

Berntsen, S., Mowinckel, P., Carlsen, K.-H., Carlsen, C. L., Kolsgaard, M. L. P., Joner, G., Anderssen, S. A. (2010). Obese children playing towards an active lifestyle. *International Journal of Pediatric Obesity*, 5, 64-71.

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Obese children playing towards an active lifestyle

Sveinung Berntsen ^{1,2}, Petter Mowinckel ¹, Kai-Håkon Carlsen ^{2,3,4}, Karin C. Lødrup Carlsen ^{1,4}, Magnhild L. Pollestad Kolsgaard ¹, Geir Joner ^{1,4,5}, Sigmund A. Anderssen².

¹ *Department of Paediatrics, Woman and Child division, Ullevål University Hospital;*

² *Department of Sports Medicine, Norwegian School of Sport Sciences;*

³ *Voksentoppen, Department of Paediatrics, Rikshospitalet University Hospital;*

⁴ *Faculty of Medicine, University of Oslo;*

⁵ *Institute of Health Management and Health Economics; University of Oslo;*

Oslo, Norway.

The study is performed within the ORACLE (the Oslo Research Group of Asthma and Allergy in Childhood; the Lung and Environment) which is part of the Ga²len network.

Original Article

Title for running head: Active play in obese children

Address for corresponding author and reprint request:

Sveinung Berntsen,

Norwegian School of Sport Sciences,

PO. Box 4014 Ullevål Stadion,

NO-0806 Oslo

Norway

Tel: +47 23 26 20 00, Fax: +47 22 23 42 20,

E-mail: sveinung.berntsen@nih.no

Total word count abstract: 202

Total word count manuscript (excluding acknowledgement, tables and figures): 3058

Number of references: 34; tables: 3; figures:1.

There is no competing or conflicts of interests.

Abstract

AIM: To determine whether five months of guided active play in overweight or obese children and adolescents under multi-disciplinary management for weight reduction leads to increased physical activity levels in leisure time, as well as changes in aerobic fitness and body composition.

METHODS: Sixty overweight or obese children and adolescents were randomly assigned to an intervention or control group. All participants received dietary advice and were encouraged to increase physical activity level. The intervention group additionally participated in 60 minute guided active play/physical activity twice a week for 5 months. Physical activity was recorded; aerobic fitness and body composition were measured at inclusion and after cessation of intervention.

RESULTS: Physical activity level during weekend days was significantly higher for the intervention group compared to the controls after five months intervention ($p=0.04$). The mean reduction in percentage of body fat was 1.8 (95%CI; 0.6, 3.1) % in the intervention group ($p=0.04$) and not significant among the controls (0.9 (-0.9, 2.7)). There was no change in aerobic fitness.

CONCLUSION: Five months of guided active play was associated with increased physical activity levels during weekend days and reduced body fat, although weakly, in overweight and obese children and adolescents participating in multi-disciplinary weight reduction programmes.

Keywords: children; exercise; obesity; physical activity; randomized controlled trial

Introduction

Childhood obesity is a major concern in many industrial countries, and the proportion of obese Norwegian children has tripled in the last three decades (1). Short and long term adverse effects of childhood obesity are well established, including increased risk of cardiovascular disease, asthma, adult morbidity and mortality (2); however, for some obesity related diseases such as asthma, it was recently suggested that the lack of physical activity more than the obesity itself that increased the risk of disease (3). Thus, to prevent obesity related diseases, weight reduction per se may not be sufficient. A focus upon physical activity in weight reduction programmes in childhood obesity is required as part of multi-disciplinary approaches including dietary changes, nutritional education, behavioural modification, and parental involvement (4).

Physical activity levels attained during childhood and adolescence are likely to set the pattern for adult life (5), and behaviourally based lifestyle physical activity programmes are reported equally effective to structured exercise programmes in promoting habitual physical activity in obese children (6). Encouraging active play to increase energy expenditure has been effective in reducing obesity in children (7) and in order to induce lifestyle changes it should be fun, age-specific, and tailored to the child's fitness level (8).

In (obese) children physical activity is culturally, environmentally and individually determined (9), thus positive early experiences is important to stimulate physical activity levels (10). By becoming habitually physically active, obese children may reduce the risk for developing a variety of lifestyle diseases (2) and improve the chance to maintain body composition changes following weight reduction programmes (11).

Reported physical activity levels vary with methods of assessment (12), and in questionnaires children may recall only ~50 % of physical activity in the previous week (13). Furthermore, in obese subjects, self reported physical activity has been over-reported compared to objective measurements (14), particularly after attending management programmes for weight reduction (15). Biases in interventions with children and adolescents can arise when subjective rather than objective methods are used to assess outcomes (16).

Few studies have reported longitudinal changes in physical activity during weight reduction management (17-21) and objective measurements of physical activity (20;21) has rarely been included. Information is lacking as to how participation in sustained exercise programmes influences objectively measured physical activity among obese children.

The present study therefore aimed to determine whether five months of guided active play in overweight or obese children and adolescents under multi-disciplinary management for weight reduction would lead to increased physical activity levels in leisure time, and to examine possible changes in aerobic fitness and body composition.

Study design and subjects

Study design

Obese and overweight children and adolescents (hereafter called children) from the Department of Paediatrics, Ullevål University Hospital, **were** referred by their general practitioner doctor or public health nurse to the outpatient paediatric clinic for participation in a multi-disciplinary obesity management programme ('The Oslo Adiposity Intervention Study' (22)). Subjects living in Oslo aged 3-17 years were examined by a paediatrician and enrolled if they were obese according to the Norwegian percentile diagram (body mass above the 97.5th percentile for height). At inclusion all participants received dietary advice by a clinical nutritionist, and were encouraged to increase their physical activity level to reduce sedentary lifestyles.

The present randomized controlled intervention study included 7-17 year old participants with the truncated age limitation set due to aerobic fitness measurements. Participants could not have overt- or organic disease (in which there were anatomical or path physiological changes in some bodily tissue or organ) for the obesity, medical conditions that could restrict the ability to be physical active and receiving medication which could interfere with growth or weight control. The subjects were randomized in January 2005 in the 3:2 ratio, with a computerized, random number generator to participate in an intervention (n=36) or control group (n=24). At baseline intervention- and control groups did not differ significantly with respect to peak oxygen consumption ($\dot{V}O_{2peak}$), body composition and physical activity during week or weekend days (table 1).

The intervention consisted of five months bi-weekly 60 minutes guided active play. At baseline and end-intervention all participants underwent a clinical examination with body weight, height and Tanner pubertal stage assessments (23), followed by measurements of $\dot{V}O_2$ peak and body composition as well as seven days accelerometer recordings of physical activity level.

After the intervention period control subjects were offered participation in a similar active play program.

The study was approved by the Medical Research Ethics Committee and the Data Inspectorate of Norway. Written informed participation consent was obtained from the children and their parents.

Subjects

Of the 120 invited children 60 subjects (♂/♀: 29/31) with a mean age of 12.1 (Standard Deviation (SD); 2.4) years (table 1) attended the present study. Ten children were overweight and 50 obese according to the age- and gender specific definition of the International Obesity Task Force (24). The sample was representative of 7-17 year old subjects in the 'The Oslo Adiposity Intervention Study' with respect to gender, age, pubertal status, body mass and body mass above the 97.5th percentile for their height.

Methods

The intervention program

The guided active play (defined as spontaneous gross locomotor movement in which children engage to amuse and to occupy themselves (25)) sessions were conducted

week days in groups of 10-12 participants according to age and gender (one with girls only and two mixed groups). The sessions were directed by five experienced instructors at The Norwegian School of Sport Sciences and focused on introducing the participants to physical activity games and development of positive attitudes towards activities that could also be carried out at home. An instructor phoned participants who failed to come to sessions to encourage attendance. Duration and intensity of activities varied, with individual exercises/games focusing on coordination, flexibility skills and self-esteem in the first four weeks, thereafter including team-play, endurance- and strength-type activities such as body weight callisthenics, ball games, wrestling or fun-related movements.

Parents were offered simultaneous exercise sessions and families received a pedometer and an exercise diary book to inspire increased leisure time activities.

Anthropometric measurements

Body mass was measured (Seca 770, Hamburg, Germany) in underwear only to the nearest 0.1 kg. Stature was measured by a stadiometer to the nearest 0.5 cm.

Body composition measurement

Body composition measured by one experienced observer was assessed by dual-energy X-ray absorptiometry (DXA; GE-Lunar Prodigy, Madison, WI, USA).

Participants were scanned from head to toe in supine position, providing values for bone mineral content (BMC), non-bone lean tissue, and fat mass in total body, as well as in arms, legs and trunk separately. Test-retest analyses from 30 scans in 15 participants demonstrated intra class correlation from 0.94 to 0.98 (all with $p < 0.001$) for percentage of body fat, fat mass, lean mass, and bone mineral content (BMC)

respectively. Limits of agreements (mean differences \pm 1,96 standard deviations (SD) of the differences) were 0.30 ± 4.5 % for percentage of body fat, 0.01 ± 3.27 kg for fat mass, -0.36 ± 3.25 kg for lean mass and 0.01 ± 0.383 kg BMC, with 87-93 % of the values within two SD.

Aerobic fitness

Aerobic fitness was determined as $\dot{V}O_2$ peak during treadmill running (Woodway, WI, USA), starting at four kilometres per hour ($\text{km}\cdot\text{h}^{-1}$) and an inclination of 0 %, increasing the work load (speed and inclination) until exhaustion. Heart rate was recorded continuously, and minute ventilation (\dot{V}_E), respiratory exchange ratio (RER) and $\dot{V}O_2$ were measured during running using the Sensor Medics, Vmax Spektra (Yorba Linda, CA, USA). Maximal effort was based on a subjective assessment that the participant had reached his or her maximal effort.

Physical activity

Physical activity was registered by the ActiGraph 7164 (LLC, Fort Walton Beach, FL, USA), attached by an elastic belt to the hip. All participants received verbal and written instructions to position and subsequently wear the accelerometer all day for seven days, except during water activities which were recorded by participants or parents. The output was sampled every 20 seconds and presented as mean counts per minute (cpm). Sequences of ≥ 10 min with consecutive zero counts were automatically deleted. Light physical activity (LPA) was defined as all activity below 2000 cpm, whereas moderate-very vigorous physical activity (MVPA) was defined as all activity above 2000 cpm. This cut-off value has also been used in other studies (26;27).

Statistical analysis

With few relevant published studies of objectively measured physical activity, power calculations **were** based upon a predicted difference in $\dot{V}O_{2peak}$ of $3 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and percentage of body fat of 3 %, SD of $5 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and 3 %, a power of 0.80 and a significance level of 0.05, indicated a required sample size of 45 participants. To account for the expected dropout and loss of follow-up rates of 25 %, assessing a higher dropout rate for the intervention group, we randomly added 12 subjects to the intervention group and 3 subjects to the control group, and thus 60 subjects were included in the present study. All analysis were conducted using an “intention to treat” approach, including all randomized participants who had at least one post-baseline efficacy variable measurement. Some of the data sets are deficient due to accelerometer failure, incomplete monitoring data (e.g. one participant was too heavy for measurements of body composition) or absence on the test day. However, all 60 subjects were included in the final analysis.

Differences between groups were assessed by Pearson Chi-square tests for categorical variables and by two-sample t-tests for continuous variables.

Effects of intervention on physical activity levels, expressed in cpm and minutes per day in LPA and MVPA, aerobic fitness and body composition were assessed by mixed models repeated measures analysis of variance. Regression analyses were performed with the post values as dependent variables adjusting for the baseline values as well as age, gender, pubertal stage (entered puberty or not) and attendance to the intervention program (core set variables). Number of days and hours per day wearing the ActiGraph were included as a confounder for the physical activity outcomes. Jackknife

residuals, Cook's d, the covariance ratio statistic and the covariance trace statistics were used to assess the underlying assumptions and the validity of the model.

Physical activity was analysed for week days (Monday to Friday) and weekend days (Saturday and Sunday) separately.

Level of significance was set to 0.05. Analyses were conducted in SAS[®] (SAS Institute Inc., Version 9.1.3, NC, USA) and SPSS[®] (Statistical Package for Social Sciences, Version 14 for Windows. SPSS Inc., IL, USA, 2006).

Results

The mean attendance in active play sessions was 60 % with 23 % of subjects attending less than 45 % of the sessions. Attendance was included as a covariate; however, it did not influence the outcome variables. The mean minutes per day (range) the accelerometer was worn at baseline and after five months was 11.8 (8.5, 15.7) and 13.1 (8.8, 15.5) hours·day⁻¹, respectively, with recordings for seven days in 50 %, for ≥ 4 days in 83 % and < 2 days in 2 % of subjects. At study entry 23 subjects had not started puberty, whereas three subjects had their first signs of puberty during the intervention period.

Physical activity levels and aerobic fitness

The intervention group increased their adjusted physical activity level from baseline (524 (441, 606) cpm) to the end of the intervention (615 (527, 704) cpm) in contrast to the controls (616 (514, 704) to 581 (459, 702) cpm), although the changes were not significant ($p=0.18$). Adjusted physical activity level during weekend days after the intervention period was significantly higher ($p=0.04$) for the intervention than control subjects (table 2). The intervention group in contrast to the controls increased their physical activity level 117 cpm vs. -36 cpm ($p=0.04$), respectively from baseline to the end of the intervention. The corresponding adjusted physical activity levels did not differ between the groups during week days (table 2).

Although there was no significant change in the over-all LPA or MVPA in total or during week days and weekend days, during the five months (table 2), 61 % of the intervention subjects in contrast to 33 % of controls increased their time in MVPA level during weekend days ($p=0.06$). In the intervention group, participants who

fulfilled the international physical activity guidelines, which recommend children to be physically active for at least 60 minutes a day **seven days per week**, increased from 10 to 30 % during weekend days, although not significantly ($p=0.21$). There were small changes during the week days. In the controls, a small non-significant decrease was observed during weekend as well as week days. Baseline (a and b) and post intervention (c and d) unadjusted physical activity levels (mean cpm) from 06:00 until 23:59 during week and weekend days are given in Figure 1.

$\dot{V}O_{2peak}$ was not significantly different between groups after the intervention period when adjusted for the core set variables (table 2).

Body composition and body mass

Percentage of body fat decreased by 1.8 (0.6, 3.1) % in the intervention group ($p=0.04$) only after adjusting for the core set variables (table 3). Neither fat mass, lean body mass, BMC nor body weight differed significantly ($p\geq 0.26$) between the groups after five months (table 3). Following the intervention, 34 subjects reduced their body mass exceeding the 97.5 percentile, with a group mean of 4.2 (-1.7, 10.2) kg for the intervention group vs. 0.6 (-1.4, 2.6) kg for controls), but without significant group differences.

Discussion

Overweight or obese children receiving multi-disciplinary weight reduction management had increased sustained physical activity levels during weekend days and reduced percentage of body fat if they attended an additional five months guided active play programme. The activity sessions did not significantly influence lean body mass, BMC, body mass, physical activity levels at week days or $\dot{V}O_2$ peak.

The increased sustained physical activity level at weekend days in the intervention compared to the control group is supported by others (17-20), although randomized controlled trials with objective physical activity measures in obese children are limited (20). In a study similar to the present, Lazzer and co-workers (20) found that time and energy expenditure (measured by heart rate and activity diaries for seven days) spent at sedentary activities decreased to the benefit of moderate or higher intensity activities in 27 obese adolescents during multi-disciplinary weight management. In a trial without control children, Sothorn et al. reported sustained weight reduction one year after intervention in 73 obese children attending physical activity programmes (17), whereas two year weight reduction was found by Epstein et al. among obese children whose families received additional advice on reducing sedentary or increasing physical activity behaviour (18). On the other hand, although self reported participation in moderate-vigorous physical activities increased and sedentary (low intensity) activities decreased during 10 months multi-disciplinary management, activity levels decreased again to baseline levels six months after intervention in 23 10-17 year old children (19).

Our finding that leisure time physical activities increased during weekend- compared to week days in the intervention group has to our knowledge not previously been reported. This could be due to (non-significant) lower physical activity level during weekend days at baseline, similar to the reported lower level of physical activity during weekends in obese compared to normal-weight individuals (28), or due to type II error with missing complete recordings in some subjects. Most of the participants were physically active during week days. On the other hand, the increase in physical activity level may actually be underestimated since baseline accelerometer recordings were conducted at the start of the intervention. However, our findings suggest that there may be more room for behavioural activity changes during the weekends than during school days. An increase in physical activity of 117 cpm is small and its influence on future health maybe uncertain. However, introducing the participants to physical activity games and development of positive attitudes towards activities, in order to induce physical activity changes may have health benefits on long term basis.

$\dot{V}O_2$ peak did not change significantly after intervention in the present study.

Improved $\dot{V}O_2$ peak is reported after physical activity programmes (29), whereas others found no effect (20); however, the intervention in the present study may not have been sufficient in intensity and duration to observe significant changes.

The greater reduction in percentage of body fat in the intervention group only, is in line with results reported by others (11). **Even small changes in the amount of physical activity is shown to have beneficial effects on body composition (29).**

The main *strengths* of the present study are the objective measurements of physical activity and body composition in a multi-disciplinary management programme (4)

with close follow-up of the subjects and parental involvement. Accelerometer recordings give reliable measures of physical activity having advantages compared to self reports with recall biases (12) and the over-reporting of physical activity in obese subjects (14), particularly after attending a treatment regime for weight reduction (15). The dual-energy X-ray absorptiometry is reliable in children (30) and sensitive to even small changes elicited by regular physical activity (31).

The main *limitations* of the present study are the relatively short time of the intervention programme, and the lack of complete adherence to active play sessions and that may have influenced our results; however, our adherence to wearing accelerometers was similar to that of Van Coevering and co-workers (32). More than 80 % of subjects had successful recordings for at least 4 days per period, and 50 % obtained the seven consecutive days which are recommended to obtain a valid, reliable measure of habitual physical activity (33). However, it is important to find the optimal balance between obtaining a sufficiently long measurement period and prevention of drop out. Hours per day wearing the activity monitor was inversely associated with the number of days wearing the accelerometer.

The cut-off point for MVPA is also a critical issue. There is no consensus of which cut-off point to use and different cut-off points may affect MVPA (34); however, since each subject is his or her own control and one cut-off point was used for all participants, likelihood of introducing bias is small.

In conclusion, overweight or obese children in a multi-disciplinary weight reducing programme had additional benefit of guided bi-weekly active play for five months with increased physical activity levels at weekend days and a reduced percentage of

body fat, although the changes were small. Our study supports the importance of active play and physical activity programmes, particularly aiming at behavioural changes during weekends as part of management of overweight and obese children and adolescents.

Acknowledgements

The present study was supported by grants from the Eastern Norway Regional Health Authority and the County Governor in Oslo and Akershus. The authors would like to thank Olov Belander, Thomas Ingebrigtsen, Line Hurrød, Gro Ingvarsen, Lene Aanensen for assisting in planning and carrying out the active play sessions, Alexis Hinojosa and Lars Nordsletten for their help with the DXA measurements, Elisabeth Edvardsen and Cathrine Lind doing the exercise testing and Thomas Ingebrigtsen, Elin Kolle and Lars Bo Andersen for invaluable help collecting and analysing the accelerometer data. We thank the children who participated, and the parents of the participants for contribution to the study.

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Table 1. Baseline physical characteristics of the participants. Data are given as mean and standard deviation in parentheses unless otherwise stated.

	Intervention group (n=36)		Control group (n=24)		
	Mean	(SD)	Mean	(SD)	
Age (yrs); Mean (Min-Max))	12.1 (7-17)		12.1 (8-17)		
Weight (kg)	74.2	(19.1)	79.3	(30.2)	
Height (cm)	156.2	(11.5)	157.7	(14.9)	
Obese <i>n</i> (%)	30 (83)		20 (83)		
Fat mass (kg)	34.8	(10.8)	33.7	(12.4)	
Percentage of body fat (%)	47.6	(5.9)	45.1	(5.2)	
Lean body mass (kg)	37.3	(8.7)	39.5	(10.8)	
Bone mineral content (kg)	2.2	(0.8)	2.3	(0.6)	
PA; mean·day ⁻¹ (cpm)	Week	599	(172)	659	(314)
	Weekend	428	(154)	546	(43)
MVPA; mean·day ⁻¹ (min·day ⁻¹)	Week	75	(31)	79	(38)
	Weekend	36	(24)	43	(28)
$\dot{V}O_2$ peak (L·min ⁻¹)	2.5	(0.6)	2.6	(0.8)	
$\dot{V}O_2$ peak (mL·kg ⁻¹ ·min ⁻¹)	34.0	(6.2)	33.7	(5.4)	

Min: minimum; Max: maximum; PA: Accelerometer-measured Physical Activity; cpm: Counts Per Minute; Moderate-very vigorous physical activity: MVPA; Week: during weekdays, Monday to Friday; Weekend: during weekend days, Saturday and Sunday; $\dot{V}O_2$ peak : highest recorded oxygen uptake during treadmill test.

Table 2. Adjusted* physical activity (mean count per minute and minutes above 2000 cpm) at week- and weekend days, and highest recorded oxygen uptake at baseline and after 5 months intervention.

		Intervention group		Control group		<i>P</i> -value**
		Baseline (n=33)	After 5mo (n=32)	Baseline (n=23)	After 5mo (n=19)	
		Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	
PA; mean·day ⁻¹ , (cpm)	<i>Week</i>	583 (501,665)	649 (550,747)	669 (570,767)	704 (576,832)	0.77
	<i>Weekend</i>	448 (349,547)	586 (455,717)	571 (448,695)	471 (303,640)	0.04
MVPA; mean·day ⁻¹ , (min·day ⁻¹)	<i>Week</i>	72 (62,83)	81 (68,94)	79 (66,91)	94 (77,111)	0.60
	<i>Weekend</i>	36 (27,45)	52 (37,67)	43 (33,54)	48 (30,67)	0.39
VO ₂ peak (L·min ⁻¹)		2.44 (2.14,2.73)	2.44 (2.11,2.77)	2.68 (2.25,3.11)	2.73 (2.27,3.20)	0.35
VO ₂ peak (mL·kg ⁻¹ ·min ⁻¹)		32.6 (28.6,36.6)	33.4 (29.1,37.8)	31.2 (25.3,37.0)	32.3 (26.1,38.5)	0.69

Abbreviations: PA, Accelerometer-measured Physical Activity; cpm, Counts Per Minute; Moderate-very vigorous physical activity:

MVPA; VO₂peak, highest recorded oxygen uptake during treadmill test; Week,

during weekdays, Monday to Friday; Weekend, during weekend days, Saturday and Sunday.

* Adjusted for age, pubertal stage (entered puberty or not), gender, attendance and days and minutes each day the accelerometer was worn (only PA and MVPA). Data are given as estimated means with 95% confidence intervals in parentheses.

** The changes from baseline to five months, but not baseline values were significantly different between the intervention and control group. Statistically significant values are given in bold

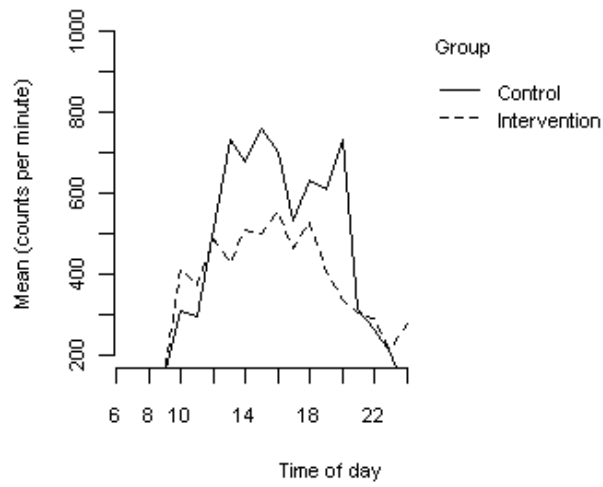
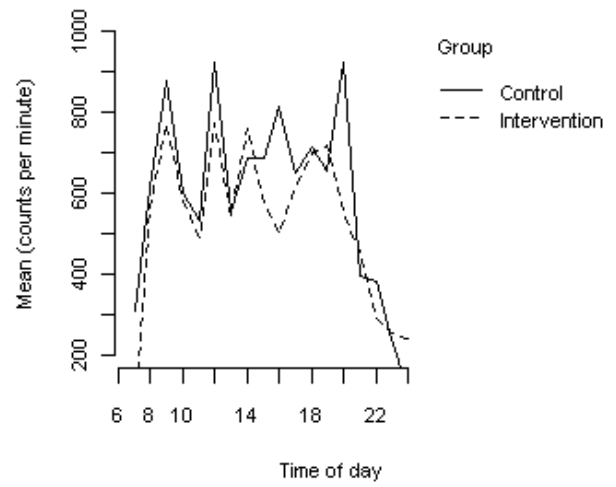
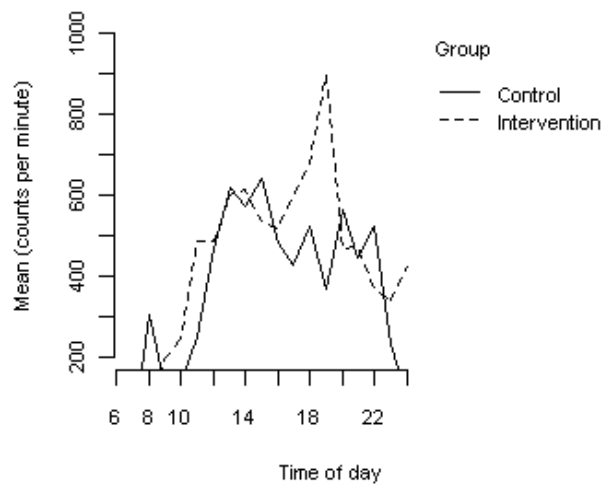
Table 3. Adjusted* height, weight, fat mass, percentage of body fat, lean body mass and bone mineral content at baseline and after 5 months intervention.

	Intervention group		Control group		<i>P</i> -value**
	Baseline (n=36) Mean (95% CI)	After 5mo (n=32) Mean (95% CI)	Baseline (n=23) Mean (95% CI)	After 5mo (n=16) Mean (95% CI)	
Height (cm)	156 (151,161)	157 (152,162)	156 (151,162)	157 (151,163)	0.91
Body mass (kg)	74 (69,78)	75 (70,80)	75 (70,81)	76 (69,82)	0.63
Fat mass (kg)	35.0 (32.2,37.8)	33.9 (30.7,37.1)	33.9 (30.4,37.4)	32.5 (28.4,36.6)	0.64
Percentage of body fat (%)	47.6 (46.0,49.1)	45.8 (43.6,47.9)	45.1 (43.2,47.0)	44.2 (41.4,47.0)	0.04
Lean body mass (kg)	38.7 (34.9,42.5)	39.6 (35.5,43.6)	40.5 (36.2,44.9)	40.3 (35.6,44.9)	0.26
Bone mineral content (kg)	2.22 (1.98,2.47)	2.15 (1.86,2.44)	2.35 (1.99,2.71)	2.34 (1.93,2.76)	0.51

* Adjusted for age, pubertal stage (entered puberty or not), gender and attendance. Data are given as estimated means with 95% confidence intervals in parentheses.

** The changes from baseline to five months but not baseline values were significantly different between the intervention and control group. Statistically significant values are given in bold

Figure 1. Hour-by-hour physical activity (mean counts per minute) during weekend- and weekdays for subjects in the intervention (---) and control (—) group at baseline (a and b) and after five months intervention (c and d).

a**Baseline Weekend****b****Baseline Weekday****c****Post Weekend****d****Post Weekday**