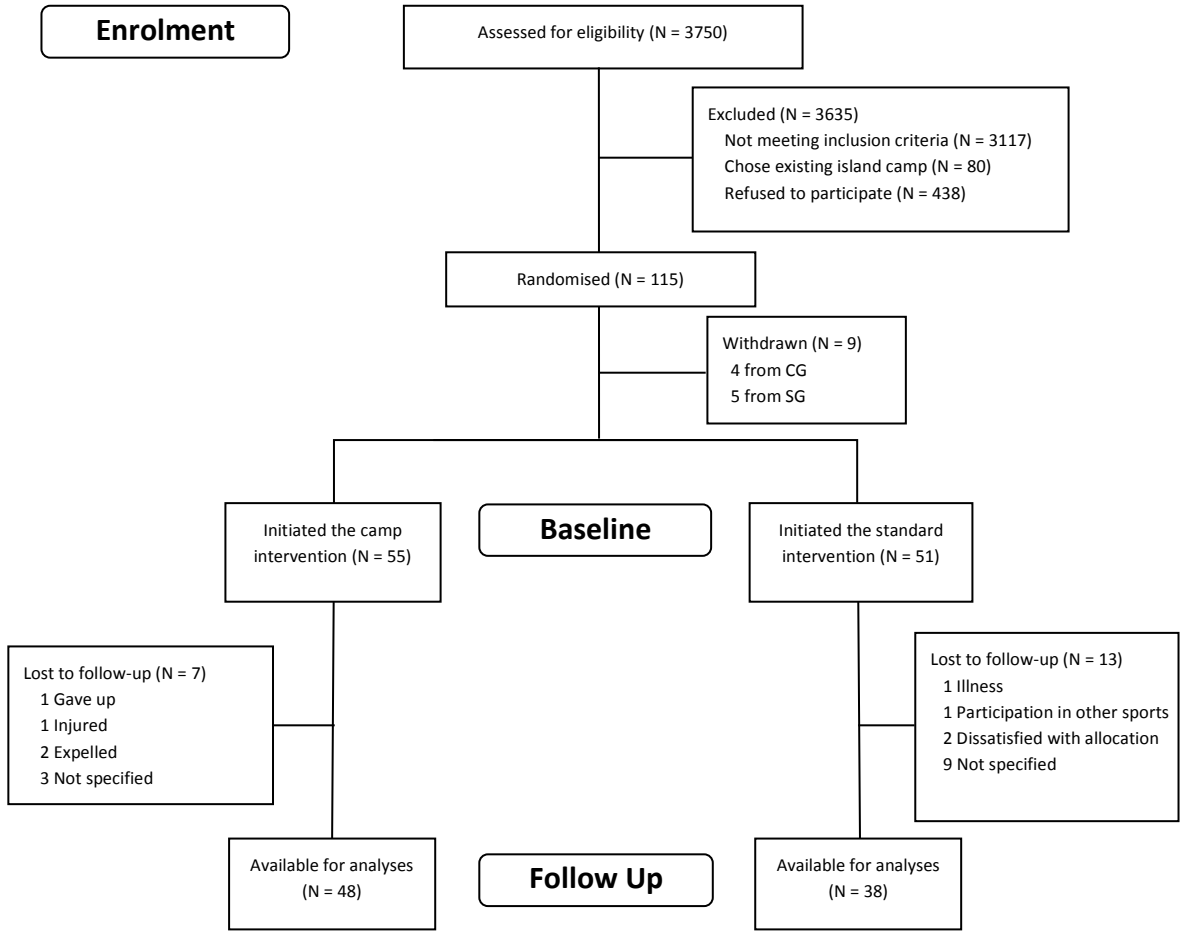
Results

Characteristics of the two groups of participants are presented in Table 1, and the flow of participants in Figure 1. One-hundred-and-fifteen children were randomised (65 in 2012 and 50 in 2013) and baseline measurements were obtained from 106 participants (55 from the CG). Nine children withdraw from the study before baseline measurements. No baseline differences could be observed between the two groups with the exception of waist circumference. Most children (50/55) who started attending the day-camp programme also completed it according to the predetermined attendance rate (≥85% of the total time). Twenty-five children (48.1%) fulfilled the predefined attendance rate during the subsequent family-based intervention period (≥4 of 6 sessions, including the activity day and the initial counselling session). In the SG, 36 of 56 (64%) participants completed according to the predetermined attendance rate (minimum 4/6 sessions). After 52 weeks, 48 children from the CG (19% loss to follow-up) and 38 children from the SG (32% loss to follow-up) participated in the follow-up measurements.

Effects

The difference in mean change between the two groups after 52 weeks was 1.2 (95% CI -1.8 to -0.5) BMI unit points. After 52 weeks, the SG children had maintained their BMI level (mean BMI change: 0.1 (95% CI -0.4 to 0.6)), while the CG children had changed their BMI by -1.1 (95% CI -1.5 to -0.6) (Table 2). The difference in change of BMI z-score was -0.20 (95% CI -0.35 to -0.05) (Table 2) indicating significant weight reduction in the CG. Despite this difference, children from both intervention groups had significantly decreased their BMI z-score after 52 weeks (Table 2).

Figure 1 Flow of participants in the trial



SG = Standard Group. CG = Camp Group.

Table 1 Baseline characteristics.

	Total	Day-Camp Intervention Group	Standard Intervention Group	P-value
Total N (male %)	106 (44.3)	55 (47.3)	51 (41.2)	0.53
Age, mean years (SD)	12.0 (0.4)	12.0 (0.4)	12.0 (0.4)	0.30
Ethnic Danish (%)	66.0‡	70.6	61.8	0.34
Socio-economic status (based on education length) ♂ / ♀ (N)†				
Short	11 / 14	7 / 8	4 / 6	
Medium	18 / 21	11 / 13	7 / 8	
Long	12 / 23	6 / 7	6 / 16	0.08
Pubertal stage ♂ / ♀ (N)				
1	4 / 0	3 / 0	1 / 0	
2	24 / 4	13 / 2	11 / 2	
3	17 / 37	9 / 18	8 / 19	
4	2 / 15	1 / 9	1 / 6	
5	0 / 3	0 / 0	0 / 3	0.34
Body height, mean cm (SD)	156.0 (6.1)	156.4 (6.6)	155.5 (5.7)	0.46
Body weight, median kg (IQR)	60.1 (53.9 – 65.5)	61.3 (55.4 – 66.2)	59.2 (52.4 – 62.9)	0.12
Waist circumference, mean cm (IQR)	83.0 (78.5 – 88.0)	84.5 (80.5 – 89.0)	81.5 (77.0 – 85.0)	0.02
BMI, median kg/m² (IQR)	24.3 (22.6 – 26.9)	24.8 (22.8 – 27.1)	23.9 (22.5 – 26.9)	0.22
BMI z-score, mean (SD)	1.94 (0.49)	1.99 (0.46)	1.87 (0.51)	0.21

Means with standard deviations (SD) for normal distributed data and medians with inter quartile ranges (IQR) for non-normal distributed data are presented for each intervention arm and for the total sample. † = Only 99 parents completed the questions regarding educational level.

Table 2 BMI and BMI z-score at baseline and difference in group changes after 52 weeks using two-sided linear mixed effects models for repeated measures.

	Mean (SD)		Within group change at 52 weeks	Difference in change at 52 weeks	
	Baseline SG, N=51 CG, N=55	52 weeks SG, N=38 CG, N=48	Mean (95 % CI)	Mean (95 % CI)	P-value
BMI (kg/m2)					
SG	24.5 (2.9)	24.8 (3.7)	0.1 (-0.4 to 0.6)	-1.2 (-1.8 to -0.5)	0.001
CG	25.2 (2.8)	23.8 (3.1)	-1.1 (-1.5 to -0.6)*		
BMI z-score					
SG	1.87 (0.51)	1.73 (0.66)	-0.19 (-0.30 to -0.08)*	-0.20 (-0.35 to -0.05)	0.008
CG	1.99 (0.46)	1.53 (0.63)	-0.39 (-0.49 to -0.29)*		

SD = Standard Deviation. CI = Confidence interval. CG = Day-Camp Intervention Group. SG = Standard Intervention Group. * = significant changes within group change. The results are extracted from the earlier published main effects analyses [19].

Costs

The running cost of the day-camp intervention for two years with 55 participants was DDK 1,692,548 (Table 3). The cost of the standard intervention with 51 participants was DDK 43,852 (Table 3). The average incremental cost per child was DDK 29,914. With the assumption of full

participation in the two programmes, the costs were DDK 1,771,245 and DDK 46,070, respectively. The incremental cost per child with full participation was DDK 21,565.

Table 3 Cost for the camp during two years and, alternatively, for the day-camp assuming full participation (40 children per year per intervention group).

Day-camp Intervention Group						
6 weeks day-camp			**Actual participation (55 children)**		**Full participation (80 children)**	
Staff	Hours	Hourly wage	Costs	Total	Costs	Total
Instructors	4576.6	DDK 105	DDK 480,000		DDK 480,000	
Project manager	869.5	DDK 200	DDK 173,900		DDK 173,900	
Kitchen staff	2400	DDK 143	DDK 343,882		DDK 343,882	
Dieticians	40	DDK 150	DDK 26,000		DDK 26,000	
				DDK 1,023,782		DDK 1,023,782
Operating expenses						
Rental of facilities			DDK 179,000		DDK 179,000	
Cleaning			DDK 53,000		DDK 53,000	
Food*			DDK 164,749		DDK 239,635	
Kitchen equipment			DDK 4,515		DDK 4,515	
Equipment and expenses for activities			DDK 8,983		DDK 8,983	
Education for instructors			DDK 124,732		DDK 124,732	
Mails and postage*			DDK 5,705		DDK 8,297	
				DDK 540,684		DDK 618,162
Family-based intervention						
Staff						
Nurses	192	DDK 300	DDK 57,600		DDK 57,600	
Instructors	248	DDK 200	DDK 49,600		DDK 49,600	
Dieticians	48	DDK 150	DDK 7,200		DDK 7,200	
				DDK 114,400		DDK 114,400
Other expenses						
Education material			DDK 11,000		DDK 11,000	
Catering*			DDK 2,682		DDK 3,901	
				DDK 13,682		DDK 14,901
Total CG expenses				DDK 1,692,548		DDK 1,771,245
6 weeks standard intervention			**Actual participation (51 children)**		**Full participation (80 children)**	
Staff	Hours	Hourly wage	Costs	Total	Costs	Total
Instructors	72	DDK 200	DDK 14,400		DDK 14,400	
Dieticians	15	DDK 150	DDK 2,250		DDK 2,250	
Project manager	70.5	DDK 200	DDK 14,100		DDK 14,100	
				DDK 30,750		DDK 30,750
Other expenses						
Mail and postage*			DDK 1,902		DDK 2,983	
Rental of facilities			DDK 7,200		DDK 7,200	
Equipment			DDK 2,000		DDK 2,000	
Food for health class*			DDK 2,000		DDK 3,137	
				DDK 13,102		DDK 15,320
Total SG expenses				DDK 43,852		DDK 46,070

All prices are in 2012 prices, Danish crowns (DDK). * = Costs dependent on number of participating children. Other costs are fixed up to 40 children participating children per year. CG = Day-Camp Intervention Group. SG = Standard Intervention Group.

Cost-effectiveness

The ICERs per point decrease in BMI were DDK 24,928 and DDK 17,971 with assumption of actual and full participation, respectively (Table 4). The corresponding ICERs per unit decrease in BMI z-score were DDK 149,569 and DDK 107,823 for actual and full participation, respectively (Table 4).

Table 4 Costs and cost-effectiveness per child in relation to difference in BMI, and BMI z-score for the day-camp during, and alternatively, for the day-camp assuming full participation (40 children per year per intervention group).

	Costs for actual participation			**Costs for full participation (hypothetical)**		
	CG	**SG**	**Difference**	**CG**	**SG**	**Difference**
N	55	51		80	80	
Total cost (DDK)	1,692,548	43,852	1,648,696	1,771,245	46,070	1,725,175
Cost per child (DDK)	30,774	860	29,914	22,141	576	21,565
ICER per point decrease in BMI			24,928			17,971
ICER per unit decrease in BMI z-score			149,569			107,823

All prices are in 2012 prices, Danish crowns (DDK). CG = Day-Camp Intervention Group. SG = Standard Intervention Group. ICER = Incremental Cost Effectiveness Ratio.

Discussion

The CG participants achieved a significant reduction in BMI and BMI z-score when compared to the SG participants. At the same time the day-camp programme was significantly more expensive than the standard programme. For each reduced BMI point on the individual level, the incremental cost for the CG would be DDK 24,928 compared to the SG. The equivalent for BMI z-score would be DDK 149,669. Assuming full participation in both intervention groups, the ICER would be reduced by approximately 25%.

The results in the light of other research

To our knowledge, this is one of the first studies that have assessed the cost-effectiveness of a camp-based intervention programme. One previous study by Gately et al. has reported the costs of a camp-based intervention programme but did not consider cost-effectiveness [16]. Taking the reported effects into account *the Gately camp* was slightly more costly per reduced BMI unit than the present day-camp. However, actual costs for *the Gately camp* might have been even lower as it was intended to make a profit and the costs reported were the fees for participating. Furthermore, direct comparison is difficult as Gately et al. did not report the long term effects and had no randomisation of participants.

Previous reviews have shown that few studies focus on cost-effectiveness of weight-loss programmes for children [26]. However, increasing awareness of the importance of adding a cost perspective to the traditional effectiveness studies has recently resulted in an increasing number of cost-effectiveness publications [18, 27-30]. In the LEAP2 trial, Wake et al. evaluated a surveillance and advisory programme conducted by general practitioners and found no significant effects of the intervention on either BMI, physical activity, nor nutrition[30]. Targeting overweight/obese families, Epstein et al. stated that a family-based treatment were more cost-effective compared to separated child and parent treatment as cost were comparable, but the effects differed[27]. Hollinghurst et al. found that a diet restricting instrument (Mandometer) was less cost-effective compared to standard clinical and hospital approaches[18]. A German school-based intervention study by Kesztyüs et al. was cost-effective compared to control schools following normal curriculum[28]. In an Australian trial, the BAEW program, Moodie et al. examined the cost-effectiveness of a successful community-based intervention[29]. The cost per prevented BMI point was estimated to be AUD 576 corresponding to AUD 29,798 per saved *Disability adjusted life year*[29]. Overall, only a few studies of variable approaches have evaluated the cost-effectiveness of weight-loss interventions in children, but the majority of these have been shown to be more or less cost-effective.

There is reason to assume that most of the children from the SG who reduced their BMI, to some extent would succeed without much (or any) intervention as the SG programme was very sparse. Similarly, the higher effect sizes in the CG could indicate that some children only would improve as a consequence of participating in this intervention group. Thus, the more expensive, but also more effective, day-camp intervention programme could be justified for overweight children not responding to low-intense standard interventions.

The cost of the present day-camp intervention could be reduced slightly without jeopardising the effects, e.g. with regards to project management and kitchen staff. Furthermore, shortening the camp duration one or two weeks and adding resources to the family-based intervention by including favourable programme elements, e.g. cognitive behavioural therapy [14, 31], could potentially improve the sustainability of the effects. As this is among the first cost-effectiveness studies of an intervention for overweight children, the results may offer important methodological

insights that are relevant for the design of future studies and for aid the establishment of a collective trial evidence base to model health consequences in a Danish context.

Limitations and strengths

Some important limitations may reduce generalisability.

It would be theoretically possible to model the development of health status including future morbidity and mortality for the participating children as e.g. done by Moodie et al.[29], thus, being able to carefully estimate the health-related consequences of participating in the OOIS. However, assuming that the observed effect last into adulthood without applying some form of follow-up programme appears to be highly uncertain given that the intervention is provided relatively early in the participants' life [29, 32]. Therefore, assessing the long-term health consequences of interventions for children aged 12-13 years old seem difficult and challenging based on this study.

Another concern for the interpretation of the cost-effectiveness analysis is the lack of a do-nothing/placebo control group, as participants from both intervention groups initially have accepted to participate in a weight loss programme. If children from the CG were compared to their overweight peers who declined to participate, a larger effect size would likely have been observed. As remarked earlier, weight gain and increased BMI could be expected to change over time in the overweight peers[32]. To illustrate how much this would influence the cost-effectiveness over one-year, we performed a post-hoc analysis assuming that children from the SG would gain weight as expected by the age- and sex-specific BMI curves from the International Obesity Task Force[21]. The simulated data revealed that for each additional decreased BMI unit, the incremental cost for the CG would be reduced from DDK 24,928 to DDK 6,232 per child. Although this estimate is speculative, it emphasises how much impact the weight loss achieved by the SG participants has on the ICER and, furthermore, it suggests that the cost-effectiveness reported in this study is relatively conservative.

When assuming full participation each year, the costs per participant in both interventions would be reduced, and the ICER would be reduced also (from DDK 24,928 to DDK 17.971 per BMI unit). It would be fair to assume that the day-camp could be fully occupied in a Danish city down to half the size of Odense, as 40 overweight children still participated in the existing camp each year

simultaneously with the OOIS. Undesirable allocation was the primary reason for rejecting participation among children and parents in the present study. Consequently, the sampling of participants maybe biased as participating children and families would be more determined to engage in and complete a weight-loss programme, than what would be expected from the background population.

Strengths of the study included the randomised study design and the novel cost-effectiveness evaluation of an immersive weight-loss intervention programme. The municipal perspective makes the programme relevant for municipal decision makers. Furthermore, with no overnight stay required for participants, the intervention can take place in numerous settings and would be relative easily implemented.

Conclusion

The present study is among the first to evaluate the cost-effectiveness of an immersive camp-based weight-loss programme and to evaluate the cost-effectiveness of weight-loss programmes for children in general. The study showed that a day-camp intervention programme with a subsequent family-based focus was more effective but also more expensive than a low-intense standard intervention. Camp-based programmes may be relevant options for municipalities with responsibility for prevention or treatment of overweight or obesity in children. Future camp-based programmes should focus on reducing expenses without jeopardising the promising health effects.

Acknowledgments

The authors acknowledge the significant support from the municipality of Odense. Especially, Mette Mørkenborg and Mie Hansen for making a huge effort to run the camps and support children and parents participating in the intervention program. The authors acknowledge all participants in the study, as well as the many school nurses involved in the project. We also thank the members of the OOIS Steering Committee for their advice and support, especially Professor Lars Bo Andersen and Mathias Ried-Larsen. Finally, the authors acknowledge the tenacious work of the test personnel.

Data availability

Data is available on request from The Danish National Archives (http://dda.dk/catalogue/30519).

Financial Disclosure

The study was funded by Trygfonden (Grant number 7-11-0700). Professor Lars Bo Andersen is the receiver of the funding.

Declaration of conflicting interests

The Authors declare that there is no conflict of interest.

References

1. De Niet JE and Naiman DI. Psychosocial aspects of childhood obesity. *Minerva pediatrica*. 2011; 63: 491-505.
2. Freedman DS, Dietz WH, Srinivasan SR and Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics*. 1999; 103: 1175-82.
3. Han JC, Lawlor DA and Kimm SY. Childhood obesity. *Lancet*. 2010; 375: 1737-48.
4. Zeitler P, Fu J, Tandon N, et al. ISPAD Clinical Practice Consensus Guidelines 2014. Type 2 diabetes in the child and adolescent. *Pediatric diabetes*. 2014; 15 Suppl 20: 26-46.
5. Singh AS, Mulder C, Twisk JW, van Mechelen W and Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obesity reviews : an official journal of the International Association for the Study of Obesity*. 2008; 9: 474-88.
6. Rasmussen M, Holstein BE and Due P. Tracking of overweight from mid-adolescence into adulthood: consistent patterns across socio-economic groups. *European journal of public health*. 2012; 22: 885-7.
7. Finkelstein EA, Graham WC and Malhotra R. Lifetime direct medical costs of childhood obesity. *Pediatrics*. 2014; 133: 854-62.
8. Wang YC, McPherson K, Marsh T, Gortmaker SL and Brown M. Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet*. 2011; 378: 815-25.
9. Christensen A, Davidsen M, Ekholm O, Pedersen P and Juel K. Danskernes Sundhed–Den Nationale Sundhedsprofil 2013 (The health of the Danes–the national health profile 2013). In: Hvass LR, (ed.). *Copenhagen: Danish Health Authority*. 1 ed. Copenhagen: National Institute of Public Health, University of Southern Denmark, 2014, p. 123.
10. Juel K, Sørensen J and Brønnum-Hansen H. *Risikofaktorer og folkesundhed i Danmark*. Syddansk Universitet. Statens Institut for Folkesundhed, 2006.
11. Hoelscher DM, Kirk S, Ritchie L, Cunningham-Sabo L and Committee AP. Position of the Academy of Nutrition and Dietetics: interventions for the prevention and treatment of pediatric overweight and obesity. *Journal of the Academy of Nutrition and Dietetics*. 2013; 113: 1375-94.
12. Oude Luttikhuis H, Baur L, Jansen H, et al. Interventions for treating obesity in children. *The Cochrane database of systematic reviews*. 2009: Cd001872.
13. Wang Y, Cai L, Wu Y, et al. What childhood obesity prevention programmes work? A systematic review and meta-analysis. *Obesity Reviews*. 2015; 16: 547-65.
14. Kelly KP and Kirschenbaum DS. Immersion treatment of childhood and adolescent obesity: the first review of a promising intervention. *Obesity reviews : an official journal of the International Association for the Study of Obesity*. 2011; 12: 37-49.
15. Carraway ME, Lutes LD, Crawford Y, et al. Camp-based immersion treatment for obese, low socioeconomic status, multi-ethnic adolescents. *Childhood obesity (Print)*. 2014; 10: 122-31.
16. Gately PJ, Cooke CB, Barth JH, Bewick BM, Radley D and Hill AJ. Children's residential weight-loss programs can work: a prospective cohort study of short-term outcomes for overweight and obese children. *Pediatrics*. 2005; 116: 73-7.
17. Huelsing J, Kanafani N, Mao J and White NH. Camp jump start: effects of a residential summer weight-loss camp for older children and adolescents. *Pediatrics*. 2010; 125: e884-90.
18. Hollinghurst S, Hunt LP, Banks J, Sharp DJ and Shield JP. Cost and effectiveness of treatment options for childhood obesity. *Pediatric obesity*. 2014; 9: e26-34.
19. Larsen KT, Huang T, Ried-Larsen M, Andersen LB, Heidemann M and Møller NC. A Multi-Component Day-Camp Weight-Loss Program Is Effective in Reducing BMI in Children after One Year: A Randomized Controlled Trial. *PloS one*. 2016; 11: e0157182.

20. Larsen KT, Huang T, Moller NC, Andersen LB and Ried-Larsen M. Effectiveness of a one-year multi-component day-camp intervention for overweight children: study protocol of the Odense overweight intervention study (OOIS). *BMC public health*. 2014; 14: 313.
21. Cole TJ, Bellizzi MC, Flegal KM and Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ (Clinical research ed)*. 2000; 320: 1240-3.
22. Astrup AV, Andersen NL, Stender S and Trolle E. [Dietary Recommendations 2005]. *Ugeskrift for laeger*. 2005; 167: 2296-9.
23. Tanner JM. Normal growth and techniques of growth assessment. *Clinics in endocrinology and metabolism*. 1986; 15: 411-51.
24. Organization IL. International Standard Classification of Occupations International Labour Organization, 2012, p. 422.
25. Drummond F. *Methods for the Economic Evaluation of Health Care Programmes*. Oxford University Press, 2005.
26. John J, Wolfenstetter SB and Wenig CM. An economic perspective on childhood obesity: recent findings on cost of illness and cost effectiveness of interventions. *Nutrition (Burbank, Los Angeles County, Calif)*. 2012; 28: 829-39.
27. Epstein LH, Paluch RA, Wrotniak BH, et al. Cost-effectiveness of family-based group treatment for child and parental obesity. *Childhood obesity (Print)*. 2014; 10: 114-21.
28. Kesztyus D, Schreiber A, Wirt T, et al. Economic evaluation of URMEL-ICE, a school-based overweight prevention programme comprising metabolism, exercise and lifestyle intervention in children. *The European journal of health economics : HEPAC : health economics in prevention and care*. 2013; 14: 185-95.
29. Moodie ML, Herbert JK, de Silva-Sanigorski AM, et al. The cost-effectiveness of a successful community-based obesity prevention program: the be active eat well program. *Obesity (Silver Spring, Md)*. 2013; 21: 2072-80.
30. Wake M, Baur LA, Gerner B, et al. Outcomes and costs of primary care surveillance and intervention for overweight or obese children: the LEAP 2 randomised controlled trial. *BMJ (Clinical research ed)*. 2009; 339: b3308.
31. Vignolo M, Rossi F, Bardazza G, et al. Five-year follow-up of a cognitive-behavioural lifestyle multidisciplinary programme for childhood obesity outpatient treatment. *European journal of clinical nutrition*. 2008; 62: 1047-57.
32. Haby MM, Vos T, Carter R, et al. A new approach to assessing the health benefit from obesity interventions in children and adolescents: the assessing cost-effectiveness in obesity project. *International journal of obesity (2005)*. 2006; 30: 1463-75.