



Hypertension among obese children and youth age 8–12: project EDDY-Kids 2019

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ABSTRACT

Hypertension in children and adolescents has increased over the years and is considered as a major public health issue. The correlation between obesity and hypertension is well established; data show the persistence of elevated blood pressure in children and adolescence into adulthood, which leads to cardiovascular diseases. In the EDDY-Kids 2019 prevention programme, we measured the blood pressure of 123 school children (ages 8–12) over the period of 6 months, starting in January, additionally giving weekly nutrition lessons and sports activities to evaluate the influence of a nutrition-, sports-, and lifestyle intervention on the children's body composition, weight, and blood pressure.

At all stages of the project, the number of children with elevated pressure was lower in the normal and below-normal cohorts compared to the overweight and obese group. This demonstrates a positive correlation between obesity and hypertension. In both groups, blood pressure values dropped over the time period of the programme. This could be the result of the intervention programme or the children adapting to the unusual situation. A lot of children were nervous or haven't even experienced a blood pressure measurement before. The results clearly underline the necessity of measuring children's blood pressure on a regular basis (annually or semi-annually) to allow nurses and doctors to facilitate the earliest possible diagnosis of elevated blood pressure in children, thereby helping to prevent a persistence of hypertension into adult age.

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Background

Repeated measurements of blood pressure among children show a correlation of blood pressure in childhood with blood pressure and a propensity for metabolic syndrome in the adult years (Sun et al. 2007; Chen and Wang 2008; Theodore et al. 2015; Weaver). Children with

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elevated blood pressure already showed vascular changes and damages, signs of accelerated vascular aging, atherosclerosis, and enlargement of the left ventricle, indicating predictors of cardiovascular events among adults (Tracy 1995; Urbina et al. 2011). Furthermore, there is a clear correlation between obesity and hypertension (Antza et al. 2017), which adds to the other cardiovascular risk factors and may lead to early cardiovascular diseases (Ajala et al. 2017). Studies from the US report an increase in the prevalence of hypertension among children over the last few years (Din-Dzietham et al. 2007). Prevalence is at about 1,4% among healthy children and youth of normal weight, but at 7% among overweight and at 25% among obese subjects (Bald and Wühl 2019). This underlines the need to diagnose and possibly treat elevated blood pressure as early as possible. Appropriate measures should be included in prevention programmes. This intervention study aims to detect children with elevated blood pressure and to evaluate the influence of a nutrition-, sports-, and lifestyle intervention on the children's body composition, weight, and blood pressure. Furthermore, this paper only aims to point out the prevalence of children with elevated blood pressure in a randomly selected school and to detect the number of children who are overweight/obese and have elevated blood pressure. Further statistical analysis will be reported elsewhere.

Intervention

At the beginning of the study, anthropometric data (height, weight, body mass index) were measured, as well as body composition with bioelectric impedance analysis and blood pressure. At the beginning of the study, the children participated in the “Deutscher Motorik Test – DMT”, to measure physical fitness and activity, guarded and organized by students of the sports university of Vienna.

Beginning from January, weekly nutrition lessons (once a week) were given by students of the medical university of Vienna. The children got to know the importance of nutrients (vitamins, minerals, proteins, carbohydrates, etc.) from healthy food like fruits and vegetables. They were able to make healthy snacks on their own. In addition, the children got to do weekly exercises (twice a week), guarded by students from the sports university of Vienna. In the middle of the project (march), blood pressure values were measured. At the end of the project, anthropometric data had been measured again, as well as blood pressure.

The inclusion criteria of the EDDY-Kids intervention program and hence for the nutrition lessons are, on the one hand, that all children (including the parents) signed and accepted letters of agreement, and on the other hand, that they wanted their blood pressure measured. Criteria for exclusion were

a lack of consent, and when a student wasn't present at the day of measurement.

In the control group, only anthropometric data and blood pressure values were measured, without conducting any nutrition or sports lessons. The intervention program received lessons, anthropometric data, and blood pressure values were collected as well.

Children of the third grade (three classes) were in the control group, and children of the fourth grade (three classes) were in the intervention group. This led to a difference in age (1-year difference) between the two groups. Due to limitations, the choice of these groups had been necessary: a few schools were available where we could conduct the intervention program, and too few children were in one class to match them among each other.

Blood pressure measurement

In the course of the pursued Viennese EDDY-Kids Project 2019 (Widhalm et al. 2018) we took one measurement at the beginning of the study in January (t_0 , baseline) and followed up in 2-month intervals (t_1 , t_2), finishing in June. To receive more reliable blood pressure values and to oversee progress in those values, there were taken three measurements over the period of the project (Negroni-Balasquide et al. 2016). The sample included a control group in third grade (age ~9, 58 children, 33 boys and 25 girls) and an intervention group in fourth grade (age ~10, 65 children, 37 boys and 28 girls). Blood pressure was measured using auscultation according to international guidelines (Flynn et al. 2017), using a stethoscope with a blood pressure monitor (sphygmomanometer). A cuff of appropriate size was attached to the upper arm and inflated up to the expected arterial blood pressure. During the subsequent slow deflation, the manifestation and disappearance of Korotkoff sounds can be detected via the stethoscope at the brachial artery. The systolic pressure corresponds to the value indicated at the first appearance of Korotkoff sounds: at that moment, systolic pressure exceeds cuff pressure. Conversely, the Korotkoff sounds disappear when cuff pressure falls below arterial pressure, indicating a diastolic value.

Arterial hypertension is defined as the enduring elevation of blood pressure above a certain threshold. For adult patients, these thresholds for systolic and diastolic blood pressure have been determined in studies in relation to cardiovascular risk. However, such data are largely lacking for children. The Fourth report by the US National Institute of Health proposed standardised blood pressures based on observations of 50000 healthy subjects aged 0–18 (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004). Based thereon, the American Academy of Pediatrics made revised recommendations for systolic and diastolic values based on age, gender and height

Table 1. Updated definitions of blood pressure categories and stages (Flynn et al. 2017).

For children aged 1-<13 years:	For children aged ≥13 years:
<i>Normal BP:</i> <90. percentile	<i>Normal BP:</i> 120/<80 mmHg
<i>Elevated BP:</i> ≥90. to <95. percentile or 120/80 mmHg to <95. percentile (whichever is lower)	<i>Elevated BP:</i> 120/<80 to 129/<80 mmHg
<i>Stage 1 hypertension:</i> ≥95. to <95 percentile + 12 mmHg, or 130/80 to 139/89 mmHg (whichever is lower)	<i>Stage 1 hypertension:</i> 130/80 to 139/89 mmHg
<i>Stage 2 hypertension:</i> ≥95. percentile +12 mmHg, or ≥140/90 mmHg (whichever is lower)	<i>Stage 2 hypertension:</i> ≥140/90 mmHg

percentiles (Flynn et al. 2017). Among children, the 50th percentile indicates normal blood pressure, while values in the 90th percentile and above are considered “elevated”, Stage 1 and Stage 2 hypertension. Table 1 (Table 1) shows the categorisation.

In our measuring process, we took one repeat measurement after 30 seconds whenever children exhibited elevated pressure, and we averaged the results.

Results

The following results show the systolic blood pressure values. In the control group, 19 children (13 boys, 6 girls) exhibited blood pressure in the 90th percentile and above in at least one measurement. In the intervention group, 20 children (15 boys, 5 girls) had elevated blood pressure in at least one measurement.

Table 2 (Table 2) shows the following results:

Table 3 (Table 3) shows the following results: At the beginning of the project, 6 children (4 boys, 2 girls) were classified as below-normal weight (4,9%), 3 in the control group (2 boys, 1 girl), 3 in the intervention group (2 boys, 1 girl). Seventy-nine children (37 boys, 42 girls) were classified as normal weight (64,2%), 40 children in the control group (20 boys, 20 girls) and 39 in the intervention group (17 boys, 22 girls). Fourteen children (10 boys, 4 girls) were classified as overweight (11,4%), 5 in the control group (4 boys, 1 girl), 9 in the intervention group (6 boys, 3 girls). Twenty-four

Table 2. Number of subjects with elevated blood pressure at t_0 , t_1 , and t_2 (number and percentage of experimental group).

	1st meas. >90. %ile (January 2019, t_0)	2nd meas. >90. %ile (March 2019, t_1)	3rd meas. >90. %ile (May/June 2019, t_2)
Control group (58)(33 boys, 25 girls)	17 (29,3%)(13 boys, 4 girls)	6 (10,3%)(4 boys, 2 girls)	5 (8,6%)(3 boys, 2 girl)
Intervention group (65) (37 boys, 28 girls)	17 (26,1%)(15 boys, 2 girls)	11 (16,9%)(8 boys, 3 girls)	10 (15,4%)(8 boys, 2 girls)
Total group (123)(70 boys, 53 girls)	34 (27,6%)(28 boys, 6 girls)	17 (13,8%)(12 boys, 5 girls)	15 (12,2%)(11 boys, 4 girls)

Table 3. Subjects categorised by weight categories and groups for t_0 and t_2 (number and percentage of total).

	Below-normal weight children	Normal weight children	Overweight children	Obese children
Control group (58)(33 boys, 25 girls)at t_0	3 (2,4%)(2 boys, 1 girl)	40 (32,5%)(20 boys, 20 girls)	5 (4,1%)(4 boys, 1 girl)	10 (8,1%)(7 boys, 3 girls)
Intervention group (65)(37 boys, 28 girls)at t_0	3 (2,4%)(2 boys, 1 girl)	39 (31,7%)(17 boys, 22 girls)	9 (7,3%)(6 boys, 3 girls)	14 (3,3%)(12 boys, 2 girls)
Total group (123)(70 boys, 53 girls)at t_0	6 (4,9%)(4 boys, 2 girls)	79 (64,2%)(37 boys, 42 girls)	14 (11,4%)(10 boys, 4 girls)	24 (19,5%)(19 boys, 5 girls)
Control group (58)(33 boys, 25 girls)at t_2	3 (2,4%)(2 boys, 1 girl)	37 (30,1%)(18 boys, 19 girls)	7 (5,7%)(5 boys, 2 girls)	10 (8,1%)(7 boys, 3 girls)
Intervention group (65)(37 boys, 28 girls)at t_2	4 (3,3%)(3 boys, 1 girl)	37 (30,1%)(14 boys, 23 girls)	14 (3,3%)(11 boys, 3 girls)	11 (8,9%)(9 boys, 2 girls)
Total group (123)(70 boys, 53 girls)at t_2	7 (5,7%)(5 boys, 2 girls)	74 (60,2%)(32 boys, 42 girls)	21 (17,2%)(16 boys, 5 girls)	21 (17,2%)(16 boys, 5 girls)

children (19 boys, 5 girls) were classified as obese (19,5%), 10 in the control group (7 boys, 3 girls) and 14 in the intervention group (12 boys, 2 girls).

At the end of the project, 7 children (5 boys, 2 girls) were classified as below-normal weight (5,7%), 3 in the control group (2 boys, 1 girl), 4 in the intervention group (3 boys, 1 girl). Seventy-four children (32 boys, 42 girls) were classified as normal weight (60,2%), 37 children in the control group (18 boys, 19 girls) and 37 in the intervention group (14 boys, 23 girls). Twenty-one children (16 boys, 5 girls) were classified as overweight (17,2%), 7 in the control group (5 boys, 2 girls), 14 in the intervention group (11 boys, 3 girls). Twenty-one children (16 boys, 5 girls) were classified as obese (17,2%), 10 in the control group (7 boys, 3 girls) and 11 in the intervention group (9 boys, 2 girls).

There are zero children with elevated blood pressure at t_0 and t_2 .

Table 4 (Table 4) shows the number of subjects with elevated blood pressure in the normal-weight group. At the beginning of the project, 7 children (5 boys, 2 girls) had elevated blood pressure in the control group, 3 children (2 boys, 1 girl) in the intervention group. Ten children (7 boys, 3 girls) had elevated blood pressure in total. At the end of the project, 1 child (1

Table 4. Number of normal-weight subjects with blood pressure >90. %ile at t_0 and t_2 (number and percentage of weight group).

	t_0	t_2
Control group (t_0 : 40; t_2 : 37)	7 (17,5%)(5 boys, 2 girls)	1 (2,7%)(1 boy)
Intervention group (t_0 : 39; t_2 : 37)	3 (7,7%)(2 boys, 1 girl)	2 (5,4%)(1 boy, 1 girl)
Total (t_0: 79; t_2: 74)	10 (12,7%)(7 boys, 3 girls)	3 (4,1%)(2 boys, 1 girl)

Table 5. Number of overweight subjects with blood pressure >90. %ile at t_0 and t_2 (number and percentage of weight group).

	t_0	t_2
Control group (t_0 : 5; t_2 : 7)	4 (80%)(3 boys, 1 girl)	1 (14,3%)(1 girl)
Intervention group (t_0 : 9; t_2 : 14)	2 (22,2%)(2 boys)	3 (21,4%)(3 boys)
Total (t_0: 14; t_2: 21)	6 (42,9%)(5 boys, 1 girl)	4 (19,1%)(3 boys, 1 girl)

Table 6. Number of obese subjects with blood pressure >90. %ile at t_0 and t_2 (number and percentage of weight group).

	t_0	t_2
Control group (t_0 : 10; t_2 : 10)	6 (60%)(5 boys, 1 girl)	3 (30%)(3 boys)
Intervention group (t_0 : 14; t_2 : 11)	12 (85,7%)(11 boys, 1 girl)	5 (45,5%)(4 boys, 1 girl)
Total (t_0: 24; t_2: 21)	18 (75%)(16 boys, 2 girls)	8 (38,1%)(7 boys, 1 girl)

boy) had elevated blood pressure in the control group, 2 children (1 boy, 1 girl) in the intervention group. Three children (2 boys, 1 girl) had elevated blood pressure in total.

Table 5 (Table 5) shows the number of subjects with elevated blood pressure in the overweight group. At the beginning of the project, 4 children (3 boys, 1 girl) had elevated blood pressure in the control group, 2 children (2 boys) in the intervention group. Six children (5 boys, 1 girl) had elevated blood pressure in total. At the end of the project, 1 child (1 girl) had elevated blood pressure in the control group, 3 children (3 boys) in the intervention group. Four children (3 boys, 1 girl) had elevated blood pressure in total.

Table 6 (Table 6) shows the number of subjects with elevated blood pressure in the obese group. At the beginning of the project, 6 children (5 boys, 1 girl) had elevated blood pressure in the control group, 12 children (11 boys, 1 girl) in the intervention group. Eighteen children (16 boys, 2 girls) had elevated blood pressure in total. At the end of the project, 3 children (3 boys) had elevated blood pressure in the control group, 5 children (4 boys, 1 girl) in the intervention group. Eight children (7 boys, 1 girl) had elevated blood pressure in total.

Discussion

We have found that the prevalence of hypertension in the overweight and obese group was higher than in the underweight and normal weight group. Blood pressure values dropped in both groups over the time of the intervention. 27,6% have elevated blood pressure values at the beginning of the project (29,3% in the control group; 26,1% in the intervention group), 12,2% in the end (8,6% in the control group; 15,4% in the intervention group). There is no wide difference in the amount of children with elevated

blood pressure between the control and intervention group at the beginning and end of the study. The two comparable studies among school children came to differing results, respectively, finding 7% and 17% of children to have elevated blood pressure (Kidy et al. 2014; Hertiš et al. 2018).

Overweight and obese children showed a high percentage of those with elevated blood pressure. In the overweight group, 42,9% had elevated blood pressure at the beginning of the project in total, 19,1% at the end. 80% had elevated blood pressure in the control group at t_0 , 14,3% at t_2 ; 22,2% had elevated blood pressure at the beginning of the project in the intervention group, 21,4% at t_2 . In the obese group, 75% had elevated blood pressure at the beginning of the project in total, 38,1% at the end. 60% had elevated blood pressure in the control group at t_0 , 30% at t_2 ; 85,7% had elevated blood pressure at the beginning of the project in the intervention group, 45,5% at t_2 . This is in line with findings from other authors about the correlation of weight and blood pressure, and the connection between increasing BMI and hypertension (Mazor-Aronovitch et al. 2014; Antza et al. 2017; Martín-Espinosa et al. 2017).

At all stages of the project, the number of children with elevated pressure is lower in the normal (and below-normal) cohort than in the overweight group or obese group. Pressures dropped in both groups over the course of the project. This could be the result of either the intervention programme (nutrition, sports, lifestyle) or habituation effects in both groups; other studies have also shown a decrease in blood pressure values measured over a period of time (Marcovecchio et al. 2016). Most of the children haven't even seen a blood pressure monitor or mentioned that their paediatrician hasn't even measured their blood pressure once. Psychological stress and nervousness could also be a reason, why the blood pressure values were high. This phenomenon is also called "White Coat Hypertension" (Hanevold 2019). Although the person measuring blood pressure in this project was the same in all three measurements and didn't wear scrubs or a white coat, that could have identified him as a doctor, causing the psychological stress and nervousness in the children elevating their blood pressure, the situation itself could have put pressure on the children after all. If high blood pressure values and White Coat Hypertension depend on the specific person that measures blood pressure, which hasn't been evaluated (Batide-Alanore et al.).

The seasonality of blood pressure, the effects of temperature on blood pressure and its change through times (from January to June) should also be considered. Studies have shown the influence of temperature on blood pressure in children and adolescents; increase in blood pressure values in winter and decrease in summer has been reported (Miersch et al. 2013).

When diagnosed with hypertension, the treatment goal with nonpharmacologic and pharmacologic therapy should be a reduction in SBP and DBP to

<90th percentile (Flynn et al. 2017). These values can be reached, at first, through lifestyle changes, diet, weight loss, and physical activity. If the children remain hypertensive despite the lifestyle modification, ACE-inhibitors can be used starting with a low dose, if ineffective, the dose can be increased, or a second medication can be added (Croxtall 2012).

Given our findings, we recommend that nurses and doctors at primary schools take an annual or semi-annual measurement of blood pressure. This would facilitate the earliest possible diagnosis of elevated blood pressure in children, thereby helping to prevent a persistence of the condition into adult age.

Conclusion

From our data, we conclude that hypertension seems to be a big health issue in children and adolescents. It could be clearly shown that overweight/obese children show higher blood pressure than normal weight children. Therefore, it is recommended that measurement of blood pressure should be included in routine school health examinations.

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