Research

Physical activity to prevent obesity in young children: cluster randomised controlled trial

John J Reilly, Louise Kelly, Colette Montgomery, Avril Williamson, Abigail Fisher, John H McColl, Rossella Lo Conte, James Y Paton, Stanley Grant

Abstract

Objective To assess whether a physical activity intervention reduces body mass index in young children.
Design Cluster randomised controlled single blinded trial over 12 months.
Setting Thirty six nurseries in Glasgow, Scotland.
Participants 545 children in their preschool year, mean age 4.2 years (SD 0.2) at baseline.
Intervention Enhanced physical activity programme in nursery (three 30 minute sessions a week over 24 weeks) plus home based health education aimed at increasing physical activity through play and reducing sedentary behaviour.
Main outcome measure Body mass index, expressed as a standard deviation score relative to UK 1990 reference data. Secondary measures were objectively measured physical activity and sedentary behaviour; fundamental movement skills; and evaluation of the process.
Results Group allocation had no significant effect on the primary outcome measure at six and 12 months or on measures of physical activity and sedentary behaviour by accelerometry. Children in the intervention group had significantly higher performance in movement skills tests than control children at six month follow-up ($P = 0.0027$; 95% confidence interval 0.3 to 1.3) after adjustment for sex and baseline performance.
Conclusions Physical activity can significantly improve motor skills but did not reduce body mass index in young children in this trial.
Trial registration Current Controlled Trials ISRCTN36363490.

Introduction

Systematic reviews have reported a dearth of evidence from randomised controlled trials on interventions aimed at preventing obesity in children. Most intervention studies were short term, underpowered, and had other weaknesses such as failure to include a control group.[1 2] More recent interventions have usually been unsuccessful.[3] Only a single long term randomised controlled trial found benefits to the intervention.[4]

In 2001 in Scotland at least 10% of children aged 4-5 and 20% of children aged 11-12 were obese.[5] As many young children attend preschool education (>90% in Scotland), the nursery provides population based opportunities for prevention of obesity. In a pilot study we found that a physical activity programme in nursery was a promising means of preventing obesity.[6] We tested the hypothesis that a physical activity intervention would reduce body mass index.

Participants and methods

Nurseries and children

In 2002 we invited 124 nurseries to participate in the movement and activity Glasgow intervention in children (MAGIC) trial. Eligible nurseries had at least 12 children in their preschool year. We randomly selected 36 of the 104 nurseries willing to participate. Nurseries were stratified by type and size, and socioeconomic status of the area. Pairs of nurseries were randomly selected from the same stratum, one randomly allocated to intervention and one to control. We used a cluster randomised controlled trial to avoid contamination between intervention and control participants.

Intervention

The intervention tested had nursery and home based elements.

Nursery element—A physical activity programme consisting of three 30 minute sessions of physical activity each week over 24 weeks. The intervention was intended to increase levels of physical activity and fundamental movement skills.[6]

Home element—Each participating family received a resource pack of materials with guidance on linking physical play at nursery and at home, and two simple health education leaflets. For six weeks during the intervention, nurseries displayed posters focused on increasing physical activity.

Control group—Nurseries continued with their usual curriculum and headteachers agreed not to enhance their physical development and movement curriculum.

Objective and outcome measures

We compared nurseries allocated to intervention with those in the control group at six and 12 months after the start of the intervention.

ELPS *This is the abridged version of an article that was posted on bmj.com on 6 October 2006: http://bmj.com/cgi/doi/10.1136/bmj.38979.623773.55*

Editorial by Yancey

Division of Developmental Medicine, University of Glasgow, Yorkhill Hospitals, Glasgow G3 8SJ
John J Reilly *professor of paediatric energy metabolism*
Louise Kelly *research assistant*
Colette Montgomery *postdoctoral research fellow*
Abigail Fisher *research assistant*
James Y Paton *reader in paediatric respiratory disease*
Glasgow City Council Education Department, Merchant City, Glasgow G1 1HL
Avril Williamson *honorary research fellow*
Department of Statistics, University of Glasgow, Glasgow G12 8QQ
John H McColl *reader in statistics*
Rossella Lo Conte *research student*
University of Glasgow Faculty of Biomedical and Life Sciences, West Medical Building, Glasgow G12 8QQ
Stanley Grant *reader in exercise physiology*
Correspondence to: J J Reilly jjr2y@clinmed.gla.ac.uk

BMJ 2006;333:1041–3

Table 1 Baseline characteristics of 545 nursery age children according to activity intervention aimed at reducing body mass index (BMI). Figures are means (SD) unless stated otherwise

	Intervention			Control		
	Boys	Girls	Total	Boys	Girls	Total
Sample size	128	140	268	145	132	277
Age (years)	4.2 (0.3)	4.2 (0.3)	4.2 (0.3)	4.2 (0.3)	4.1 (0.3)	4.1 (0.3)
BMI (kg/m^2)	16.5 (1.5)	16.2 (1.5)	16.3 (1.5)	16.5 (1.6)	16.2 (1.4)	16.4 (1.5)
BMI SD score	0.50 (1.01)	0.29 (0.94)	0.39 (0.98)	0.49 (1.05)	0.31 (0.94)	0.41 (1.00)
No (%) overweight (BMI SD score ≥1.04)	35 (27)	27 (19)	62 (23)	34 (23)	27 (20)	61 (22)
No (%) obese (BMI SD score ≥1.64)	16 (13)	11 (8)	27 (10)	18 (12)	10 (8)	28 (10)
Total physical activity (cpm)	773 (151)	694 (165)	732 (163)	823 (211)	794 (206)	809 (209)
Median (range) % monitored time sedentary	67.6 (50.5-81.3)	71.1 (50.4-86.6)	69.3 (50.4-86.6)	66.5 (45.6-83.7)	67.7 (52.5-88.7)	66.9 (45.6-88.7)
Median (range) % monitored time in MVPA	3.1 (0.4-9.5)	2.3 (0.5-11.1)	2.6 (0.4-11.1)	3.1 (0.5-13.0)	2.9 (0.3-11.7)	3.0 (0.3-13.0)
Fundamental movement skills score	7.8 (2.7)	8.0 (2.6)	7.9 (2.6)	7.6 (2.7)	7.9 (2.7)	7.7 (2.7)

SD score=standard deviation score; cpm=accelerometry count per minute; MVPA=moderate-vigorous intensity physical activity.

Primary outcome measure—Our primary outcome was body mass index expressed as a standard deviation score.[7] This was calculated at baseline and at six and 12 months after the start of the intervention.

Secondary outcome measures—We measured habitual levels of physical activity and sedentary behaviour objectively over six days with accelerometry at baseline and at six months.[8–10] Activity data were summarised as total physical activity (accelerometer count per minute) and proportion of waking hours in moderate or vigorous physical activity (accelerometer count >3200 per minute)[8 10] and in sedentary behaviour (no trunk movement; accelerometer count <1100 per minute).[9] We objectively assessed performance in fundamental movement skills at baseline and six months using the movement assessment battery.[10]

Sequence generation and blinding

All 36 participating nurseries were allocated to group with stratified random sampling. Allocations were concealed. The researchers who made the outcome measures were blinded to nursery allocation.

Statistical analysis and evaluation

We used multi-level modelling for all statistical analysis (see bmj.com). We analysed and compared baseline and later results using two level models (individual child and the nursery cluster).

Results

Thirty six nurseries and 545 children entered the trial. Table 1 shows characteristics of the children. All 36 participating nurseries remained in the trial to its completion. Of the 545 children entered at baseline, 481 (88%) were available at the six month follow-up and 504 (93%) were available at the 12 month follow-up, when they were attending 153 different primary schools.

We attempted to measure physical activity and sedentary behaviour in 482 children at baseline, and accelerometry was successful in 424. Of the 424 children with accelerometry at baseline, 355 were available at six months, with successful (six day) accelerometry achieved in 285. We obtained data on fundamental movement skills in 489 (90%) children at baseline and 420 at six months.

From the modelling of baseline data, sex was the only fixed effect to enter the model for baseline standard deviation score, the mean score being 0.20 (95% confidence interval 0.03 to 0.36, P=0.02) lower for girls than for boys.

Table 2 shows summary statistics for outcome variables at follow-up. The intraclass correlations were ≤0.11, indicating less clustering of final results than expected. The correlation between measurements at baseline and six months was so high that we included the baseline measurement in the final model for every outcome variable.

Group (intervention *v* control) was not a significant effect in the model for standard deviation score at six months (P=0.87) or at 12 months (P=0.90) nor was any other fixed effect significant at either time point. Group was not significant for modelling log accelerometer counts per minute (P=0.18) or percentage of time spent sedentary (P=0.08) but was marginally significant for log percentage time in moderate or vigorous physical activity (the mean value being greater in the control nurseries by 0.1, 0.0 to 0.2, P=0.05). We found that girls improved on fundamental movement skills more than boys, the average difference in improvement being 0.7 units (0.3 to 1.1, P=0.001). There was a group effect for fundamental movement skills: children in the intervention nurseries improved their movement skills significantly more than children

Table 2 Characteristics of nursery age children at follow-up according to activity intervention aimed at reducing body mass index (BMI). Figures are means (SD) unless stated otherwise

	Intervention group			Control group		
	Boys	Girls	Total	Boys	Girls	Total
Sample size at 6 months	110	121	231	134	116	250
BMI SD score at 6 months	0.51 (1.04)	0.42 (1.02)	0.46 (1.03)	0.52 (1.10)	0.32 (1.05)	0.43 (1.08)
BMI SD score at 12 months	0.41 (1.02)	0.40 (1.07)	0.41 (1.05)	0.54 (1.19)	0.31 (0.98)	0.43 (1.10)
Total physical activity (cpm)	841 (183)	782 (172)	809 (179)	916 (228)	881 (207)	899 (218)
Median (range) % monitored time sedentary	64.8 (47.0-82.9)	68.5 (51.7-86.0)	67.0 (47.0-86.0)	62.5 (43.1-79.9)	64.1 (43.2-81.6)	62.9 (43.1-81.6)
Median (range)% monitored time in MVPA	3.8 (0.5-12.4)	3.1 (0.7-9.5)	3.5 (0.5-12.4)	4.2 (0.7-12.1)	3.8 (0.6-12.0)	4.1 (0.6-12.1)
Fundamental movement skills score	11.0 (2.4)	11.8 (2.1)	11.5 (2.3)	10.4 (2.4)	11.0 (2.6)	10.7 (2.5)

SD score=standard deviation score; cpm=accelerometry count per minute; MVPA=moderate-vigorous intensity physical activity.

in the control nurseries, the average difference in improvement being 0.8 units (0.3 to 1.3 units).

At the nursery level, 83% of prescribed sessions of the physical activity programme were actually offered. At the level of the child, 71% of prescribed sessions were attended (lower quartile 57%, upper quartile 81%).

Discussion

Despite rigorous implementation, we found no significant effect of the intervention on physical activity, sedentary behaviour, or body mass index. Our intervention was intended to alter physical activity and sedentary behaviour, not diet. Interventions that have focused intensively on modification of just one or two behaviours have generally been the most promising,[2 4 6] and reduced physical activity or increased sedentary behaviour seem to be important in causing and maintaining obesity.[6 11]

Generalisability and implications

Our trial was successful from a practical and methodological point of view. In a pilot study over 12 weeks (in four nurseries, with 60 children) we observed significant improvements in physical activity with the intervention,[6] though we could not replicate these findings in the present study. Quantitatively, implementation of the intervention in our study was apparently good, but the quality of the activity programme might have been higher in the pilot study. Our physical activity programme was delivered by nursery staff (to enhance generalisability), while in the pilot it was delivered by two nursery headteachers. There was evidence of a benefit of the intervention for movement skills. This is an important educational aim and may have other benefits: it might foster an increase in activity levels in future by increasing confidence or ability, and may have direct effects on body fat content in the long term.[10 12]

To enhance generalisability of our intervention we randomly selected nurseries and used an inexpensive intervention that met curriculum requirements and that the pilot study[6] suggested was learned easily by staff and enjoyed by children.

Strengths and limitations

Our intervention probably provided an inadequate "dose" of physical activity to have any net impact on overall physical activity or body mass index. The home based element of the intervention was based largely on the health education model. More behavioural or more extensive interventions with parents[13] might have been more successful. Our emphasis on using only objective outcome measures provided a rigorous test of the intervention.

Conclusions

Successful interventions to prevent obesity in early childhood may require changes not just at nursery, school, and home but in the wider environment.[14 15] Changes in other behaviours, including diet, may also be necessary. Further research is necessary to identify successful and sustainable interventions for prevention of obesity and promotion of physical activity in young children.

What is already known on this topic

Many children are obese, even at preschool age

Preschool children typically have physically inactive lifestyles

Evidence on appropriate interventions for prevention of obesity in preschool children is lacking

What this study adds

A physical activity intervention had no effect on body mass index or habitual physical activity

The intervention improved movement skills, which may increase future participation in physical activity or sport

Alternative interventions to prevent obesity in young children are required

We thank Glasgow City Council for their encouragement, advice, and access to nurseries and primary schools. We are immensely grateful to the participating families, nurseries, and schools for their enthusiastic and highly motivated participation. This research was presented in abstract form at the annual meeting of the American College of Sports Medicine in June 2005.

Contributors: See bmj.com.

Funding: British Heart Foundation, Glasgow City Council, and the Caledonian Research Foundation. The pilot study was funded by Sport Aiding Medical Research for Kids (SPARKS).

Competing interests: None declared.

Ethical approval: Yorkhill Hospitals research ethics committee approved the research.

1 Summerbell CD, Waters E, Edmunds LD, Brown T, Campbell KJ. Interventions for preventing obesity in children. *Cochrane Library* 2006;(3)CD001871.
2 Reilly JJ, Wilson M, Summerbell C, Wilson D. Obesity diagnosis, prevention, and treatment: evidence-based answers to common questions. *Arch Dis Child* 2002;86:312-95.
3 Sahota P, Rudolf MCJ, Dixey R, Hill AJ, Barth JH, Cade J. Randomised controlled trial of primary school-based intervention to reduce risk factors for obesity. *BMJ* 2001;323:1029-32.
4 Gortmaker SL, Peterson K, Wiecha J, Sobol AM, Dixit G, Fox MK, Laird N. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Arch Pediatr Adolesc Med* 1999;151:409-18.
5 *NHS quality improvement indicators: childhood obesity in 2001*. NHS Scotland, December 2003. www.scot.nhs.uk/indicators (accessed 31 Mar 2005).
6 Reilly JJ, McDowell ZC. Physical activity interventions in the prevention and treatment of paediatric obesity: systematic review and critical appraisal. *Proc Nutr Soc* 2003;62:611-9.
7 Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. *Arch Dis Child* 1995;73:25-9.
8 Puyau MR, Adolph AL, Firoz AV, Butte NF. Validation and calibration of activity monitors in children. *Obes Res* 2002;10:150-7.
9 Reilly JJ, Coyle J, Kelly LA, Burke G, Grant S, Paton JY. An objective method for measurement of sedentary behavior in 3-4 year olds. *Obes Res* 2003;11:1155-8.
10 Fisher A, Reilly JJ, Montgomery C, Williamson A, Paton JY, Grant S. Fundamental movement skills and habitual physical activity in young children. *Med Sci Sports Exerc* 2005;37:684-8.
11 Robinson TN. Reducing children's television viewing to prevent obesity: a randomised controlled trial. *JAMA* 1999;282:1561-7.
12 Okely AD, Booth ML, Chey T. Relationships between body composition and fundamental movement skills among children and adolescents. *Res Q Exerc Sport* 2004;75:238-47.
13 Hardeman W, Griffins, Johnston M, Kinmonth AL, Wareham NJ. Interventions to prevent weight gain: a systematic review of psychological models and behaviour change methods. *Int J Obes* 2000;24:131-43.
14 Koplan JP, Dietz WH. Caloric imbalance and public health policy. *JAMA* 1999;282:1579-81.
15 Swinburn B, Egger G, Razza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritising environmental interventions for obesity. *Prev Med* 1999;29:513-70.

(Accepted 24 August 2006)

doi 10.1136/bmj.38979.623773.55