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ORIGINAL ARTICLE

Effect of the DASH-diet and salt Kardisal® on blood pressure in adolescents with prehypertension
(Cooperative multicentre interventional study)

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Abstract

BACKGROUND: In a cooperative multi-center interventional study of 60 probands with prehypertension and normal BMIs were followed for 3 months.
DESIGN: The intervention included the DASH diet for 3 months in 30 probands plus sodium limited intake using the low sodium salt Kardisal® (60% NaCl, 40% KCl) (group A) and the DASH diet for 3 months in 30 probands without Kardisal® (group B).
RESULTS: In group A (n=26 probands evaluated) the systolic blood pressure (median) decreased significantly from 138 to 129 mmHg (p<0.001), while the diastolic blood pressure had a statistically non-significant decrease. In group B (n=25 probands evaluated) the SBP decreased significantly from 135 to 132 mmHg (p<0.001), and the DBP decreased significantly from 85 to 69 mmHg (p<0.001).
CONCLUSION: Despite a relatively short period on the DASH diet, the intervention produced a significant decrease in the blood pressure of prehypertensive adolescents. The additional use of a low sodium salt for home cooking was not found to have any advantages over the DASH diet alone.

INTRODUCTION

The aim of this interventional study was to determine if the DASH diet and DASH diet combined with the use of low sodium salt could influence the blood pressure (BP) of adolescents with a normal BMI and with prehypertension. Obesity is generally recognized as well known major risk factor for the development of prehypertension/hypertension. Therefore, we excluded in our study individuals with increased body mass index. Originally, the nomenclature used for blood pressure between 90th–95th percentile was "high normal blood pressure". Later, the term prehypertension replaced the original term "high normal blood pressure". Definition of prehypertension in adults

is systolic blood pressure between 120–139 mmHg and/or a diastolic BP between 80–89 mmHg. In children, prehypertension is defined as systolic and/or diastolic blood pressure exceeding ≥90th percentile but are lower than <95th percentile for age, sex, and height according percentile tables reported in the Fourth Task Report (Fourth Report 2004). Data from previous studies in adolescents recognized prehypertension as a clear risk factor for hypertension in adulthood. Prehypertension may herald already underlying cardiac and vascular changes. Adolescents with prehypertension reveal progression to hypertension approximately 7% per year. Nevertheless, the progression of prehypertension to hypertension based on blood pressure measurements at 3 separate visits was significantly lower. However, the largest risk for progression to hypertension revealed adolescents with already elevated BP/or prehypertenison at all three visits.

MATERIAL AND METHODS

A pilot field study was used to determine the BP of 500 adolescents of both sexes, aged 13–19 years. The BP was measured using an automated BP-monitor. Prehypertension was found in 60 probands with a normal body mass index (BMI <25 kg/m^2).

Criteria of probands recruitment

Age 13–19 years old, normal body weight (BMI <25 kg/m^2), prehypertension, informed consent for use of the DASH diet and use of Kardisal® and agreement to cooperate with the stated protocol. The families were provided with written instructions on how to follow the DASH diet and how to use Kardisal® in home cooking. Altogether 60 probands were included in the study. Exclusion criteria: previous use of BP altering drugs, prior use of any diet to manage BP, and no eating disorders.

Group A: 30 probands – 3 months on (DASH diet plus low sodium salt for home cooking)
Group B: 30 probands – 3 months on DASH diet only).

Study protocol

At the time the first outpatient examination visit and next 3 visits (at one month intervals) the following data were gathered: body weight (b.w.), standardized BP office measurement using *Omron*® (upper arm blood pressure monitor), urine sodium, potassium, and creatinine concentration, adherence with the DASH diet and low sodium salt use (4 sets of data were collected). Nine of original 60 probands did not meet the criteria (adherence to the DASH-diet and use of special salt resp., non-compliance at regular outpatient visits. As a result, only 51 probands completed the study.

Group A: 26 probands on the DASH-diet combined with use of low sodium salt
Group B: 25 probands on DASH-diet only

RESULTS

Group A (DASH–diet plus Kardisal®), n=26: the systolic blood pressure, SBP (median) decreased significantly during the study period (median) from 138 mmHg on the first, to 128 mmHg on the last follow-up (p<0.001). The diastolic blood pressure, DBP also decreased, from 79 mmHg to 74 mmHg, although the change was not significant (Table 1 and Figure 1)

Group B (DASH-diet only), n=25: the SBP (median) decreased significantly during the study period (median) from 135 mmHg on the first, to 132 mmHg on the last follow-up (p<0.001). The DBP showed a significant decrease from 85 on the first, to 79 mmHg on the last follow-up (p<0.001). Body weight in both groups A and B between the baseline and at the last

Tab. 1. Group A – DASH diet plus salt (60% NaCl, 40% KCl) – systolic and diastolic blood pressure.

number probands	1st examination SBP/DBP mmHg (mean)	last examination SBP mmHg (mean)	*p*-value
26	SBP 138	SBP 128	0.00052
26	DBP 78.8	DBP 73.7	n.s.

Tab. 2. Group B – DASH diet only – systolic and diastolic blood pressure.

number probands	1st examination SBP/DBP mmHg (mean)	last examination SBP mmHg (mean)	*p*-value
25	SBP 135	SBP 132	<0.001
25	DBP 85	DBP 69	<0.001

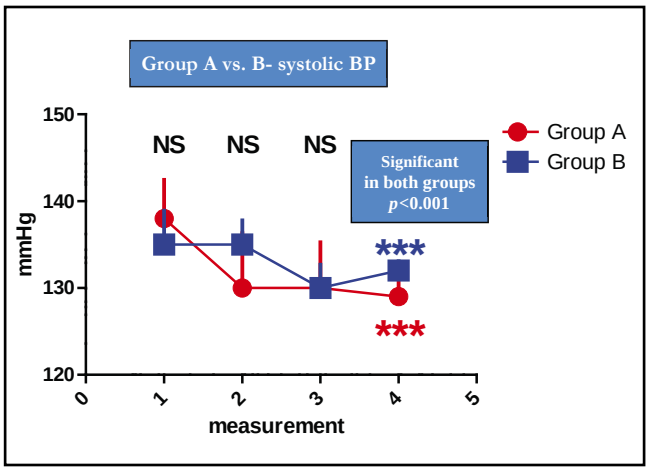

Fig. 1. 51 adolescents with prehypertension and normal BMI – 3 months intervention – on DASH-diet and DASH diet plus Kardisal resp. NS= non statistically significant, ***p<0.001

measurement after 3 months did not change significantly. Sodium and potassium urine excretion in Group A and B in fresh voided morning urine (expressed as U_{Na}:U_{cr} (1st, 2nd, 3rdand 4th sample did not revealed significant differences in A and B resp. (Table 2, Figure 2) All data collected in both grups are displayed in Table 3.

Limitations: A single, rather than multiple urine samples, were collected during the study period and some samples were missing. A comparison of blood pressures from each follow-visit was used carried out using the Friedman test, which is a nonparametric analogy of ANOVA for repeated measures. Results are presented in Table 3. The post hoc test, which was part of the Friedman test in the Medcalc program, revealed that in group A there were significant differences the median SBP for each follow-up and the other follow-up measurements (see Table 3).

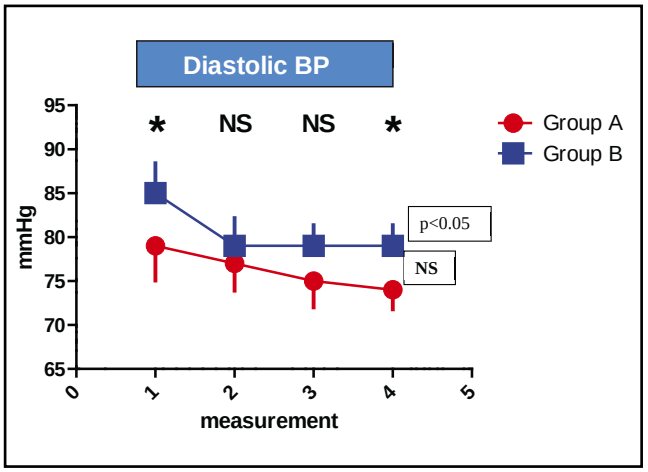

Fig. 2. DPB in 51 adolescents with prehypertension and normal BMI – 3 months intervention – on DASH-diet and DASH diet plus Kardisal resp. NS= non statistically significant, *p<0.05

DISCUSSION

Hypertension is a significant risk factor for cardiovascular morbidity/mortality. The prevalence of hypertension in the population of the Czech Republic (CZ) during the last years has approached almost 50% of men and 37% of women resp. (p<0.001). About 60% of patients diagnosed with hypertension are treated with drugs, however, only 30.9% of those patients reach target BP values of BP <140/90 mmHg (Cífková *et al.* 2011) Epidemiological field studies of BP in adolescents organized in the CZ often found prehypertension in adolescents (girls 6.5%, boys 9%). However, these individuals revealed often overweight or obesity, conditions often associated with HBP (Velemínský *et al.* 2003). Recent reports indicate that increased salt consumption may result in obesity through sugar-sweetened beverage consumption. Thus, the increased supply of salt in children/adolescents can have a dual effect – high intake of sodium presents risk of an increase of blood pressure, which is potentiated by obesity, an independent risk factor for increase of blood pressure (McGregor 2016). Salt intake (NaCl) in the Czech Republic often reaches values of 15 g/day for men, and 10 g/day for women. Data available from Czech preschool (Kindergarten) and school children are similar, with salt intakes greatly exceeding the limits recommended, based on age, by the WHO. There is increasing evidence that hypertension may begin at ages when pediatricians are still taking care of children/adolescents and this trend may be an indicator of early premature cardiovascular disease (Murgan *et al.* 2013). High salt intake can directly increase the risk of stroke, left ventricular hypertrophy, and renal disease. Increased salt intake in adolescents is often connected with high soft drink consumption and is also associated with obesity (He *et al.* 2011; 2010).

In adults, prehypertension (originally high normal BP) is defined as SBP 120–139 mmHg and DBP between 80–89 mmHg. However, in children and adolescents the use of percentile BP charts of has become routine and prehypertension is defined as a BP between the 90th–95th percentile of normal values for a healthy population according to age and body height. Some recommendations for the treatment of prehypertension suggest starting with a non-pharmacological approach. The DASH diet (Dietary Approaches to Stop Hypertension) has been shown to significantly lower BP. The DASH diet is rich in vegetables, fruits, low in fat, and rich in calcium, magnesium, and particularly, potassium. The original DASH diet did not require full control of body weight nor did it restrict daily salt intake, nevertheless, it effectively lowered blood pressure. Further study by the DASH-research group has shown that combination of the DASH diet plus limited salt intake is even more effective than dietary interventions alone (Fleet 2001).

Recently, there have been studies using even standard antihypertensive drugs in individuals with prehypertension. A meta-analysis in adults with prehypertension (70,664 probands included, randomized – on antihypertensives or without therapy) showed significant decrease in the incidence (22%) of cerebral stroke in treated patients compared with patients on placebo only (p<0.000001).

Several studies have shown that the DASH diet decreases blood pressure not only through reduced sodium intake, but also through increase potassium intake. Early diet intervention in pre-school children (increased consumption of vegetables and fruits (4 or more servings/day) or/and dairy products (2 or more servings/day) resulted in significantly lower systolic blood pressure (3 mmHg) compared to those who did not follow the diet. The effect on DBP was weaker (Moore *et al.* 2012).

It is very important to remember that even a minor decrease in BP can significantly reduce cardiovascular

Tab. 3. All data colected in Group A and Group B.

	A						B						Two-Sample Test		N_B
	Mean	95% LCL	95% UCL	Median	95% LCL	95% UCL	Mean	95% LCL	95% UCL	Median	95% LCL	95% UCL	distr	*p*-value	25
SBP1	141	136	146	138	133	146	138	134	142	135	135	142	NG	0.533	25
DBP1	79	74	84	79	71	86	85	82	89	85	80	91	G	0.032*	25
Osmol1	707	602	812	787	520	831	698	566	830	707	478	898	G	0.912	25
Na1	129.9	106.5	153.3	113	93	182	121.3	94.3	148.3	117	89	137	G	0.623	25
K1	41.1	31.0	51.1	35	27	48	38.8	27.8	49.8	31	22	41	NG	0.604	25
Creat1	10.53	8.27	12.79	10	8	12	15.48	9.02	21.94	14	8	18	NG	0.266	25
SBP2	132	126	137	130	123	142	135	131	139	135	130	140	G	0.310	25
DBP2	77	74	81	79	75	82	79	75	83	80	74	85	G	0.536	25
Osmol2	693	576	810	801	428	903	717	608	828	724	516	845	G	0.060	15
Na2	129.6	105.2	154.0	126	84	180	105.7	86.2	125.3	110	55	135	G	0.717	23
K2	43.9	28.7	59.2	27.2	17.7	54.4	39.5	30.5	48.4	34	28	44	NG	0.417	23
Creat2	9.42	7.06	11.79	8.41	5.98	11.28	11.74	9.12	14.36	11	7	14	G	0.113	23
SBP3	130	124	136	130	122	140	130	128	133	130	130	135	G	0.966	25
DBP3	75	71	79	75	70	79	79	76	82	80	78	80	G	0.074	25
Osmol3	723	638	807	769	584	872	696	567	827	682	511	889	NG	0.717	15
Na3	154.5	120.1	189.0	132	109	194	119.8	97.7	141.8	122	89	138	NG	0.210	20
K3	42.4	34.4	50.4	39	26	54	47.0	34.3	59.6	41	30	54	NG	0.690	20
Creat3	9.34	7.62	11.06	8.83	6.96	11.12	11.30	8.29	14.31	9.5	8	14	NG	0.181	20
SBP4	127	122	132	129	122	133	131	124	133	132	127	134	G	0.977	25
DBP4	74	70	77	73	70	78	79	76	82	79	77	82	G	0.013*	25
Osmol4	713	626	800	702	590	852	701	600	802	688	516	898	G	0.826	15
Na4	138.2	110.3	166.2	124	92	175	113.1	95.8	130.4	127	88	139	G	0.121	23
K4	38.3	26.5	50.0	30	22	44	44.6	35.4	53.8	40	31	57	NG	0.061	23
Creat4	12.48	10.31	14.64	12.2	8.8	16.5	13.65	10.35	16.95	12	8	18	NG	0.688	23
U_{Na}1:Creat1	16.22	12.70	19.74	13.8	11.2	18.18	11.05	8.75	13.36	10.75	7.00	13.56	NG	0.098	25
U_{Na}2:Creat2	20.46	14.40	26.52	13.8	11.7	24.75	13.00	6.65	19.35	8.67	5.96	11.18	NG	0.004*	23
U_{Na}3:Creat3	20.55	16.02	25.08	17.14	12.58	23.25	13.06	9.45	16.68	11.33	8.57	15.50	NG	0.012*	20
U_{Na}4:Creat4	13.67	9.69	17.64	11.14	8.19	13.63	10.45	7.53	13.36	8.93	6.95	11.91	NG	0.127	23
U_K1:Creat1	4.81	3.55	6.07	4.00	2.35	5.29	3.96	2.52	5.40	3.00	2.11	3.73	NG	0.187	25
U_K2:Creat2	6.26	4.20	8.31	3.20	2.43	8.75	4.22	2.89	5.56	3.50	2.14	4.61	NG	0.307	23
U_K3:Creat3	6.17	4.11	8.22	4.14	2.84	5.90	4.96	3.44	6.47	4.07	2.75	5.71	NG	0.499	20
U_K4:Creat4	3.70	2.37	5.03	2.86	1.75	3.58	4.54	2.75	6.33	2.86	2.00	4.45	NG	0.489	23

SBP – systolic BP, DBP – diastolic BP, Osmol – osmolarity, Na – sodium concentration, K – potassium concentration, Creat – creatinine concentration; 1 – values at the first examination, 2 – values after one month 3 – after 2 months, 4 – after 3 months. G means that data were from Gaussian distribution and Two sample t-test was used, NG means that null hypothesis about the data normality was rejected and Mann-Whitney U test was used. * shows that the difference were statistically significant at $\alpha \leq 0.05$.

complications and cerebral strokes. Despite this well-known fact, as well as the established link between salt and HBP, salt consumption in developed countries continues to significantly exceed recommended daily allowances (He *et al.* 2011; 2010).

In our study the adolescents with prehypertension on the DASH diet/DASH diet combined with low sodium salt produced significant decreases in BP after as little as 3 months of intervention. Surprisingly, individuals treated with the DASH diet alone had better

results than those treated with the DASH diet plus low sodium salt.

CONCLUSIONS

This interventional prospective study using the DASH diet together with low sodium salt showed that after as little as 3 months, a significant decrease in BP could be achieved in adolescents with prehypertension and normal BMIs. The additional use of a special low sodium salt for home cooking did not reveal any advantages over the DASH diet alone.

These results seem to show that there are benefits to an active (non-pharmacological) approach to the treatment of children and adolescents with prehypertension, even while they are under the care of a pediatrician.

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