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PEDIATRIC REVIEW

Interventions to prevent obesity in children and adolescents: a systematic literature review

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Objective: Preventive measures to contain the epidemic of obesity have become a major focus of attention. This report reviews the scientific evidence for medical interventions aimed at preventing obesity during childhood and adolescence.
Design: A systematic literature review involving selection of primary research and other systematic reviews. Articles published until 2004 were added to an earlier (2002) review by the Swedish Council on Technology Assessment in Health Care.
Methods: Inclusion criteria required controlled studies with follow-up of at least 12 months and results measured as body mass index, skinfold thickness or the percentage of overweight/obesity. Children could be recruited from normal or high-risk populations.
Results: Combining the new data with the previous review resulted in an evaluation of 24 studies involving 25 896 children. Of these, eight reported that prevention had a statistically significant positive effect on obesity, 16 reported neutral results and none reported a negative result (sign test; $P = 0.0078$). Adding the studies included in five other systematic reviews yielded, in total, 15 studies with positive, 24 with neutral and none with negative results. Thus, 41% of the studies, including 40% of the 33 852 children studied, showed a positive effect from prevention. These results are unlikely to be a random chance phenomenon ($P = 0.000061$).
Conclusion: Evidence shows that it is possible to prevent obesity in children and adolescents through limited, school-based programs that combine the promotion of healthy dietary habits and physical activity.
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Keywords: childhood; prevention; review; adolescents

Introduction

Overweight and obesity are growing problems in much of the world. In Sweden, the number of overweight individuals has nearly doubled during the past 20 years. Obesity has a negative impact on health and quality of life. From the perspective of both the individual and society, it is therefore essential to identify strategies for managing this problem. Once present, obesity is difficult to treat, making effective preventive intervention all the more important.

In 2002, the Swedish Council on Technology Assessment in Health Care (SBU) published a report (in Swedish) that examined the body of scientific evidence on interventions to prevent and treat obesity.[1] The Swedish report was later published as a book in English.[2] At that time, the evidence was not sufficiently solid to draw reliable conclusions about the effects of prevention in either adults or children.

SBU has recently updated the evidence concerning the value of preventive interventions against obesity intended to include publications released between 2001 and 2004. The present paper addresses children and adolescents.

Key questions include:

- How many studies of acceptable quality have been added?
- What do the new results show?
- What are the combined results from the earlier and the more recent studies?
- How do the findings in the SBU review compare with those from other systematic literature reviews in recent years?

Methods

Literature search and review

A search in PubMed and the Cochrane Library identified literature published from 2001 to May 2004. Table 1 presents

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the search terms and combinations. Additional studies were found in reference lists of relevant articles, in recently published medical journals and in other review articles.

To find studies related to health economics, the NHSEED (NHS Economic Evaluation Database) and PubMed databases were searched using the search terms 'obesity' and 'overweight' in combination with 'prevent' (using various suffixes). In PubMed, the search terms also included 'cost' and 'cost analysis'.

The search aimed to identify studies that met the following inclusion criteria:

- The study should address prevention of overweight or obesity.
- Follow-up in the study should be at least 12 months.
- The study must include a control group.
- The study must include relevant outcome measures, primarily the percentage of overweight/obese subjects, body mass index (BMI) or skinfold thickness.
- To be considered 'prevention', the study must address a normal population, that is, participants should not be selected, but should represent a normal group such as a school, or the population within a particular area. The search also included studies of high-risk groups, unless the participants were selected only for having the risk factor overweight/obesity. These were considered to be treatment studies and were excluded.

Two independent reviewers (one of the authors (Mona Britton) and one medical student (Johan Skånberg)) used abstracts to initially evaluate the studies. Inclusion criteria were used to eliminate non-relevant studies. The full text of selected articles was then reviewed. Languages accepted were Swedish, Norwegian, Danish, English, German and French.

Quality

The quality of included studies was rated according to a three-grade scale: high, medium and low. To assess quality, the reviewers used the following criteria, which are ranked from high to low in each category.

Type of study: randomized trials; studies with matched controls/ecological controls; studies with poorly defined control groups.

Follow-up:	>5 years; 3–5 years; 1–2 years.
Dropout:	<20%; 20–30%; 30–40%.
Study size:	total patients followed up >1000; 500–1000; 25–500.

Studies with high values in most of the variables were assessed to be of high quality and studies with low values were assessed to be of low quality. Medium quality was assigned to those in the mid-range. If a study lacked essential information, the grade could be lowered by one level. Two reviewers worked independently.

Interventions were judged to have positive effects when the percentage of obese individuals decreased, or if weight, BMI or skinfold thickness were reduced in comparison with the results in the control group. Only statistically significant differences were considered ($P<0.05$).

Results

The primary literature search (phase 1) yielded 64 articles. Of these, 51 were excluded since they did not focus on prevention, or were debate articles, editorials or studies without control groups (Figure 1). A search of other systematic literature reviews and the reference lists of relevant studies yielded an additional 72 studies, which were included in the review process. From the 85 publications that reached phase 2, 40 were eliminated for various reasons and 45 were further evaluated in phase 3.

The new studies

Forty-five publications were selected for final review in phase 3 (Figure 1). Fourteen contained supplementary information about the studies or strategies and 17 were review articles. Three studies did not meet the inclusion criteria on closer scrutiny and were excluded.[3–5] In total, 10 studies on the effects of obesity prevention and one study on the costs of intervention were included.

Of the 10 studies, nine concerned a normal population and one concerned participants with an elevated risk for obesity and cardiovascular disease. Three of the studies used the percentage of overweight or obese participants as the outcome measure. Other studies used either mean BMI or triceps skinfold thickness. Study quality was found to be high in one study, medium in five studies and low in four studies (Table 2).

Four of the studies had been published prior to the earlier SBU report, but had either not been identified or were too late for inclusion.[6–9] The publication of Müller's study coincided with the final phase of the earlier SBU report. Although the study was mentioned, it was not included in the table since the quality had been rated as low.[10] This study has now been included. Results from the study by Luepker,[11] referred to previously, were followed up further, 5–6 years in total.[12] No differences in weight trends between the intervention and control groups were found in either primary or extended follow-up.

To summarize, three studies show that interventions have had a positive effect on preventing obesity. In seven studies, no differences were found between the groups. Intervention did not have a negative effect in any of the studies (Table 2).

Combined results of the systematic literature reviews by SBU

Table 3 summarizes the information from the new and the earlier SBU review. Combined, the two reviews included 24 studies involving 25 896 children and adolescents. The

Table 1 Strategies used to search the literature on preventing obesity in children and adolescents

Medline/PubMed 2001–2004					
Obesity/prevention and control	AND	Clinical trial (PT) Epidemiological studies Cohort (TW)			
Body weight (MeSH:NoExp) Obesity (MeSH:NoExp) Body mass index Weight gain Weight loss Skinfold thickness BMI (TW) Weight (TW) Body fat (TW) Skinfold thickness (TW) Skinfolds (TW) Obesity (TW) Overweight (TW)	AND	Health promotion Health education (MeSH:NoExp) Patient education handout (PT) Patient education Health behavior (MeSH:NoExp) Health knowledge, attitudes, practice School health services Community health services (MeSH:NoExp) Child health services Community health nursing Social environment Consumer participation Counseling (MeSH:NoExp) Preventive health services (MeSH:NoExp)	AND	Clinical trial (PT)	
Body weight (MeSH:NoExp) Obesity (MeSH:NoExp) Body mass index Weight gain Weight loss Skinfold thickness BMI (TW) Weight (TW) Body fat (TW) Skinfold thickness (TW) Skinfolds (TW) Obesity (TW) Overweight (TW)	AND	Physical education training Physical fitness Exertion Sports Exercise movement techniques Motion therapy, continuous passive Leisure activities (MeSH:NoExp) Dancing Play and playthings (MeSH:NoExp) Television	AND	Clinical trial (PT)	Selected relevant ref for 2–18 years
Body weight (MeSH:NoExp) Obesity (MeSH:NoExp) Body mass index Weight gain Weight loss Skinfold thickness BMI (TW) Weight (TW) Body fat (TW) Skinfold thickness (TW) Skinfolds (TW) Obesity (TW) Overweight (TW)	AND	Nutrition assessment Nutrition policy Nutrition Nutrition therapy Food habits Food services Food preferences Food labeling Appetite regulation Food industry (MeSH:NoExp) Diet records Eating Food and beverages Dietary carbohydrates	AND	Risk Risk assessment Risk factors Risk management/ prevention & control Reduction (Ti) Reducing (Ti) Decreasing (Ti) Decrease (Ti)	
Body weight (MeSH:NoExp) Obesity (MeSH:NoExp) Body mass index Weight gain Weight loss Skinfold thickness BMI (TW) Weight (TW) Body fat (TW) Skinfold thickness (TW) Skinfolds (TW) Obesity (TW) Overweight (TW)	AND	I. Motivation Cognition Behavior therapy Counseling Behavior Parents/education II. Cardiovascular diseases/prevention and control Gave one relevant reference, which via related articles gave additional rel. ref.	AND	Clinical trial (PT)	
Obesity Overweight/TW	AND	Prevent[a]	AND	Costs and cost analysis	NOT Letter/PT Editorial/PT News/PT
NHSEED 2001–2004 (Oct.)					
Obesity/Ti, Ab Overweight/Ti, Ab	AND	Prevent[a]/Ti, Ab			

[a]Unless otherwise specified, MeSH terms (Medical Subject Headings) were used in the MEDLINE search. Subgroups in the MeSH hierarchy and subheadings (/) have been included (with the exception of 'MesSH:NoExp'). Ab = abstract, PT = publication type; Ti = title, TW = text word.

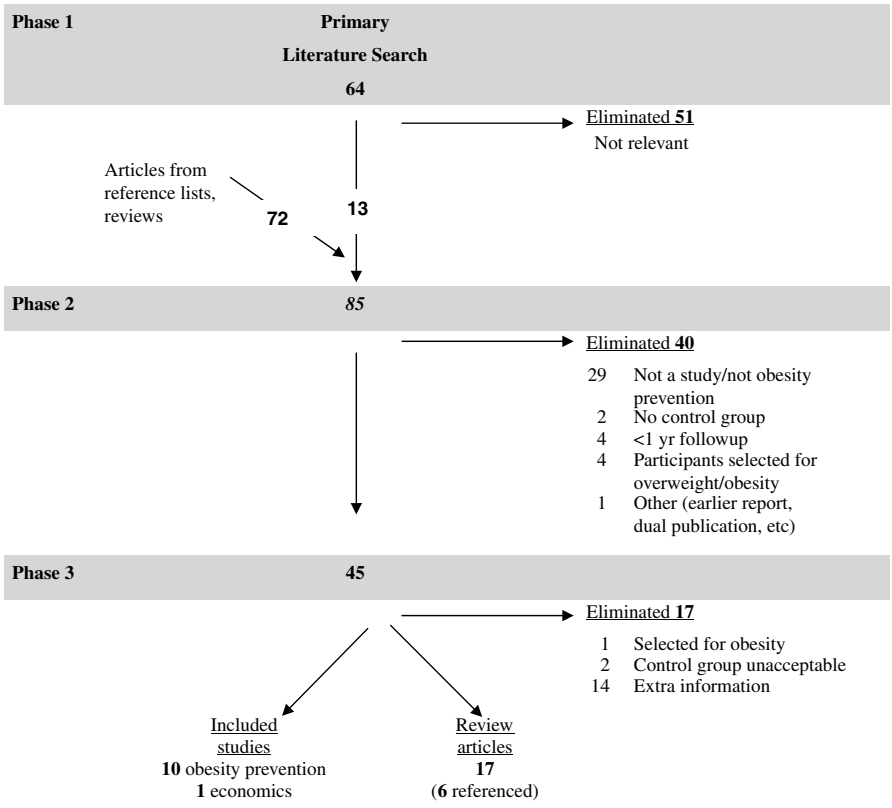

Figure 1 Flow chart of the analysis.

interventions were found to have positive effects on weight in eight (33%) of the 24 studies, involving 32% of the study participants. In the remaining studies, no statistically significant differences were found between the groups. In no instance was the weight trend negative in an intervention group. Positive results did not appear at a higher frequency in studies with low quality than in studies with high and medium qualities.

Combined results of the systematic literature reviews by SBU and other organizations

A comprehensive systematic review from Canada, published in 2004, focused on other published systematic reviews.[13] It identified and approved the quality of six relatively concurrent, systematic reviews, one of which was the earlier SBU review. Table 4 presents the six reviews and the studies included in each. We have checked each study, added the number of participants and follow-up periods, and corrected errors. A couple of studies were excluded since we require that the studies use one of the following outcome measures: skinfold thickness, BMI or percentage of overweight or obese participants. Furthermore, we also include newer studies that have not been identified in other reviews. Previously, no article has attempted to combine the results or analyze the probability of the outcome distribution achieved.

The major difference among the various reviews concerns the requirements for accepting a study. Some require randomized trials, while we also accepted non-randomized studies, as mentioned in Materials and methods. The 1-year minimum follow-up required by SBU is another factor that distinguishes the reviews. The reviews that used lower time thresholds presumably did not consider these time differences to be decisive. In fact, even 1 year is a very short time for following up health effects in children and adolescents. Furthermore, all reviews missed some studies in their literature searches.

All the reviews presented in Table 4 showed a similar percentage of positive studies, independent of whether they were evaluated as having higher or lower quality in terms of study design, follow-up period, number of study participants and dropout.

Combined, these systematic literature reviews present 15 different studies with positive results, 24 with neutral results and 0 with negative weight trends in the intervention groups. Hence, 41% of the studies, including 40% of total children participating, showed a more positive weight trend with intervention than without intervention.

Statistical analysis

A formal meta-analysis would be difficult since the studies use different outcome measures. Outcomes expressed as

Table 2 Studies revealed for the new SBU review

First author[reference], year, country	*Study design*	*Inclusion criteria (recruitment)*	*Intervention method (study groups)*	*Treatment/extra follow-up period*	*No. of patients followed up/dropout*	*Results (weight change)*	*Results/other*	*Study quality (comments)*
Alexandrov AA[6], 1988, Russia	CCT	Schools from two districts in Moscow. Boys and girls 11 years	I: Children, parents, teachers received health education via printed material, in meetings and in discussion groups. Regular follow-up. C: Usual school education	3 years	4213 tot. Dropout not reported	Skinfold thickness: Improved in I*. No significant difference in BMI	Improved blood pressure and blood lipids in I*	Medium
Alexandrov AA[7], 1992, Russia	CCT	Schools from two districts in Moscow. Boys 11–12 years	I: Counseling, nutrition education, changed diet, physical activity and smoking prevention. Children and parents. Repeated during 1 year. More intensive if higher risk (smoking, hyperlipidemia, blood pressure and high BMI)	3 years	766. Dropout 24%	BMI – 1 year: I = 18.0*, C = 18.4; 3 years: I = 19.7, C = 19.7. No difference after 3 years	Less smoking after 3 years. I = 17%*, C = 26%	Medium
Nader PR[9], 1992, USA	RCT	Families with children in 12 elementary schools, grades 5 and 6. Two groups: Anglo-Americans, I+C; Mexican-Americans, I+C. Children 11–12 years	I: Nutrition education, changed diet with low fat and salt content and increased physical activity for 3 months Reminders during 9 months. C: usual education. Intervention was culturally adapted	1-year intervention. Follow-up 4 years	206 families. 323 children. Dropout 18% for adults and children. No info on dropout of children only	No significant difference in BMI between I and C among either Anglo- or Mexican-Americans	Higher BMI in Mexican-Americans than in Anglo-Americans	Medium
Howard JK[8], 1996, USA	RCT	School classes 9–12 years	I: Lifestyle education, diet, physical exercise, antismoking. 5 modules C: Usual education	Education 1 mo, Followup 1 year	83. Dropout 15%	No significant difference in BMI or skinfold thickness (triceps skinfold)		Low. Few participants
Müller MJ[10], 2001, Germany KOPS study	CCT	I: 3 schools C: 3 sociodemographic matched schools. Aged 5–7 years	I: Nutrition education and health promotion for students, parents, and teachers. Repeated information sessions for 3 months. C: usual program	1 year	297. Dropout 28%	Lower increase in skinfold thickness (triceps skinfold) in the intervention group. I: from 10.9 to 11.3*. C: from 10.7 to 13.0	Intervention group showed significant increase in nutrition knowledge, increased physical activity, increased intake of fruit and vegetables, increased intake of food with low-fat content and decreased TV viewing	Low. Unclear information on several aspects
Caballero B *et al.*[17], 2003, USA Pathway study	RCT	School children, American Indian >90%, 41 schools randomized. Age 7.6±0.6 years	I: Changed diet. Increased physical activity. Health education. Family involvement. C: Reference schools. 12 weeks/year including four components: classroom lectures. Support school kitchen staff. Exercise+recess activities+free-time. Family involvement	3 years	1409. Dropout 17%	BMI. I = 22.0 C = 22.2. NS	No significant difference in % body fat between I and C. Underweight not more frequent in any of the groups. No significant difference in physical activity	High

Table 2 (continued)

First author[reference], year, country	*Study design*	*Inclusion criteria (recruitment)*	*Intervention method (study groups)*	*Treatment/extra follow-up period*	*No. of patients followed up/dropout*	*Results (weight change)*	*Results/other*	*Study quality (comments)*
Warren JM[22], 2003, Great Britain	RCT	School children from three schools in Oxford. Randomized to three intervention groups and one control. Aged 5–7 years	I1: 'Eat Smart': Dietary education. I2: 'Play smart': Physical activity program. I3: Combination of 'Eat Smart' and 'Play Smart'. C: Education on food without nutritional perspective. Education for 8 weeks each term. Total length of intervention 20 weeks	14–16 months	181. Dropout 17%	No significant difference in % overweight between groups	In all groups increased dietary knowledge and intake of fruit and vegetables	Low. Few participants in each group
Saarilehto S[20], 2003, Finland STRIP study	RCT/ CCT	Families with infants aged 5 months were recruited in Helsinki. The studies were started when the children were aged 7 months	Intervention families received regular dietary advice. Aim was low content of cholesterol/ saturated fat. Contact with physician/dietician/nurse: 1–3 months interval. After 2 years: every 6 months	8 years/ongoing	658. Dropout 38%. Followed for 8 years. 435 of 658 now studied. Dropout 34%	Overweight % – Girls: I = 9.6, C = 15.8; Boys: I = 6.2, C = 7.7. NS. Underweight % – Girls: I = 1, C = 0.9; Boys: I = 2, C = 3.4. NS	Intervention program did not have negative influence on body perception, growth or neurological development of the children	Medium. Initially RCT. In follow-up CCT
Sallis JF[23], 2003, USA	RCT/ CCT	Children in 24 middle schools were randomized. Age 11–14 years	I: Increased physical activity before, during and after school. Reduced fat in school diet, student restaurants. C: No special interventions	2 years	Cross-sectional study. Before I: 1678. After I: 1484	BMI change – Girls: I = +0.12, C = +0.21; Boys: I = −0.28*, C = +0.36	Increased physical activity in I	Low
James J[24], 2004, Great Britain Chopps study	RCT	Children in six primary schools. Cluster randomized. Age 7–11 years	I: Education 1 h 4 times, same person. Drink water, no carbonated or 'light' drinks. Tooth in Coca-Cola, music with health message, various fruits. C: No special interventions	1 years	574. Dropout 11%	Overweight and obesity %, change. I = −0.2%*; C = +7.5%	Fewer carbonated drinks. I = −0.6* glass; C = +0.2 glass	Medium

* = Statistically significant difference between intervention and control group. C = control group; I = intervention group; NS = no statistically significant difference (non-significant).

Table 3 Studies on preventing obesity in children and adolescents in SBU's literature review in 2004 and combined with the studies reported in 2002

Study quality	*Better in I*			*No difference in I compared to C*		*Worse in I*	*Total*	
	Author[reference], year	*No. of participants*	*% of total participants*	*Author[reference], year*	*No. of participants*	*Studies*	*Author[reference], year*	*No. of participants*
Year 2004								
High+medium	James[24], 2004	574		Alexandrov[7], 1992	766	0		
	Alexandrov[6], 1988	4213		Nader[9], 1992	323			
				Caballero[17], 2003	1409			
				Saarilehto[20], 2003	1062			
Total	2	4787	57	4	3560	0	6	8347
Low	Müller[10], 2001	297		Howard[8], 1996	83	0		
				Sallis[23], 2003	1484			
				Warren[22], 2003	181			
Total 2004	3	5084	49	7	5308	0	10	10 392
Year 2002								
High+medium	3	2728	26	5	7777	0	8	10 505
Low	2	553	11	4	4446	0	6	4999
Total 2002	5	3281	21	9	12 223		14	15 504
Total 2002+2004	8	8365	32	16	17 531	0	24	25 896

The results of weight trends in the intervention group (I) are compared with the control group (C). Only statistically significant results were considered.

Table 4 Overview of review articles

First author[reference], year	*Better in I*			*No difference in I compared to C*			*Worse in I*	*Total*	
	Author[reference], year	*⩾1 year*	*No. of participants*	*Author[reference], year*	*⩾1 year*	*No. of participants*		*Author[reference], year*	*No. of participants*
Resnicow K[25], 1997	Harrell[26], 1996	–	1274	Alexandrov[7], 1992	+	766			
	Killen[27], 1988	–	1447	Bush[30], 1989	+	687			
	Tamir[28], 1990	+	406	Donnelly[31], 1996	+	200			
	Lionis[29], 1991	+	147	Luepker[11], 1996	+	4019			
				Resnicow[32], 1992	+	1209			
				Vandongen[33], 1995	–	1147			
				Walter[34], 1988	+	1765			
				Puska[35], 1982	+	851			
				Tell[36], 1987	–	543			
Total studies+participants	4		3274	9		11 187	0	13	14 461
Hardeman W[37], 2000	Simonetti[38], 1986	+	1321	Donnelly (see above)	+				
				Stolley[39], 1997	–	105			
Total studies+new participants	1		1321	2		105	0	3	1426
Campbell K[40], 2002	Flores[41], 1995	–	49	Donelly (see above)	+				
	Gortmaker[15], 1999	+	1295	Epstein[18], 2001	+	60			
	Müller[10], 2001	+	297	Mo-suwan[43], 1998	–	292			
	Robinson[42], 1999	–	192	Sahota[44], 2001	+	595			
	Simonetti (see above)	+		Stolley (see above)	–				
Total studies+new participants	5		1833	5		947	0	10	2780
Reilly JJ[45], 2003	Gortmaker 1999 (see above)	+		Luepker (see above)	+				
				+03, Sahota (see above)	+				
Total studies+new participants	1			2			0	3	—
Schmitz KH[46], 2002	Alexandrov[6], 1988	+	4213	Bush (see above)	+				
	Dwyer[47], 1983	–	500	Donelly (see above)	+				

Table 4 (continued)

First author[reference], year	*Better in I*			*No difference in I compared to C*			*Worse in I*	*Total*	
	Author[reference], year	*⩾1 year*	*No. of participants*	*Author[reference], year*	*⩾1 year*	*No. of participants*		*Author[reference], year*	*No. of participants*
	Flores (see above)	–		Fardy[49], 1996	–	346			
	Gortmaker (see above)	+		Luepker (see above)	+				
	Harrell (see above)	–		Mo-suwan (see above)	–				
	Killen (see above)	–		Resnicow (see above)	+				
	Lionis (see above)	+		Sallis[50], 1997	+	547			
	Robinson (see above)	–		Vandongen (see above)	–				
	Simonetti (see above)	+		Walter (see above)	+				
	Tamir (see above)	+		Tell (see above)	–				
	Worsley[48], 1987	–	456						
Total studies+new participants	11		5169	10		893	0	21	6062
Total no. of different studies and participants in all reviews	12		11 597	16		13 132	0	28	24 729
SBU[1], 2002+2004	Gortmaker (see above)	+		Bush (see above)	+				
	Lionis (see above)	+		Donelly (see above)	+				
	Müller (see above)	+		Alexandrov 1992 (see above)	+				
	Tamir (see above)	+		Luepker (see above)	+				
	Alexandrov 1988 (see above)	+		Resnicow (see above)	+				
	Manios[51], 1998	+	962	Sahota (see above)	+				
	Manios[52], 1999	+	471	Sallis (see above)	+				
	James[24], 2004	+	574	Walter (see above)	+				
				Puska[35], 1982	+	851			
				Bal[53], 1990	+	2350			
				Nader[9], 1992	+	323			
				Howard[8], 1996	+	83			
				Saarilehto[20], 2003	+	435			
				Caballero[17], 2003	+	1409			
				Warren[22], 2003	+	181			
				Sallis[23], 2003	+	1484			
Total studies+new participants	8		2007	16		7116	0	24	9123
Total no. of different studies and participants in all reviews including SBU's	15 (41% of all studies)		13 604 (40% of all participants)	24		20 248	0	39	33 852

Studies containing weight-related findings were included: weight, BMI, skinfold thickness, percentage of overweight or obese subjects. Results of weight trends in the intevention group (I) have been compared with the control group (C). Only statistically significant findings have been considered. Studies with ⩾1-year follow-up are indicated by+ and shorter followup by–. Number of participants in each study are also presented.

skinfold thickness, BMI or percentage of obese subjects must therefore be converted to effect size. This is controversial, and many studies do not provide the data required. Hence, other methods of statistical analysis must be used to interpret the results.

The compilation of all systematic literature reviews includes results from 39 studies (Table 4), wherein 15 were positive (+), 24 did not show any significant effect and 0 were negative (–). Analysis using the sign test based on the results 15 (+) and 0 (–) shows that the observed results are not likely to be a random phenomenon ($P = 0.000061$).

Another way to view the results is that most studies were designed using a 5% significance level. If there were no effect, random chance should yield a positively significant result in approximately 2.5% of the studies. In 39 studies, slightly less than 1 should be positively significant ($0.025 \times 39 = 0.98$). Given that 15 studies were positive, clearly this is not a matter of 'random significances'.

Through random chance, 600 studies would be needed to yield 15 studies with positive results (15/0.025 = 600 studies).

Even if only the studies accepted in the SBU review were analyzed, the result (8 + and 0− among 24 studies) is unlikely to have occurred by random chance, *P*-value = 0.0078.

The compilation of the 24 and 39 studies, respectively, clearly shows that under certain conditions intervention has a positive effect.

Economic aspects

The earlier SBU report did not present any cost data on obesity prevention. No cost analyses were found in any of the studies on preventive programs reviewed by SBU. Likewise, none of the other literature reviews present data of this type. In a renewed comprehensive literature search, we found one study on children that attempted to analyze cost effectiveness.[14]

The study was based on a randomized clinical prevention trial by Gortmaker *et al*.[15] that was included in the earlier SBU report. The authors retrospectively estimated the costs of all interventions, for example, training, instructor time, etc. for the entire group of children. Costs were estimated at 14 US dollars (USD) per student and year. The effect achieved among girls was extrapolated to show that obesity could be avoided in 1.9% of adult women. This would be accompanied by lower healthcare costs and less productivity loss. Hence, the estimated cost was 4305 USD per quality-adjusted life-year, and a net savings for society. The preventive interventions were therefore found to be cost effective and remained so in most cases when applying sensitivity analysis. This study contains many uncertainties. The findings that appear to favor preventive interventions need to be based on stronger data and confirmed by other researchers.

Discussion

As in the earlier report, several of the new studies use mean BMI or skinfold thickness as outcome measures, but several studies also use the percentage of overweight or obese children. Since the studies have used different outcome variables, intervention periods and follow-up periods, the results cannot be added through any type of meta-analysis. The option available is to add the number of studies and participants with significantly better weight trends in the intervention than in the control groups, comparing this with the neutral and negative outcomes, respectively.

In total, the reviews included 39 studies involving 33 852 participants. Hence, the topic has been thoroughly studied, and positive effects were found in 41% of cases. Overall, the results suggest that it is possible to avoid overweight and obesity in children and adolescents by using preventive interventions. This was also found in an ongoing Swedish study, Stockholm Obesity Prevention Project (STOPP), where the preliminary results after 2 years favor the intervention group.[16]

High-risk groups

The earlier SBU report did not include any studies aimed at children and adolescents at higher risk for obesity. The current review includes Caballero's study on American Indian schoolchildren.[17] Epstein studied children of obese parents and compared two strategies, one that increased fruit and vegetable intake and the other that decreased fat and sugar intake.[18] One of the studies by Alexandrov[7] included, to some extent, a high-risk strategy, since boys with multiple risk factors for cardiovascular disease received more intensive preventive intervention than the others. None of these studies found a confirmed positive effect from intervention. An ongoing study, 'Hip-Hop for Health Jr', has targeted ethnic minority groups at higher risk for obesity, in this case relatively small children.[19] To date, the high-risk strategy has been poorly tested and is without confirmed beneficial effects. Nevertheless, it is possible that special interventions could be effective for exposed groups.

Risks of preventive interventions

Previously, no reports addressed the risks of preventive programs. However, several recent studies have investigated underweight, anorexia, negative body perception and low self-confidence in the children and adolescents who participated in the intervention programs. None of these studies have reported any harmful effects, which is encouraging for future plans and projects.[17,20]

Publication bias

One could ask whether publication bias might be responsible for the distribution of positive and neutral studies and the lack of negative findings. However, a large number of studies have been included, many of which did not present positive results, but were published nevertheless. Many experts in searching scientific literature have been involved in different countries. Cochrane, for example, is known for rigorously pursuing uncommon sources and unpublished material. Obesity researchers have participated in the review and often know of other researchers and studies. Furthermore, schools, teachers and students in many areas are involved in studies that often receive public financing. It is difficult to escape presenting the results, even if they would be negative. Also, the statistical reasons argue in the same direction. Hence, the risk appears to be very small that the findings of this report could be misinterpreted due to publication bias.

Concluding remarks

Since many studies did not demonstrate positive effects, this can be interpreted to mean that it is difficult to create an effective program based only on limited interventions in schools. We have not been able to identify any particular interventions that characterize the positive studies and differentiate them from the others.

An inspiring and educational example in the context of lifestyle changes is the gradual and successful decline in smoking. This has been achieved in the population through multiple, enduring, and gradually escalating methods.[21] For prevention of obesity, a combination of long-range and massive interventions throughout society to promote healthy dietary habits and physical activity could be expected to have effects that are much different and more powerful than the effects demonstrated by measures limited to the school environment. Advancing on all fronts with interventions enhanced by mass media campaigns, and political action to promote or prevent various types of consumption and to facilitate increased physical activity, may promote more effective results. Committing resources to high-risk groups might also possibly be an effective approach. Thus, the prevention of obesity among children and adolescents is possible and is a must in today's societies.

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This paper is based on a Swedish report published by the SBU in January 2005.[54] The SBU report contained an update of 'Interventions to Prevent Obesity' from an earlier report. The present paper is a condensed version of the section on children and adolescents. Johan Bring, Professor and statistician from Uppsala, Sweden, performed the statistical analysis.

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