Web appendix: Supplementary material

Contents

Web appendix 1. Search terms

Population	Intervention (measured item)	Outcomes	Exclude
Terms: Children aged 5-16 years	Terms: Overweight Underweight Obes* Body Mass Index Waist circumference Neck circumference % body fat Adipos* Waist hip ratio Skinfold thickness	Terms: Cardiovascular disease Coronary heart disease Blood pressure Hyperlipidaemia Cholesterol Diabetes Pulse rate VO_2Max Fit* Atherosclerosis Arterial stiff* Arterial wall thick*	Prader Willi Syndrome Polycystic Ovary Syndrome AIDS Cerebral Palsy All disabilities All mental illness All eating disorders Cancer Pilot studies Study protocols Non-developed world Studies including the parents Studies taking place in an inpatient setting Pharmacological treatments
Synonyms: School age* children, schoolchild*, adolescen*, teenage*, pubescent, pre-pubescent, pre-teen*	Synonyms: Body weight disorder Over nutrition Under nutrition Thinness Leanness Morbid obesity Abdominal obesity BMI	Synonyms: Hypercholesterolemia Hypertriglyceridemia Impaired glucose tolerance Glucose intoleran* Atherosclerotic plaque Hypertension Heart rate Exercise tolerance Heart disease Vascular disease Coronary artery atherosclerosis Arterial pressure Diastolic blood pressure DBP Systolic blood pressure SBP Ischemic heart disease Aerobic capacity Aerobic exercise	

Limits:
Publication date January 2000 to December 2011
Human participants
Children aged 5-16 years
Articles published in peer reviewed journals

Web appendix 2.1. Parameters measured in studies included in the descriptive-analysis

Paper	Country of Origin	Number of Participants	Age of participants	Type of study	Parameters measured	Reason for exclusion from meta-analysis
Alhassan 2008 (73)	USA	208	8-10	Cross-sectional	Weight, height, resting BP, cholesterol, triglycerides, fasting insulin, fasting glucose	No weight comparison group
Andersen 2003 (48)	Denmark	1020	9-16	Cross-sectional	Weight, height, BMI, cholesterol, triglycerides, fasting glucose, fasting insulin, resting BP	No weight comparison group
Andersen 2006 (74)	Denmark, Estonia, Portugal	1732	9 and 15	Cross-sectional	Weight, height, resting BP, HOMA-IR, cholesterol, triglycerides	No weight comparison group
Bouziotas 2004 (75)	Greece	210	11-14	Cross-sectional	Weight, height, cholesterol, triglycerides, resting BP	No weight comparison group
Brage 2004 (76)	Denmark	589	8-10	Cross-sectional	Weight, height, resting BP, cholesterol, fasting insulin, fasting glucose, triglycerides	No weight comparison group
Carrel 2005 (77)	USA	50	12 (0.5)	RCT	Weight, height, fasting insulin, fasting glucose	No weight comparison group
Du Bose 2006 (52)	USA	375	7-9	Cross-sectional	Weight, height, BMI, triglycerides, cholesterol, resting BP, fasting glucose	No weight comparison group
Ekelund 2007 (78)	Denmark, Estonia, Portugal	1746	9 and 15	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglycerides, fasting glucose, fasting insulin	No weight comparison group
Evans 2009 (39)	USA	168	13.4 (1.8)	RCT	Weight, height, BMI, cholesterol, triglycerides, fasting glucose	No weight comparison group
Flouris 2007 (79)	Canada	3293	14-15	Cross-sectional	Weight, height, resting BP, cholesterol	No weight comparison group
Graf 2005 (40)	Germany	1677	5.4-12	Cross-sectional	Weight, height, BMI, resting blood pressure	No weight comparison group
Hansen 2005 (80)	Denmark	696	6-7	RCT	Weight, height, BMI, fasting glucose, fasting insulin, cholesterol, triglyceride, resting BP	No weight comparison group
Jago 2006 (49)	USA	1717	13.6 (0.6)	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglycerides	No weight comparison group
Johnston 2010 (81)	USA	54	10-14	RCT	Weight, height, BMI, cholesterol, triglycerides, resting BP	No weight comparison group
Kalarchian 2009 (82)	USA	192	8-12	RCT	Weight, height, BMI, resting blood pressure	No weight comparison group
Kim 2010 (83)	South Korea	405	9-10	Cross-sectional	Weight, height, BMI, resting BP, fasting glucose, insulin, triglyceride, cholesterol, HOMA-IR,	No weight comparison group
Klasson-Heggebo 2006 (84)	Denmark, Estonia, Portugal, Norway	4072	9 and 15	Cross-sectional	Weight, height, BMI, resting BP	No weight comparison group
Kovacs 2009 (85)	Hungary	38	6.5-12.5	RCT	Weight, height, BMI, resting BP, fasting glucose, fasting insulin, cholesterol, HOMA-IR, triglycerides	No weight comparison group
Kriemler 2010 (86)	Switzerland	502	6.9 (0.3) and 11.1 (0.5)	RCT	Weight, height, BMI, resting BP, fasting glucose, cholesterol, triglyceride, fasting insulin, HOMA-IR	No weight comparison group
McMurray 2002 (87)	USA	1140	11-14	RCT	Weight, height, BMI, resting BP	No weight comparison group
Mirzaei 2007 (42)	Australia	1230	8-10	Longitudinal	Weight, height, BMI, resting BP	No weight comparison group
Raman 2010 (88)	USA	121	9-13	Cross-sectional	Weight, height, BMI, cholesterol, triglycerides, resting blood pressure	No weight comparison group
Reed 2008 (89)	Canada	268	9-11	RCT	Weight, height, BMI, resting BP, cholesterol	No weight comparison group
Reinehr 2010 (41)	Germany	66	11.6 (1.6) and 11.4 (1.7)	RCT	Weight, height, BMI, resting BP	No weight comparison group
Resnicow 2005 (90)	USA	123	13.6 (1.43)	RCT	Weight, height, BMI, resting BP, cholesterol, fasting glucose, fasting insulin	No weight comparison group
Ribeiro 2004 (50)	Portugal	1461	8-15	Cross-sectional	Weight, height, BMI, resting BP, cholesterol	No weight comparison group
Ruiz 2007 (91)	Sweden, Estonia	873	9-10	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, fasting glucose, fasting insulin, triglycerides	No weight comparison group
Sacher 2010 (92)	UK	116	8-12	RCT	Weight, height, BMI, resting BP	No weight comparison group
Savva 2000 (43)	Cyprus	1987	10-14	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglycerides	Weight groups described as ≥ or≤ a cut-off point, no weight data reported
Shalitin 2009 (93)	Israel	162	6-11	RCT	Weight, height, BMI, resting BP, triglycerides, cholesterol, fasting glucose, fasting insulin, HOMA-IR	No weight comparison group
Simon 2008 (94)	France	954	9.9-13.8	RCT	Weight, height, BMI, fasting glucose, fasting insulin, cholesterol, triglycerides, HOMA-IR, resting BP	No weight comparison group

Steene-Johannessen 2009 (51)	Norway	2299	9 and 15	Cross-sectional	Weight, height, resting BP, cholesterol, fasting glucose, triglyceride, fasting insulin, HOMA-IR	No weight comparison group
Steinberger 2002 (95)	USA	322	12-14	Cross-sectional	Weight, height, resting BP, triglyceride, fasting insulin, cholesterol, fasting glucose, LVM	No weight comparison group
Teixeira 2001 (46)	Portugal	159	10-15	Cross-sectional	Weight, height, BMI, triglycerides, cholesterol	No weight comparison group
Thomas 2007 (44)	UK	208	12.9 (0.3)	Cross-sectional	Weight, height, resting BP, cholesterol, triglycerides	No weight comparison group
Vizcaino 2007 (45)	Spain	1280	8-11	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglycerides	No weight comparison group
Vizcaino 2008 (96)	Spain	1119	9-11	RCT	Weight, height, BMI, resting BP, cholesterol, triglycerides	Number of children in groups not reported in sufficient detail for analysis
Woo 2004a (47)	Hong Kong	82	9-12	RCT	Weight, height, cholesterol, triglycerides, IMT	No weight comparison group
Yoshinaga 2008 (97)	Japan	319	6-11	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglyceride, fasting glucose, fasting insulin, HOMA-IR	No weight comparison group
Total: 39		Total: 33,033				

Web appendix 2.2. Parameters measured in studies included in the meta-analysis

Paper	Country of Origin	Number of Participants	Age of participants	Type of study	Parameters of interest measured
Aggoun 2008 (37)	Switzerland	71	6-11	Cross-sectional	Weight, height, BMI, resting BP, ambulatory BP, IMT, cholesterol, triglycerides, fasting insulin, HOMA-IR
Aguilar 2010b (98)	Spain	921	10-12	RCT	Weight, height, BMI, resting BP, cholesterol, triglycerides
Banach 2010 (99)	Canada	65	9-12	Cross-sectional	Weight, height, BMI, resting BP
Barba 2006 (100)	Italy	3923	6-11	Cross-sectional	Weight, height, BMI, resting BP
Calcaterra 2008 (101)	Italy	267	6-15	Cross-sectional	Weight, height, BMI, resting BP, fasting glucose, fasting insulin, cholesterol, triglycerides, HOMA-IR
Csabi 2000 (102)	Hungary	419	9-15	Cross-sectional	Weight, height, BMI, resting BP, fasting glucose, fasting insulin, cholesterol, triglycerides
De Sousa 2009 (103)	Germany	82	11 +-2	RCT	BMI, triglycerides., cholesterol, fasting insulin, resting BP
Di Bonito 2008 (65)	Italy	141	7-14	Cross-sectional	Weight, height, BMI, fasting glucose, cholesterol, triglycerides, fasting insulin, HOMA-IR, resting BP, LVM
Di Salvo 2006 (104)	Italy	300	6-15	Cross-sectional	Weight, height, BMI, resting BP, ambulatory BP, fasting insulin, fasting glucose, HOMA-IR, IMT, LVMi
Di Salvo 2008 (105)	Italy	320	6-15	Cross-sectional	Weight, height, BMI, resting BP, ambulatory BP, fasting insulin, fasting glucose, HOMA-IR, LVMi
Falaschetti 2010 (35)	UK	7589	9-12	Cross-sectional	Weight, height, BMI, resting BP, triglycerides, cholesterol
Farpour-Lambert 2009 (106)	Switzerland	66	6-11	RCT	Weight, height, BMI, resting BP, ambulatory BP, IMT, cholesterol, triglycerides, insulin, HOMA-IR
Giannini 2009 (53)	Italy	120	6-10	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglycerides, fasting glucose, fasting insulin, HOMA-IR, IMT
Hrafnkelsson 2009 (107)	Iceland	267	7	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglycerides, fasting glucose, fasting insulin
Iannuzzi 2004a (108)	Italy	147	6-14	Cross-sectional	Weight, height, BMI, cholesterol, triglycerides, fasting glucose, HOMA-IR, IMT
Iannuzzi 2004b (109)	Italy	143	10 (2.6)	Cross-sectional	Weight, height, cholesterol, triglycerides, fasting glucose, HOMA-IR
Maggio 2008 (110)	Switzerland	66	8.8 (1.5)	Cross-sectional	Weight, height, BMI, resting BP, ambulatory BP, LVM
Peralta-Huertas 2008 (111)	Canada	63	9-12	Cross-sectional	Weight, height, BMI, resting BP, LVM
Platat 2006 (36)	France	640	11.2-11.79	Cross-sectional	Weight, height, BMI, resting BP, fasting glucose, cholesterol triglycerides, fasting insulin
Roh 2007 (38)	Korea	83	14-16	Cross-sectional	Weight, height, BMI, cholesterol, triglyceride, resting BP, IMT
Suriano 2010 (66)	Australia	180	6-13	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglyceride, fasting insulin, fasting glucose, HOMA-IR
Van Putte-Katier 2008 (112)	Belgium	94	8-14	Cross-sectional	Weight, height, BMI, resting BP, fasting glucose, fasting insulin, cholesterol, triglycerides, LVM
Watts 2008 (113)	Australia	148	6-13	Cross-sectional	Weight, height, BMI, resting BP, cholesterol, triglyceride, fasting inulin, fasting glucose, HOMA-IR
Woo 2004b (114)	Hong Kong	72	7-12	Case-control	Weight, height, BMI, resting BP, cholesterol, triglyceride, insulin, IMT
Total in meta-analysis: 24		Total in meta-analysis: 16,187			

Web appendix 3.1. Main findings of papers included in the descriptive analysis

Paper	Number of Participants	Age of participants	Type of study	Main findings relevant to the review
Alhassan 2008 (73)	208	8-10	Cross-sectional	Physical activity was inversely associated with BMI and fasting insulin. After adjustment for pubertal stage only the association with fasting insulin remained significant. No association found between physical activity and lipids, BP, or glucose.
Andersen 2003 (48)	1020	9-16	Cross-sectional	BMI and fitness significantly associated with number of CHD risk factors present in children and adolescents. The average fitness in children with clustering was 1.2 SD lower and BMI was 1.6 SD higher than the mean.
Andersen 2006 (74)	1732	9 and 15	Cross-sectional	Negative association found between physical activity and clustering of CVD risk factors. Risk was raised in the three less active groups compared with the most active group.
Bouziotas 2004 (75)	210	11-14	Cross-sectional	Primary CHD risk factors were associated with physical activity levels, independent of fitness, fatness, and/or fat intake. Specifically, physical activity was associated positively with HDL-C and negatively with systolic BP.
Brage 2004 (76)	589	8-10	Cross-sectional	Physical activity was inversely related to metabolic risk and significantly related to risk factor clustering. A significant interaction was found between physical activity and fitness suggesting a stronger relationship between activity and risk in children with low fitness
Carrel 2005 (77)	50	12 (0.5)	RCT	Improved body fat percentage, fasting glucose and insulin levels and fitness seen in the intervention group without similar improvement in BMI. Only 1 follow up at 9 months
Du Bose 2006 (52)	375	7-9	Cross-sectional	The metabolic syndrome is prevalent at similar rates in young children and in adolescents. The prevalence of the metabolic syndrome in primary school-aged children was 5%. Half of the children had at least one component of the metabolic syndrome. Raised blood pressure was the most common component.
Ekelund 2007 (78)	1746	9 and 15	Cross-sectional	Physical activity and fitness are separately and independently associated with indicators of insulin resistance, hyperglycaemia, hyperlipidaemia and clustered metabolic risk. The association between fitness and clustered risk was partly mediated by adiposity, whereas the association between activity and clustered risk was independent of adiposity.
Evans 2009 (39)	168	13.4 (1.8)	RCT	No reduction in BMI but fitness increased. Percent body fat reduced, total cholesterol reduced and LDL- cholesterol reduced at 6 months.
Flouris 2007 (79)	3293	14-15	Cross-sectional	Higher fitness was associated with lower BMI, diastolic BP and total cholesterol in boys and lower BMI, systolic and diastolic blood pressure in girls.
Graf 2005 (40)	1677	5.4-12	Cross-sectional	Obese children had the highest values for systolic and diastolic BP. There were no significant differences between girls and boys. After 9 months of intervention, the reduction in the standard deviation score for BMI was higher in those undergoing intervention than in controls. The increase in the BMI tended to be lower in those undergoing intervention and there was a reduction of systolic BP and diastolic BP after the intervention.
Hansen 2005 (80)	696	6-7	RCT	Mean BMI, BP and blood lipids were not different between girls and boys. Peak VO2 and physical activity were higher in boys than in girls. Peak VO2 was associated with fatness independently of weight. Fitness was associated with HDL-cholesterol. Fatness assessed by skinfold was associated with blood pressure, fasting glucose and insulin. Fatness weakly associated with BP, fasting insulin and glucose.
Jago 2006 (49)	1717	13.6 (0.6)	Cross-sectional	12.8% of children were pre-hypertensive, 23.9% had high BP. Boys were more likely to have high BP and low HDL-cholesterol, girls were more likely to have borderline total cholesterol. The prevalence of risk factors was associated with the overweight group and increasing BMI group worsened all risk factors in both genders, except total cholesterol where this was only seen in boys.
Johnston 2010 (81)	54	10-14	RCT	The school-based instructor lead intervention resulted in reductions in zBMI in 79% of children at yr. 1 and most maintained to yr. 2 but the effect size was smaller. Children in the instructor lead intervention group also significantly lowered their total cholesterol at 1 year compared with those in the self-help group. Differences were not found for BP, LDL and HDL-cholesterol.
Kalarchian 2009 (82)	192	8-12	RCT	Intervention was associated with weight reduction at 6 months but no significant reductions at 12 or 18 months. Some small reductions in systolic BP and diastolic BP seen at 6 months but these level off at 12 months. Sustained decreases in overweight were observed only among children with attendance ≥75%.
Kim 2010 (83)	405	9-10	Cross-sectional	BMI thresholds at which CVD risk and insulin resistance begin to increase in Korean children were lower than proposed by the international obesity task force. The BMI centile at which CVD risk started was 71.3 in boys and 77.1 in girls. The BMI centiles at which insulin resistance started was 66.3 for boys and 67.9 for girls.
Klasson-Heggebo 2006 (84)	4072	9 and 15	Cross-sectional	Relationship between fitness waist circumference, sum of skin folds and systolic and diastolic BP was curvilinear. The difference in systolic blood pressure between the least and most fit was 6mmHg
Kovacs 2009 (85)	38	6.5-12.5	RCT	Systolic BP, LDL-cholesterol, number of children with elevated triglyceride, hypertension and abdominal obesity decreased significantly. Cardiovascular fitness parameters improved.
Kriemler 2010 (86)	502	6.9 (0.3) and 11.1 (0.5)	RCT	Children in the intervention group showed smaller increases or larger reductions in BMI, triglycerides, HDL-cholesterol, and glucose. The cardiovascular risk score decreased more in the intervention than in the control group.
McMurray 2002 (87)	1140	11-14	RCT	Systolic and diastolic BP increased more in the control group but BMI did not change significantly in any of the groups. A small increase in VO2max in the combined exercise and education group was found and was significantly greater than the education only group.
Mirzaei (2007) (42)	1230	8-10	Longitudinal	Weight was significantly associated with SBP and DBP in boys and girls at baseline and follow-up. Longitudinal BMI change significantly associated with systolic BP and diastolic BP. BMI was a predictor of BP
Raman 2010 (88)	121	9-13	Cross-sectional	BMIz was significantly associated with diastolic BPz, HDL-cholesterol and triglycerides. Waist circumference as good a predictor of risk factors as BMIz.

Reed 2008 (89)	268	9-11	RCT	Intervention children had a 20% greater increase in fitness, a 4.6% greater reduction in total cholesterol and a 5.7% smaller increase in BP compared with control children. 45% of children had at least one elevated risk factor out of fitness, BP or BMI at baseline. There were no significant differences between groups for change in BMI or in any of the blood variables
Reinehr 2010 (41)	66	11.6 (1.6) and 11.4 (1.7)	RCT	Intervention group showed a 94% reduction in degree of overweight so 24% were normal weight by the end of the trial, independent of age and sex. BMI, SBP and DBP decreased significantly in the intervention group. Diary records of the intervention group showed improvements to their eating habits.
Resnicow 2005 (90)	123	13.6 (1.43)	RCT	The intervention was not effective in reducing BMI with a 0.5 point difference between groups at 6 months. There were some positive findings among high attenders where a greater reduction in BMI was seen. At 6 months there were no significant differences in the secondary outcomes BP, insulin, lipids and glucose.
Ribeiro 2004 (50)	1461	8-15	Cross-sectional	A clustering between high BP and high total cholesterol was found in both sexes but especially females. More than half the sample had at least one CVD risk factor.
Ruiz 2007 (91)	873	9-10	Cross-sectional	Fitness was associated with clustering of metabolic risk factors. Higher fitness was associated with lower triglyceride and insulin in girls and insulin in boys.
Sacher 2010 (92)	116	8-12	RCT	Participants in the intervention group reduced BMIz at 6 months when compared with the controls. Significant between-group differences were also found in fitness and diastolic BP. Intervention group showed a reduction in sedentary behaviour and increase in physical activity and self-esteem. At 12 months, children in the intervention group had reduced their BMI z-scores by 0.23 ($P < 0.0001$) and benefits in fitness were sustained
Savva 2000 (43)	1987	10-14	Cross-sectional	All CVD risk factors worse in those in the >75th compared with <75th BMI percentile for boys and girls. Obese children had higher risk for the presence of CVD risk factors. Systolic BP, diastolic BP, LDL-cholesterol and triglycerides were correlated to BMI. Waist to height ratio and waist circumference were better predictors of risk factors than BMI. BMI was a useful predictor of triglycerides and BP.
Shalitin 2009 (93)	162	6-11	RCT	At 12 weeks all risk factors improved in all groups. BMI, systolic BP, diastolic BP, glucose, total cholesterol, HDL-cholesterol, LDL-cholesterol, HOMA-IR and insulin all regressed to no significant differences between groups after 9 months. BMI-SDS and LDL-cholesterol were lower compared to baseline. Intervention arms that involved diet or diet and exercise were more successful than exercise alone.
Simon 2008 (94)	954	9.9-13.8	RCT	Intervention children had a lower increase in BMI over time than controls. The intervention significantly prevented excessive weight gain in initially normal weight children and the incidence of overweight in the intervention group was lower than in the control group. Changes in BMI in the initially overweight children did not persist.
Steene-Johannessen 2009 (51)	2299	9 and 15	Cross-sectional	No differences found in systolic BP between sexes in 9 year olds. In 15 year olds boys had higher systolic BP. Girls had higher levels of total cholesterol and lower HDL-cholesterol than boys across both age groups. CVD risk clustering was found in 11·4% of the study population.
Steinberger 2002 (95)	322	12-14	Cross-sectional	LVM is strongly related to BMI in boys and girls, but is not related to insulin sensitivity. LVM was significantly associated with fasting insulin in boys and girls and with total cholesterol and LDL-cholesterol in boys only.
Teixeira 2001 (46)	159	10-15	Cross-sectional	Body mass index was associated with triacylglycerol, low density LDL-cholesterol and HDL-cholesterol. Obese children had higher total cholesterol and LDL-cholesterol than lean children and adolescents had a worse lipid profile.
Thomas 2007 (44)	208	12.9 (0.3)	Cross-sectional	An inverse relationship was found between fitness and fatness (BMI and sum of skin folds) in both sexes. Fitness was related to triglycerides and diastolic BP in both sexes. In a multiple regression fatness was an independent predictor of triglycerides and diastolic BP. Fatness was also a predictor of systolic BP only in girls. Fatness was related to a greater number of risk factors than fitness.
Vizcaino 2007 (45)	1280	8-11	Cross-sectional	No CV risk factors out of total cholesterol, triglycerides, HDL-cholesterol, LDL-cholesterol, systolic BP and diastolic BP were significantly associated with BMI in the lowest BMI quartile. In quartiles 2-3 BMI was significantly associated with triglycerides, HDL-cholesterol and diastolic BP. In quartiles 3-4 BMI was significantly associated with all risk factors except total cholesterol.
Vizcaino 2008 (96)	1119	9-11	RCT	Intervention was not associated with changes in total cholesterol, triglycerides or BP in either sex, apart from an increase in diastolic BP in boys. A significant interaction was found between the intervention effects, sex and systolic BP.
Woo 2004a (47)	82	9-12	RCT	At 6 weeks, both diet only and diet and exercise interventions were associated with decreased total cholesterol level. Diet and exercise was associated with a decrease in LDL-cholesterol. At 1 year, there was significantly less thickening of the carotid wall exercise program group. Exercise was associated with a significant reduction in LDL-cholesterol, increase in HDL-cholesterol but no change in BMI.
Yoshinaga 2008 (97)	319	6-11	Cross-sectional	An increase in the total number of CVD risk factors was associated with a worsening of each CVD risk factor level over 1 year in a multivariate regression analysis after adjusting for age and gender. Fasting glucose in boys was higher than in girls and fasting insulin was higher in girls than in boys. Over 1 year triglyceride, insulin, and HOMA-IR levels significantly worsened.
	Total: 33,033			

Web appendix 3.2. Main findings of papers included in the meta-analysis

Paper	Number of Participants	Age of participants	Type of study	Main findings relevant to the review
Aggoun 2008 (37)	71	6-11	Cross-sectional	24H Ambulatory Systolic BP and Ambulatory Diastolic BP significantly higher in obese children. 18 out of 38 obese children hypertensive on the Ambulatory BP measure- none of the lean were. Obese had lower HDL and higher insulin and HOMA-IR. Correlations between BMI, systolic BP, diastolic BP (ambulatory and resting), HDL-cholesterol, triglyceride, insulin and HOMA-IR all significant. BMI not associated with IMT.
Aguilar 2010b (98)	921	10-12	RCT	The intervention resulted in a reduction of total cholesterol across all baseline BMI categories without a reduction in endpoint BMI. No statistically significant differences were seen between the intervention and control group in the other factors.
Banach 2010 (99)	65	9-12	Cross-sectional	No significant difference found in SBP and DBP between overweight and normal weight children. Found that the distensibility if the common carotid artery was related to BMI and systolic BP.
Barba 2006 (100)	3923	6-11	Cross-sectional	Blood pressure z scores were significantly related to BMI z scores. Overweight and obesity significantly associated with higher risk of hypertension, almost all normal weight children were normotensive.
Calcaterra 2008 (101)	267	6-15	Cross-sectional	The prevalence of the metabolic syndrome is higher in obese than non-obese children and increases with severity of obesity. Hyperinsulinaemia was found in overweight children without metabolic syndrome suggesting that insulin resistance might precede it. The most prevalent risk factors amongst obese children were HDL-cholesterol ≤ 5^{th} centile and BP ≥95^{th} centile.
Csabi 2000 (102)	419	9-15	Cross-sectional	CVD risk factors already cluster in childhood and are strongly associated with obesity. Study found a significantly higher clustering of cardiovascular risk factors among obese children than in controls. Only 14· 4% of the obese children were free of any risk factor. Significant differences were found in the levels of risk factors present in the obese compared with the control children, with the exception of HDL-cholesterol.
De Sousa 2009 (103)	82	11 +-2	RCT	Obese children had significantly higher systolic BP and lower exercise capacity than controls which improved after the intervention. BMI, systolic SBP, diastolic BP, triglycerides, fasting insulin and HDL-cholesterol all improved after intervention
Di Bonito 2008 (65)	141	7-14	Cross-sectional	Obese children show an increased LVM. Central fat is the only independent predictor of increased LVMi. All other measured risk factors were worse in obese vs. control and worse in the highest tertile of obesity vs. lowest tertile.
Di Salvo 2006 (104)	300	6-15	Cross-sectional	Significant increase in LVM was found in overweight but otherwise healthy children. cIMT was significantly correlated with 24 h-systolic BP, but without a significant difference between obese and lean children. The findings suggest that obesity, in the absence of hypertension, is a risk factor for later CVD and is associated with significant impairment of ventricle functioning.
Di Salvo 2008 (105)	320	6-15	Cross-sectional	LVMi increased in the obese children. Significant changes in the right and left atrial myocardial function in children with excess weight. BP and 24h BP similar between obese and control children
Falaschetti 2010 (35)	7589	9-12	Cross-sectional	In pre-pubertal children there is a largely linear relationship of BMI with each of the risk factors and biomarkers evaluated. A higher BMI was found to be associated with worsened CVD risk factors and an at least ten fold increased risk ratio for hypertension in both girls and boys.
Farpour-Lambert 2009 (106)	66	6-11	RCT	Obese children had higher BP, weight, BMI, abdominal fat, HOMA-IR and lower fitness and HDL-cholesterol levels than lean subjects The physical activity program reduced BP, arterial stiffness, and abdominal fat; increased fitness; and could delay arterial wall remodelling in obese children. Training did not improve LDL-cholesterol or triglycerides, insulin and HOMA-IR became worse.
Giannini 2009 (53)	120	6-10	Cross-sectional	Pre-pubertal lean and obese children were found to have increased cIMT compared with controls with the mean value of the left and the right carotid artery showing a J-shaped curve but no difference was found between the 2 groups. Lean and obese children had higher fasting insulin, fasting glycaemia, HOMA-IR compared with controls but no differences were found between lean and obese. A negative effect of both lower and higher adipose tissue on carotid arterial wall in lean and severe obese pre-pubertal children was seen.
Hrafnkelsson 2009 (107)	267	7	Cross-sectional	Overweight children had unfavourable levels of HDL-cholesterol, LDL-cholesterol, glucose, triglycerides, insulin, systolic BP and diastolic BP. Skinfold thickness, higher triglyceride and glucose levels, and being female were associated with increased serum insulin.
Iannuzzi 2004a (108)	147	6-14	Cross-sectional	Obese children had significantly increased carotid IMT and stiffness, BP, triglycerides, glucose, cholesterol and HOMA-IR when compared with control children. All CVD risk factors were found to be worse in obese compared with control group regardless of sex.
Iannuzzi 2004b (109)	143	10 (2.6)	Cross-sectional	Compared with controls, obese children had higher blood pressure and higher total cholesterol, triglycerides, fasting glucose and insulin. Preclinical changes in the aortic elastic properties were found in obese children. This combined with insulin resistance was found in obese girls and worsen the impact on pre-clinical arterial changes.
Maggio 2008 (110)	66	8.8 (1.5)	Cross-sectional	Ambulatory systolic hypertension found in almost half of the obese children. 24-hour ambulatory systolic BP, diastolic BP, and LVMI were significantly higher in obese than in lean children. Fatness, lean tissue mass and 24 hour ambulatory BP were correlated positively with LVMi.
Peralta-Huertas 2008 (111)	63	9-12	Cross-sectional	Systolic BP and diastolic BP higher in overweight boys and girls than normal children except diastolic BP in girls where the reverse was true. LVM and LVMi were significantly higher in overweight boys and girls compared with normal children.
Platat 2006 (36)	640	11.2-11.79	Cross-sectional	Physical activity was inversely related to HOMA-IR. Metabolic syndrome was present in 26% of the overweight children but none of the normal weight children. Overweight children with the metabolic syndrome had worse results for systolic BP, HDL-cholesterol, triglycerides and HOMA-IR than both overweight children without metabolic syndrome and normal controls.
Roh 2007 (38)	83	14-16	Cross-sectional	Obese children had significantly increased IMT compared with controls. Obese children had significantly higher systolic BP, diastolic BP, LDL-cholesterol, triglycerides, and lower HDL-cholesterol than the control group. IMT was significantly correlated to BMI, systolic BP and diastolic BP and inversely correlated to HDL-cholesterol.

Suriano 2010 (66)	180	6-13	Cross-sectional	Females had lower diastolic BP and glucose, no other significant effect of sex was found. Increasing BMIz associated with higher systolic BP, diastolic BP triglycerides, insulin and HOMA-IR and lower HDL-cholesterol. Waist circumference z-score was the only significant predictor of cardiovascular risk factors Within the normal weight children, high fitness was associated with significantly reduced triglyceride levels, and lower fasting glucose, insulin and HOMA-IR
Van Putte-Katier 2008 (112)	94	8-14	Cross-sectional	Obese children were found to have increased systolic BP, diastolic BP, left ventricular wall dimensions and mass. LVMi was significantly predicted by BMI SDS. Glucose, total cholesterol, triglycerides, HDL-cholesterol and LDL-cholesterol were not predictors of LVM/LVMi.
Watts 2008 (113)	148	6-13	Cross-sectional	Waist circumference was the only significant predictor of HDL-cholesterol, triglycerides, systolic blood pressure, fasting insulin, HOMA-IR. Increased waist circumference was associated with increased CVD risk. BMIz was significantly associated with systolic BP, diastolic BP, HDL-cholesterol, triglycerides, insulin, fasting glucose and HOMA-IR in a univariate model but none in the multivariate model.
Woo 2004b (114)	72	7-12	Case-control	BMI, fasting insulin and triglycerides were higher in obese children. Overweight was associated with increased cIMT. The degree of endothelial dysfunction correlated with BMI on univariate and multivariate analysis.
	Total in meta-analysis: 16,187			

Web appendix 4. BMI cut-off points of the three most frequently cited definitions

BMI percentile	Cole et al 2000 (27)	CDC growth charts 2000 (79)	Kromeyer-Hauschild 2001 (80)
		Boys	
90th	25	26.8	25.91
95th	30	28.8	Not reported
97th	Not reported	30.5	28.78
		Girls	
90th	25	27.3	25.28
95th	30	30.3	Not reported
97th	Not reported	33	27.76