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Original Article

Data from the StEP TWO programme showing the effect on blood pressure and different parameters for obesity in overweight and obese primary school children

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Abstract Obesity in childhood, which is associated with cardiovascular risk factors such as hypertension, is on the increase. Countermeasures are necessary. In this paper, we present the baseline and final data from the StEP TWO programme, a prospective study to prevent overweight and obesity in primary schools. *Methods:* We recorded and calculated, from 1689 children, anthropometric data, including analyses of bioelectric impedance, waist and hip circumferences, body mass index and its standard deviation, and the ratio of waist to hip. Blood pressure was measured after 5 minutes at rest. From the three schools involved in a programme of intervention, 121 children were invited to take part, and 40 (33.1 per cent) completed the programme. The effect was compared with 155 overweight and obese children identified at the 4 control schools. *Results:* 830 (49.5 per cent) boys and 848 girls (50.5 per cent) took part. Their mean age was 8.2 plus or minus 1.3 years, their height was 1.31 plus or minus 0.09 metres, they weighed 30.0 plus or minus 8.2 kilograms, and their mean index of body mass was 17.1 plus or minus 2.9 kilograms per metre squared. Of the children, 7.3 per cent were obese, 10.4 per cent were overweight, 75.7 per cent had normal weights, and 6.6 per cent were underweight. Resting hypertension was observed in 2.3 per cent of the children. Increased blood pressure was associated with a higher body weight, body mass index, standard deviation score for body mass index, and waist and hip circumferences (each $p < 0.001$), but not with the ratio of waist to hip. Hypertension at rest was also found in 11.0 per cent of obese children, 4.4 per cent of those who were overweight, 1.2 per cent of those with normal weight, and 1.0 per cent of underweight children ($p < 0.001$). After the intervention, the increase of the body mass index tended to be lower in those in whom we had intervened ($p = 0.069$), and in these the decrease of the standard deviation score for body mass index was significantly higher ($p = 0.028$). Systolic blood pressure was reduced by about 10 millimetres of mercury in those in whom we had intervened ($p = 0.002$), while there were no changes in the control group. Diastolic blood pressure was lowered by 3 millimetres of mercury, but this was not significant. *Conclusion:* Obese children had the highest values for systolic and diastolic blood pressure. Increased levels of blood pressure are associated with other parameters of obesity, such as the circumference of the waist and hip. Early preventive measurements in childhood are necessary, and appropriate intervention appears to be effective.

Keywords: Hypertension; prevention; waist circumference

THE PREVALENCE OF OBESITY AMONG CHILDREN and adolescents in developed and developing countries is increasing.[1–3] Various measures of obesity among adolescents and young adults are associated with fatty streaks, raised lesions, and calcifications in the aorta and coronary arteries.[4–6] The recently published study by Muntner et al.[7] demonstrated the increase of blood pressure in childhood between 1988 and 2000, which is partially attributable to increases in weight and obesity. Within the Bogalusa Heart Study, overweight children were 4.5

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Table 1. Anthropometric data of all children and gender-specific differences.

		N	Mean	Standard deviation	Range
Age (years)	Total	1677	8.2	1.3	5.4–12.0
Height (metres)		1597	1.3	0.1	1.1–1.6
Weight (kilograms)		1597	30.0	8.2	15.9–82.9
Body mass index (kilograms per metre squared)		1597	17.1	2.9	11.6–37.2
Standard deviation score for body mass index		1597	0.3	1.1	−3.7–3.8

	Gender	N	Mean	Standard deviation	p-value
Age (years)	Boys	830	8.2	1.3	Not significant
	Girls	847	8.2	1.3	
Height (metres)	Boys	787	1.3	0.1	Not significant
	Girls	810	1.3	0.1	
Weight (kilograms)	Boys	787	30.3	8.5	Not significant
	Girls	810	29.7	7.9	
Body mass index (kilograms per metre squared)	Boys	787	17.2	3.0	Not significant
	Girls	810	17.1	2.8	
Standard deviation score for body mass index	Boys	787	0.3	1.1	Not significant
	Girls	810	0.3	1.1	

times more likely as normal or underweight children to have an elevated systolic blood pressure, and 2.4 times more likely to have an elevated diastolic blood pressure.[8] Within the special sample of 520 obese children in the Murnauer comorbidity study, one-third were found to have a premetabolic syndrome, including hypertension.[9] Overweight children are also at increased risk for various chronic diseases later in life.[10] Childhood blood pressure, and increase in body mass index, were consistently the two most powerful predictors of adult blood pressure across all ages and both genders.[11,12]

Although these risk factors are present in children, it is controversial whether these conditions should be treated, or even evaluated, in "normal" school children. Up to now, we do not know the best way to intervene in these settings.[13,14] German data related to the different parameters of obesity and blood pressure are scarce, as is data for the effect of an intervention. We examined, therefore, the effect of a school- and family-based intervention consisting of extra lessons, healthy nutrition, and physical education for overweight and obese children in school grades 1 through 4, the so-called StEP TWO programme, on the anthropometric data, parameters for obesity, and blood pressure. In this paper, we present the baseline and final data on the correlation between systolic and diastolic blood pressure and different parameters for obesity, such as body mass index, bioelectric impedance, the standard deviation score for body mass index, circumferences at the waist and hip, and the ratio of the waist to the hip.

Methods

Setting and sample

In September 2003, 7 similar primary schools were randomly selected from the schools in the region of Cologne, Germany. We chose three schools to participate in a prospective programme of intervention, the StEP TWO programme, for prevention of obesity. Four schools served as controls. The examinations started at the beginning of the school year, and were repeated in June and July of 2004. This paper presents the baseline data from all seven schools, and the data relating to those undergoing the programme of intervention relative to their controls.

The study was approved by the institutional review board of the German Sport University. Informed consent was obtained from the parents or guardians of all the children. The anthropometric baseline data are shown in Table 1. Data for those undergoing intervention and their controls, before and after the programme of intervention, are shown in Table 2.

Response

Of children in the targeted schools, 95.4 per cent took part in the first examination, 0.9 per cent were not allowed to take part, and 3.8 per cent were not at school on the day of the examination. Of these, 88.2 per cent took part in both examinations, 3.9 per cent changed to another school or moved house, 5.6 per cent were ill at either the initial or the final examination,

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Table 2. Anthropometric data of the intervention and control group before and after the intervention.

		N	Mean	Standard deviation	p-value
Baseline data					
Age (years)	Intervention group	40	8.70	1.26	Not significant
	Control group	155	8.47	1.27	
Height (metres)	Intervention group	40	1.37	0.10	Not significant
	Control group	155	1.36	0.10	
Weight (kilograms)	Intervention group	40	43.58	10.21	Not significant
	Control group	155	40.84	9.62	
Body mass index (kilograms per metre squared)	Intervention group	40	22.81	3.60	0.042
	Control group	155	21.77	2.66	
Standard deviation score for body mass index	Intervention group	40	1.99	0.52	Not significant
	Control group	144	1.87	0.41	
Final examination					
Age (years)	Intervention group	40	9.48	1.26	Not significant
	Control group	145	9.16	1.25	
Height (metres)	Intervention group	40	1.42	0.10	Not significant
	Control group	145	1.40	0.09	
Weight (kilograms)	Intervention group	40	46.90	11.44	Not significant
	Control group	144	44.66	10.72	
Body mass index (kilograms per metre squared)	Intervention group	40	23.08	4.09	Not significant
	Control group	144	22.40	3.07	
Standard deviation score for body mass index	Intervention group	40	1.83	0.59	Not significant
	Control group	144	1.82	0.47	

1.7 per cent were not allowed to take part, and 0.6 per cent were lost to follow-up for unknown reasons. We invited 121 children from the 3 schools selected to take part in intervention, and of these, 40 of them completed the programme of intervention from November 2003 till July 2004. In addition, 6 dropped out, 1 because of a change in school, and 5 for personal reasons. We selected 155 overweight and obese children from the 4 control schools as controls. Of these children, 145 (93.5 per cent) took part in both examinations.

Assessment of data

The children were examined by the same trained group of examiners at the participating schools between September and October 2003 for the initial examination, and again between June and July 2004 at the final examination.

Anthropometric data

We measured height and weight, deducting 500 grams for the clothes that the children wore. Body mass index was calculated as weight related to height in square metres. The body mass index was classified according to the German percentile graphs of Kromeyer-Hauschild et al.[15] Children with a body mass index smaller than the 10th centile were classified as underweight, between the 10th to 90th centiles as normal, between the 90th and 97th centiles as overweight, and over the 97th centile as obese. The standard deviation score for body mass index was calculated by the formula of Kromeyer-Hauschild et al.[15]

Bioelectric impedance analyses

Body composition was measured by bioelectric impedance analyses with a body fat scale (SHG KFW 181; SHG, Seefeld, Germany) in the standing position with bare feet.

Waist and ratio of waist to hip

Circumferences of the waist and hip were measured on bare skin in a standing relaxed position. Circumference of the waist was measured at the midpoint between iliac crest and lowest rib in centimetres. Circumference of the hip was measured at the widest area in centimetres. From these values, we calculated the ratio of waist to hip.

Heart rate and blood pressure

With the child sitting, heart rate, systolic and diastolic blood pressure in the left arm were measured by trained observers with an Omron sphygmomanometer after five minutes of sitting. The size of the cuff was adjusted to the circumference of the arm, as recommended by Rascher.[16] Elevated systolic and diastolic blood pressures were defined according to the data of Rascher.[16] School-aged children from 6 to 11 years old with blood pressure higher than 135 millimetres of mercury systolic, and 80 millimetres of mercury diastolic, were classified as hypertensive.[16–18]

Intervention

Intervention is part of the trial project for the health of children. Step one consists of health education and physical activity taught by regular teachers during the normal school day.[19,20] The so-called StEP TWO programme is the intervention designed for overweight and obese children. This programme was taught in the three schools selected for intervention by nutritionists, gymnasts, psychologists and medical doctors. The specialists cooked and ate with the children twice a week, using a diet based on the OPTIMIX pyramidal programme for nutrition for children.[21] After the meal, the children undertook a programme of physical activity lasting for between 60 and 90 minutes. Examples for lunch are raw fruits, vegetables, wholemeal products, and vegetarian food like the vegetarian hamburger and so on. Examples for the activity used are aerobic dance, endless relay, and games like soccer, and so on. The educational contents included information about selecting healthy foods, and the importance of getting regular physical exercise.

Parents were involved in events relating to overweight and obesity in childhood, for 1 evening, the importance of physical activity for 1 evening, healthy nutrition for 2 evenings, and psychosocial aspects of a healthy lifestyle, also for 2 evenings. Two family events were organised where they learned and practised inline skating together. Children chosen as controls did not receive any intervention, and only had their regular school programme.

Statistical analysis

The descriptive statistics of the anthropometric data and results of blood pressure measurement are provided in the Tables. We used analysis of covariance for comparing the differences in individual characteristics, such as systolic blood pressure in the classifications of body mass index, or differences in blood pressure between those undergoing intervention and their controls, adjusting for gender and age. Partial correlation was calculated by Pearson's method, adjusted for age and gender. The effect between categories, such as classification of body mass index and levels of hypertension, was analysed by means of the chi-square-test. Repeated measurement was used to analyse the differences in the variables before and after the intervention, adjusted for age and gender. P-values less than 0.05 were considered statistically significant. All analyses were performed using the Statistical Package of Social Science 11.0 (Chicago, Illinois).

Results

Anthropometric data and parameters of obesity

The anthropometric data are shown in Table 1. There were no significant differences between girls and boys. Of all children, 7.3 per cent were obese, 10.4 per cent overweight, 75.7 per cent of normal weight, and 6.6 per cent underweight. At both tests, there were no differences in the prevalence of overweight or obese children between those undergoing intervention and their controls (each $p > 0.05$).

The diameter of the waist, ratio of waist to hip, systolic and diastolic blood pressures, and heart rates for the total group and gender-related values are shown in Table 3. Table 4 shows all these parameters according to the classification of body mass index of Kromeyer-Hauschild et al.[15] All values are described after adjustment for gender and age.

Body weight showed a high correlation with the result of the bioelectric analyses ($r = 0.770$; $p < 0.001$), and waist circumference ($r = 0.857$; $p < 0.001$), and low correlation with the ratio of waist to hip ($r = 0.180$; $p = 0.001$), adjusted for gender and age. No correlation was found between body weight and heart rate.

Body mass index showed a high correlation with the result of the bioelectric analyses ($r = 0.839$; $p < 0.001$), waist circumference ($r = 0.861$; $p < 0.001$) and low correlation with the ratio of waist to hip ($r = 0.251$; $p < 0.001$), adjusted for gender and age. No correlation was found between body mass index and heart rate.

Blood pressure

In 2.3 per cent of the whole population, hypertensive values were found for systolic and diastolic blood pressures. Related to the classifications of body mass index, 11.0 per cent of obese children, 4.4 per cent of the overweight children, 1.2 per cent of the children of normal weight, and 1.0 per cent of the underweight children were hypertensive ($p < 0.001$, Fig. 1). Differences in parameters for obesity between hypertensive and normotensive children are shown in Table 5.

Interventional data

Before the intervention, all the children were of comparable age, weight, and height and had comparable standard deviation scores for body mass index. Body mass index was higher for those chosen for intervention ($p = 0.042$). After the intervention, there were no differences in any of these parameters between the two groups (Table 2). The increase in body mass index tended to be lower in those undergoing intervention ($p = 0.069$), and the decrease in the

Table 3. Anthropometric data, obesity parameters, blood pressure and heart rate of the total group and gender-specific.

		N	Mean	Standard deviation	Range
Bioelectric impedance analyses (percent)	Total	1529	21.7	6.4	7.5–48.5
Waist (centimetres)		1593	58.9	7.6	43–109
Waist to hip ratio		1593	0.8	0.1	0.7–1.1
Systolic blood pressure (millimetres of mercury)		1506	112.8	13.8	47–200
Diastolic blood pressure (millimetres of mercury)		1505	66.6	11.2	32–123
Heart rate (beats per minute)		1503	87.9	14.2	33–156

	Gender	N	Mean	Standard deviation	p-value
Bioelectric impedance analyses (percent)	Boys	772	21.9	6.1	Not significant
	Girls	757	21.4	6.8	
Waist	Boys	782	59.4	7.9	0.008
	Girls	811	58.4	7.3	
Waist to hip ratio	Boys	782	0.9	0.1	<0.001
	Girls	811	0.8	0.1	
Systolic blood pressure (millimetres of mercury)	Boys	736	113.5	13.2	0.043
	Girls	770	112.1	14.3	
Diastolic blood pressure (millimetres of mercury)	Boys	736	66.1	11.1	Not significant
	Girls	769	67.1	11.4	

Table 4. Bioelectric impedance analysis, waist, waist to hip ratio and blood pressure.

		N	Mean	Standard deviation	p-value
Bioelectric impedance analyses (percent)	Obesity	108	34.5	6.3	<0.001
	Overweight	162	28.1	4.9	
	Normal weight	1160	20.2	4.4	
	Underweight	94	14.6	3.4	
Waist (centimetres)	Obesity	116	74.2	9.9	<0.001
	Overweight	167	66.3	5.9	
	Normal weight	1200	57.0	4.7	
	Underweight	104	51.9	4.0	
Waist to hip ratio	Obesity	116	0.9	0.1	<0.001
	Overweight	167	0.9	0.1	
	Normal weight	1200	0.8	0.0	
	Underweight	104	0.8	0.1	
Systolic blood pressure (millimetres of mercury)	Obesity	109	121.5	13.8	<0.001
	Overweight	158	118.3	14.6	
	Normal weight	1134	111.7	13.0	
	Underweight	99	106.6	15.3	
Diastolic blood pressure (millimetres of mercury)	Obesity	109	75.8	10.1	<0.001
	Overweight	158	71.8	10.8	
	Normal weight	1133	65.3	10.8	
	Underweight	99	63.6	10.9	

standard deviation score was three times higher ($p = 0.028$, see Table 6).

The data of the parameters for obesity, and the values of blood pressure, before and after intervention are listed in Table 7, the differences in Table 6. Waist circumference ($p = 0.039$) and systolic blood pressure (0.001), were significantly higher in those undergoing intervention at the baseline measurement, diastolic blood pressure tended to be higher ($p = 0.070$). After the intervention, the waist circumference remained higher ($p = 0.047$), but the increase with time was lower. There were no significant differences in any of the other parameters. The change in systolic and diastolic blood pressures is shown in Figure 2.

Discussion

The prevalence of overweight and obesity among children has increased dramatically worldwide. In Germany, up to one-fifth of children are overweight

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or obese.[21] These children are more likely to have medical risks associated with cardiovascular disease.[8] Current data linking blood pressure to obesity, nonetheless, is sparse.[9] With this in mind, therefore, we examined this correlation in primary school children to obtain baseline data, and thereafter to assess

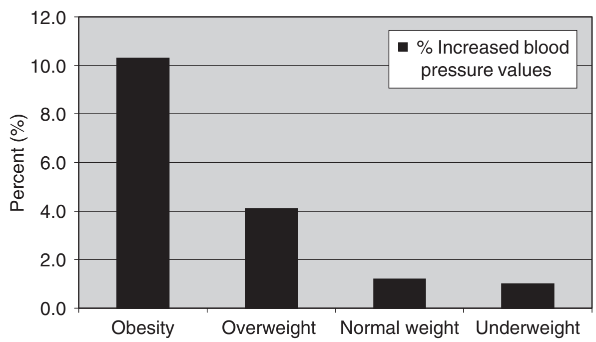

Figure 1.
Percentage of hypertensive children in the age- and gender-related classification for body mass index; within the group of obese children the percentage reaches the highest number ($p < 0.001$).

the effect of a school- and family-based intervention on different parameters for obesity along with blood pressure. In our sample, obese children had significantly higher values for blood pressure than their overweight, normal weight, and underweight counterparts. They were nearly 10 times as likely to have elevated systolic and diastolic blood pressures as those children of normal weight, and more than 2.5 times as overweight children. This is in accordance with the findings of the Bogalusa Heart Study,[8] and the Essen prospective blood pressure study.[22] Hypertensive children weighed about 9 kilograms more, and the circumferences of their waists and hips were respectively 8 and 9 centimetres above the circumferences of the normotensive children. Similar results have been recorded in earlier studies. In 504 Bahrani schoolchildren aged from 12 to 17, Al-Sendi et al.[23] found a correlation between blood pressure, body mass index, waist circumference and waist to hip ratio. In 10,215 school children aged from 5 to 14, body mass index showed a positive correlation with blood pressure, but not the ratio of waist to hip.[24] A higher body fat content is more

Table 5. Increased blood pressure and different obesity parameters, adjusted for age and gender.

	Blood pressure	N	Mean	Standard deviation	p-value
Body weight (kilograms)	Increased	34	39.2	13.9	<0.001
	Normal	1466	30.0	8.0	
Body mass index (kilograms per metre	Increased	34	20.9	5.6	<0.001
squared)	Normal	1466	17.1	2.8	
Standard deviation	Increased	34	1.2	1.4	<0.001
Score for body mass index	Normal	1466	0.3	1.0	
Waist (centimetres)	Increased	34	67.1	12.0	<0.001
	Normal	1466	58.8	7.4	
Hip (centimetres)	Increased	34	79.1	12.6	<0.001
	Normal	1466	70.4	7.8	
Waist to hip ratio	Increased	34	0.8	0.0	Not significant
	Normal	1466	0.8	0.1	
Bioelectric impedance analyses (percent)	Increased	31	25.8	9.0	0.001
	Normal	1410	21.6	6.4	

Table 6. Differences between the obesity parameters before and after the intervention between the intervention and control schools, adjusted for age and gender.

		Mean	Standard deviation	p-value
Difference body mass index	Intervention group	0.27	0.19	0.069
	Control group	0.66	0.10	
Difference body mass index-standard	Intervention group	−0.15	0.04	0.028
deviation score	Control group	−0.05	0.02	
Difference waist	Intervention group	3.11	0.84	Not significant
	Control group	4.56	0.44	
Difference systolic blood pressure	Intervention group	−10.17	3.09	0.002
	Control group	0.53	1.51	
Difference diastolic blood pressure	Intervention group	−2.83	2.48	Not significant
	Control group	0.73	1.26	

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likely to be associated with a higher blood pressure in childhood. In addition, an increased circumference at the waist, expressing a higher abdominal fat distribution, is linked with elevated blood pressure. The ratio of waist to hip plays no important role in prepubertal children,[25] and this index is of questionable validity in the assessment of the distribution of fat in prepubertal children.[26,27]

A potential limitation of this study is that single measurements of blood pressure are less reliable than repeated checks or measurements made by 24-hour ambulatory monitoring,[28,29] which were not available in our study. More precise measurements would allow for more precise estimates of risk. The examination of additional metabolic parameters, such as lipids, glucose and insulin, may allow a better assessment of atherogenic risk.

After 9 months of intervention, the reduction in the standard deviation score for body mass index was higher in those undergoing intervention than in their controls. The increase in the body mass index tended to be lower in those undergoing intervention, although these children started at a higher value. There was a significant reduction of systolic blood pressure after intervention, and a lesser reduction of diastolic pressure. This could be attributed to the increase in regularly exercise, which is known to reduce blood pressure.[30]

Data concerning the effect of a school-based intervention on cardiovascular risk factors, especially body mass index and blood pressure, are inconsistent. A recently published Cochrane review concluded that there was limited high quality data on the effectiveness of programmes designed to prevent obesity.[13] Concerning blood pressure, Harrell et al.[14] detected a trend for systolic blood pressure to increase less after a school-based intervention for eight weeks in 3rd and 4th grade children with multiple risk factors for cardiovascular disease. No significant differences were found related to diastolic blood pressure. In the Odense schoolchild study,[31] systolic and diastolic blood pressure were lowered after 8 months of extra lessons in physical education in a group of hypertensive and normotensive children aged from 9 to 11 years. In contrast to these studies, the Child and Adolescent Trial for Cardiovascular Heath[32] demonstrated no

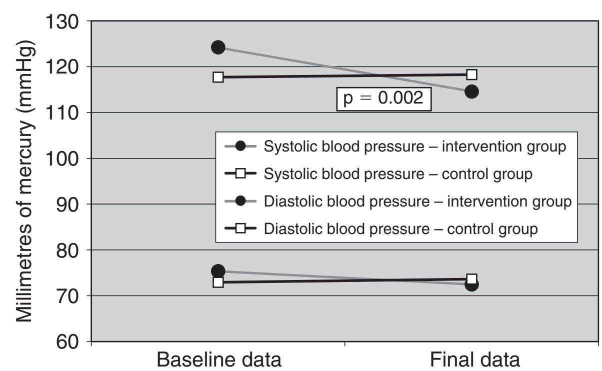

Figure 2.
Changes of systolic and diastolic blood pressure in the children undergoing intervention as compared to their controls.

Table 7. Obesity parameters of the intervention versus control group before and after the intervention, adjusted for age and gender.

		N	Mean	Standard deviation	p-value
Baseline data					
Bioelectric impedance analyses	Intervention group	36	32.37	6.01	Not significant
	Control group	150	30.91	6.25	
Waist (centimetres)	Intervention group	40	72.54	9.14	0.039
	Control group	155	69.53	7.91	
Waist to hip ratio	Intervention group	40	0.88	0.06	Not significant
	Control group	155	0.86	0.06	
Systolic blood pressure (millimetres of mercury)	Intervention group	35	125.74	14.59	0.001
	Control group	151	117.05	13.94	
Diastolic blood pressure (millimetres of mercury)	Intervention group	35	76.40	11.27	0.070
	Control group	151	72.56	11.24	
Final examination					
Bioelectric impedance analyses (percent)	Intervention group	38	33.77	7.01	Not significant
	Control group	141	32.21	6.66	
Waist (centimetres)	Intervention group	40	75.33	10.50	0.047
	Control group	145	73.80	8.65	
Waist to hip ratio	Intervention group	40	0.89	0.08	Not significant
	Control group	145	0.87	0.05	
Systolic blood pressure (millimetres of mercury)	Intervention group	40	114.55	12.25	Not significant
	Control group	145	117.67	12.15	
Diastolic blood pressure (millimetres of mercury)	Intervention group	40	72.13	10.61	Not significant
	Control group	145	73.54	10.00	

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differences in blood pressure between those undergoing intervention and their controls after two years of a school-based programme.

In summary, our data demonstrates the necessity of screening examinations and appropriate intervention. There are, however, many research challenges for all professional bodies in contributing to the knowledge base for promoting healthy nutrition and physical activity among children and their families.

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