

The effect of a multidisciplinary intervention program for overweight and obese children on cardiorespiratory fitness and blood pressure

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ABSTRACT

Background

Multidisciplinary intervention programs for overweight and obese children mainly focus on reducing bodyweight and body mass index (BMI), but they may also positively impact blood pressure (BP), and cardiorespiratory fitness (CRF), which is a stronger predictor for all-cause mortality than BMI.

Objective

To evaluate whether Kids4Fit, a multidisciplinary weight reduction program, has a positive effect on CRF and BP in overweight and obese children in socially deprived areas.

Methods

A quasi-experimental study design with a waiting list control period including children who participated in a multidisciplinary intervention program of 12 weeks was set-up. BP measurements and shuttle-run test (SRT) were performed at baseline, at the start of the intervention, at the end of intervention and after 52 weeks. The effect of Kids4Fit on BP and on SRT-scores were analyzed using mixed models.

Results

A total of 154 children were included (mean age 8.5 years(SD 1.8)). No significant change was seen in systolic blood pressure percentiles at 52 weeks after start of the Kids4Fit intervention (β 0.08, (95%CI-0.06, 0.22)). Diastolic blood pressure percentiles increased significantly over time (β 0.20 (0.08, 0.31)). Effect plots showed an initial significant increase of the SRT-scores but this effect diluted after the intervention.

Conclusion

A local multidisciplinary intervention program in deprived areas had a significant positive effect on cardiorespiratory fitness, but this effect diluted after the intervention. Diastolic blood pressure percentiles significantly increased over time. However, systolic blood pressure did not change over time.

INTRODUCTION

Childhood obesity is a global health issue and its prevalence increases every year (1). The prevalence of childhood obesity is especially high in children living in deprived areas, who are often of ethnic minorities and have low socioeconomic status (2). According to several studies, multidisciplinary interventions show effective results in reducing obesity and overweight amongst children (3, 4). However, most of these interventions did not focus on children in deprived areas.

Multidisciplinary intervention programs mainly focus on reducing bodyweight and body mass index (BMI), though recent studies have shown that cardiorespiratory fitness (CRF) is a stronger predictor for all-cause mortality than BMI (5, 6, 7). CRF is an objective measure of habitual physical activity, and defined as the ability of the circulatory, respiratory, and muscular systems to apply oxygen during sustained physical activity (8). Improving CRF may be more important than lowering the BMI in order to reduce the risk of cardiovascular disease and all-cause mortality, and is therefore an important outcome measure of multidisciplinary intervention programs.

Elevated blood pressure in childhood is related to a variety of diseases in adulthood, including type 2 diabetes mellitus, left ventricular hypertrophy, dyslipidemia, nonalcoholic steatohepatitis and obstructive sleep apnea (9). Overweight and obesity increase the risk of high blood pressure in children (10). Therefore, not only CRF, but also blood pressure levels are important outcome measures of multidisciplinary weight reduction intervention programs.

Recently, it has been shown that Kids4Fit, a multidisciplinary intervention program in deprived areas of Rotterdam, The Netherlands, has a non-significant positive effect towards a lower BMI-z, and is effective in reducing waist circumference (WC) in overweight and obese children (4). However, no previous research has studied the effects of a multidisciplinary intervention program for overweight and obese children in deprived areas on CRF and blood pressure. Therefore, the current study aims to evaluate whether Kids4Fit also has a positive effect on CRF and blood pressure in overweight and obese children in socially deprived areas. Secondary aims include the description of blood pressure status and the level of physical fitness during and after Kids4Fit.

METHODS

Study design

A quasi-experimental study design study, with a waiting list control period, with a follow-up of one year was performed. Children who were admitted to the Kids4Fit multidisciplinary intervention program were eligible for inclusion. The study protocol was

approved by Medical Ethics Review Committee (METC-2012-479) of the Erasmus MC in Rotterdam, the Netherlands.

Intervention

Kids4Fit is an ongoing multidisciplinary intervention program of 12 weeks for overweight and obese children, which runs in four locations in deprived areas of Rotterdam, The Netherlands.

Children admitted to the Kids4Fit program have to be aged 6-12 years and have to be overweight or obese according to the International Obesity Task Force Body Mass Index (BMI) cut-off points (11). Children with co-morbidities, underlying medical pathologies as a cause of the excess weight, and children with an inability to function in a group cannot participate in the program. Eligible children can be referred to Kids4Fit by general practitioners, pediatricians, youth health care workers or dietitians, or can subscribe to Kids4Fit on their own initiative.

After signing up for Kids4Fit, children are placed on a waiting list until there is a group of 8-12 children to start the intervention program. Before the start of the intervention, each child and his/her parent(s) have an intake appointment of 20 minutes with each of the treatment providers present, to receive more information about the intervention. The program consists of group sessions led by a physiotherapist, a dietitian and a child psychologist.

The physiotherapist leads the exercise component of the program, which consists of 18 group sessions. During the first six weeks, children have 2-weekly 1-hour indoor sport sessions. The last six weeks consists of a 1-weekly 1-hour session and children are stimulated to combine this with a sport in their neighborhood outside of the program. The training sessions focus on fitness and strength and includes different types of sport. Parents are invited to join four of these sessions to increase their involvement in the program. The primary aim of Kids4Fit is to activate the child and to stimulate the child to join a sports club during or at the end of the intervention.

All children participate in four 1-hour group sessions led by the dietitian, in which healthy eating behavior and physical activity are the topics. Special attention is given to having breakfast, to avoid sugared drinks, to limit the use of television or computer and to stimulate daily physical activity. Parents are also educated on the points mentioned above and attention is given to parents being a role model for their children.

The third part of the program consists of four 1-hour group sessions with a child psychologist, which aims to support the nutritional and exercise advice and to improve the child's self-image. Parents also attend four 1-hour group sessions with the child psychologist, during which they receive information on a healthy lifestyle and how to incorporate this in daily family life, and on their position as a role model.

At the end of the 12-week intervention, GP's are informed with the results by a report. GP's are expected to follow-up the child.

Subjects

In order to evaluate the effect of this multidisciplinary intervention, children participating in Kids4Fit between October 2012 and August 2014 were asked to join the current study. After subscription, parents received information from the research team about the study. If interested, the research team sent them information and scheduled an appointment for the first measurements. Written informed consent by parents (and children aged 12 years and older) was provided before the first measurements took place.

Data collection

Data was collected after children signed up for Kids4Fit (baseline), at the start of the intervention (T1), at the end of the intervention (T2), and 52 weeks after the start of the intervention (T3).

At baseline, all parents filled in a questionnaire including sociodemographic characteristics (ethnicity, highest level of education), weight and height of both parents, information on how the child became aware of Kids4Fit (self-referred or referred by health care provider), and information on whether or not the child was a member of a sports club.

Anthropometric measurements, blood pressure measurements and the SRT were performed at all time points. The child's height was measured to the nearest 0.1 cm (SECA 217 freestanding mobile stadiometer) and weight to the nearest 0.1 kg (SECA 716 weighing scale). From height and weight measures, BMI-z scores were calculated using the World Health Organization reference data (12).

Blood pressure was measured twice (OMRON M5-I) before the SRT, on the left arm with an interval of at least two minutes. Before measuring, children were instructed to sit down and relax. The second blood pressure measurements were converted to percentiles based on gender, age and height, using the blood pressure percentiles calculator constructed by the National High Blood Pressure Education Program (13); these were consequently used for the primary analyses.

Children were also categorized into a hypertensive (SBP \geq 95th percentile or diastolic blood pressure (DBP) \geq 95th percentile), prehypertensive (SBP 90-94th percentile or DPB 90-94th percentile) or normotensive (SBP and DBP <90th percentile) group according to the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents (13). CRF was tested using the shuttle run test (SRT) (14). A 10-meter SRT was used since this distance was available in all Kids4Fit locations. The running pace was given by an audio-tape and started at 5km/h and increased by 0,25 km/h every minute. Each increase of speed level was equal to one stage, therefore every stage of the SRT matches one minute of running. The test was stopped when the child stopped running or when the child was unable to reach the 1.5m zone placed ahead of

each 10m line at the moment of the audio signal, two times consecutively. The results were recorded with an accuracy of half a stage and were used for primary analyses.

Children were also categorized as 'low fit' (least fit 20%; boys $SRT \leq 2.5$, girls $SRT \leq 4$), 'moderately fit' (middle 40%; boys $SRT > 2.5$ and ≤ 7.5 , girls $SRT > 4$ and ≤ 6.5) and 'high fit' children (most fit 40%; boys $SRT > 7.5$, girls $SRT > 6.5$) (15).

Children's and parent's attendance to all group sessions during the intervention were registered, and children with $\geq 75\%$ attendance rate were considered compliant to the intervention.

Statistics

Data were analyzed using the statistical software package R (free download from www.rproject.org). Baseline demographics were described using means and standard deviations (sd) for continuous variables and frequencies with proportions (%) for dichotomous or categorical variables.

Linear mixed-effects models with random intercept and random slope were used to analyze the effect of the multidisciplinary intervention up to 52 weeks on SBP and DBP percentiles, and on SRT-scores. Linear mixed-effect models were also used to analyze the effect of being a member of a sports club at T3 on SBP and DBP percentiles, and on SRT-scores. A mixture of chi-squared distributions for likelihood ratio testing was applied to investigate whether random intercept and slope were needed. The maximum likelihood test was used to determine whether the outcomes were non-linear over time. Since SRT-scores were nonlinear over time, the splines approach was used for the random intercept and random nonlinear slope. In this model, age, gender, the waiting list period and compliance were used as covariates. For the models with SBP and DBP percentiles as outcome measures, the waiting list period and compliance were used as covariates and a random intercept was assumed. Correction for multiple testing was not applied and statistical significance was set at $p < 0.05$.

Graphics to visualize the blood pressure status and the level of physical fitness at the four different measurement times were constructed using Microsoft Excel 2010.

RESULTS

A total of 154 children were included in the study. Baseline measurements were performed in 132 children, and 22 children entered the study at T1, without a waiting list control period. The mean duration of the waiting list period was 23.3 (sd 10.9) weeks. At 52 weeks after the start of the intervention, measurements could be performed for 89 children. No significant differences in baseline demographics were present between children who completed the study and children who were lost to follow-up.

Data of all 154 children were used for analyses and consisted of 66 (42.9%) boys, and the mean (SD) age was 8.5 (sd 1.9) years (Table 1). 77.9% of the children had at least one parent that was born outside the Netherlands, and 84.4% of the children had parents of which the highest level of education was in the category ‘low’. Mean parental BMI (maternal BMI or, if not available, paternal BMI) was 30.7 (SD 6.3). Of all participants, 68 (56.2%) were compliant to the intervention.

Table 1 – Baseline characteristics of included children (N = 154)

	N	%
Gender (male)	66	42.9
Age in years [mean (sd)]	8.5 (1.9)	
Ethnicity		
Both parents born in the Netherlands	21	13.7
At least one parent born outside the Netherlands	120	77.9
Unknown	13	8.5
Parental education		
High (at least bachelor level)	21	13.7
Low (up to secondary level)	130	84.4
Unkown	3	1.9
Signed up for Kids4Fit on own initiative	31	20.1
Referred to Kids4Fit by health care provider	114	74.0
BMI-z child [mean (sd)]	2.7 (0.8)	
BMI parent (mother, or if not available father) [mean (sd)]	30.7 (6.3)	

Table 2 shows the mean blood pressure percentiles and the mean SRT-scores at all four measurement time points. Baseline SBP and DBP percentiles, and SRT-scores of children who were lost to follow-up were not significantly different from those of children who completed the study.

Linear mixed-effect model analyses showed no significant change in SBP percentiles at 52 weeks after the start of Kids4Fit intervention (β 0.07%, (95%CI -0.07, 0.21)), expressed as the effect of the intervention per week.

DBP percentiles increased significantly over time (β 0.19% (0.08, 0.31)). However, Table 2 shows that both SBP and DBP percentiles decrease during the intervention period. The percentages of participants with a normotensive, prehypertensive and hypertensive blood pressure at the four different measurement times are presented in Figure 1.

At T0, 24.8% of the children were member of a sports club, at T1 this was 27.9%, at T2 32.7% and at T3 this was 35.4%. At the end of the study period, children who were a member of a sports club did not have a lower SBP and DBP than children who did not participate in sports outside of Kids4Fit.

Table 2 – Blood pressure percentiles at all time points [mean (sd)]

	Baseline (n=129)	Pre-intervention (n=125)	Post-intervention (105)	52 weeks after start intervention (89)
Systolic blood pressure percentile	51.9 (26.9)	48.9 (28.0)	47.1 (27.8)	52.7 (26.6)
Diastolic blood pressure percentile	60.3 (23.3)	64.0 (22.6)	59.9 (21.2)	69.0 (20.2)
Shuttle run test score	6.4 (2.8)	7.8 (2.8)	8.1 (3.1)	7.5 (2.6)

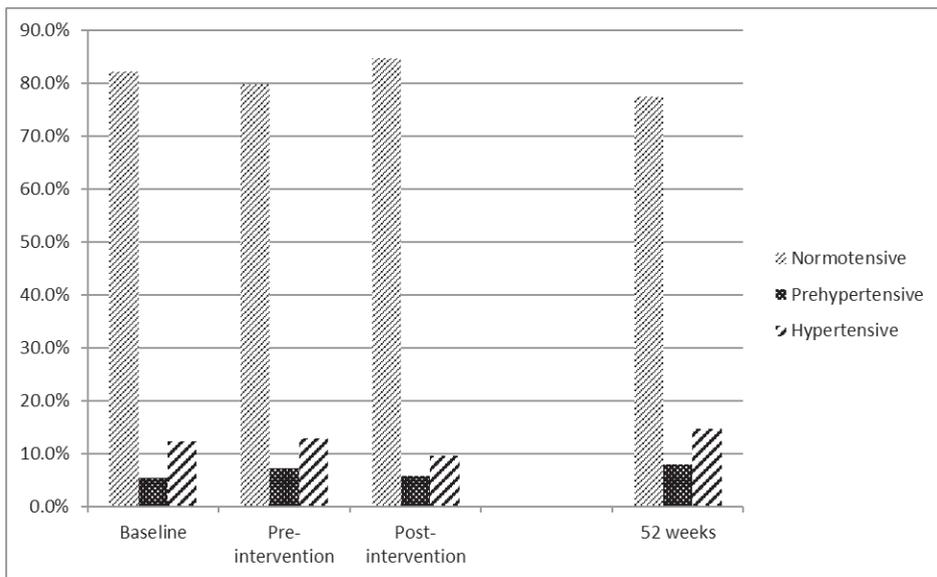


Figure 1 – Percentage of participants with a normotensive, pre-hypertensive or hypertensive blood pressure at the 4 different measurement times.

The effect of the intervention on the SRT-scores are shown in Figure 2. Figure 2a presents the effect plot of average aged (8.5 years), male participants who were compliant to the intervention. The horizontal axis denotes the time in weeks from baseline up to 52 weeks after intervention. Because of the varying waiting list period, the x-axis goes up to 80 weeks. The y-axis presents the SRT-scores. The figure shows that from baseline up to 30 weeks, which is equal to the mean waiting list period plus intervention period, the SRT scores improved significantly. After these 30 weeks, the effect on SRT-scores diluted. Since gender and compliance were non-significant confounders, the effect plot would look identical for female participants who were not compliant to the intervention. An increase in age significantly increased the SRT scores. Figure 2b presents the effect plots of ‘Young’ (5 years) participants and ‘Old’ (12 years) participants. The percentages of low fit, moderately fit, and high fit participants at the four different measurement times are presented in Figure 3. At the end of the study period, children who were member of a sports club had a significantly higher srt-score than children who were not a member of a sports club.

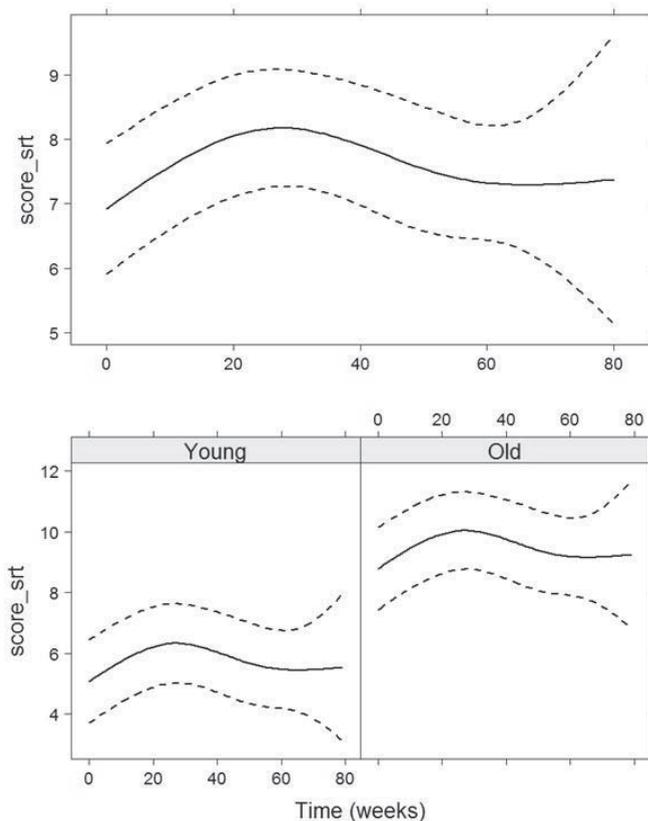


Figure 2 – (A) Effect plot based on mixed-effect model analyses for shuttle run test scores over time. The 8.5-year-old boys who were compliant to the intervention are presented. (B) Effect plot based on mixed-effect model analyses for shuttle run test scores over time. Boys of 5-year old (Young) and 12-year old (Old) who were compliant to the intervention are presented.

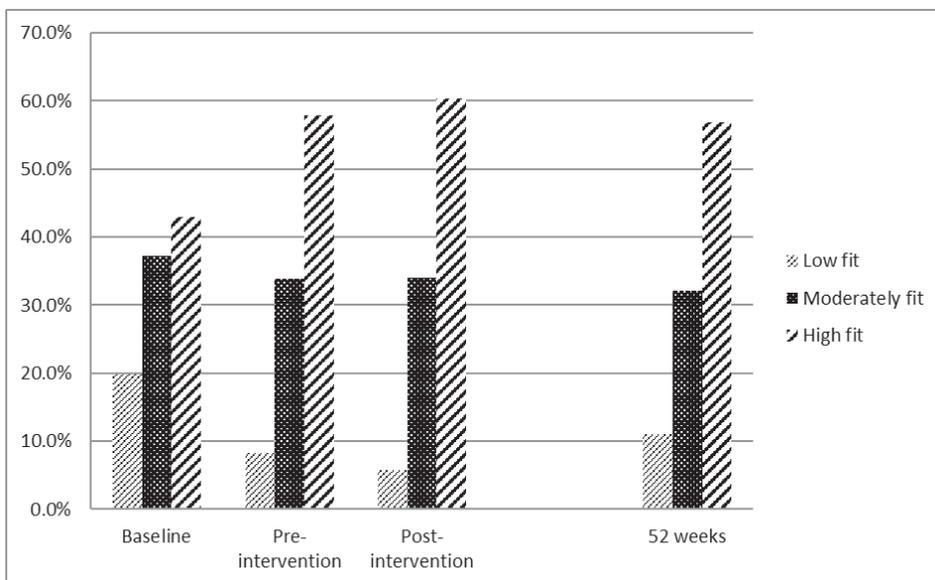


Figure 3 – Percentages of low fit, moderately fit, and high fit participants at the 4 different measurement times.

DISCUSSION

Main findings

A multidisciplinary intervention program for overweight and obese children in socially deprived areas has a significant positive effect on CRF. Furthermore, a non-significant trend towards improved physical fitness was seen over the total follow-up period of 52 weeks. The level of fitness improved from 20% of children being low fit at baseline to 11% being low fit at 52 weeks after intervention. SBP percentiles did not change, while DBP percentiles significantly increased up to 52 weeks after the intervention. Though, SBP has a stronger association with risk of coronary heart disease and better predicts coronary heart disease risks than DBP and therefore seems of less importance (16, 17). Of all children, 82.2% had a normotensive blood pressure at baseline, while 77.5% were normotensive 52 weeks after the start of the intervention. It is known that high blood pressure during childhood predicts hypertension into adulthood, which is associated with cardiovascular diseases. However, it remains unclear what the effects of childhood hypertension are during childhood and adolescence.

It has been shown that children with high CRF have less central and total obesity (7), and lower blood pressure levels (18). This is supported by the current study, where at 52 weeks after intervention, 22.2% of the low fit children was hypertensive, while of the high fit children, only 8.7% was hypertensive (data not presented).

The effect of the Kids4Fit intervention on CRF is comparable to three previous studies (19, 20, 21). They found that physical fitness improved during an intervention for overweight and obese children, but this effect was not maintained after the intervention. Our study findings are similar to these three studies, which show that SRT-scores improve during an intervention, but decrease after the intervention (19, 20, 21). Though, in the current study, a non-significant trend towards improved physical fitness was seen over the total follow-up period.

The results of our study with regard to blood pressures are in contrast with the results from a review by Garcia-Hermoso et al., that showed that exercise interventions for obese children significantly decrease both SBP and DBP (22). The duration of the included interventions ranged between 8 and 24 weeks (median 12 weeks), with no follow-up time after the intervention (22). This may well explain the difference between our results and the results of Garcia-Hermoso et al., since our results show that it is exactly in the period following the intervention that blood pressure percentiles increased, after an initial decrease during the intervention period.

Hofsteenge et al. investigated the long term effects of a 3-month multidisciplinary treatment for obese adolescents, including seven educational sessions on healthy dietary, sedentary and physical activity behavior (23). The intervention also included four booster sessions at 6, 14, 26 and 36 weeks after the intervention(23). In contrast to

our study, they found a significant reduction on both BMI-sds and SBP and DBP at 18 months, but only for obese adolescents from western descent and not from non-western descent. This suggests that ethnicity may play a role in the change in blood pressure levels of children and may also explain why we did not find a reduction on SBP and DBP percentiles as 80% of the included children of the present study were from non-western descent. Furthermore, the effect found by Hofsteenge et al. on blood pressure at 18 months (23) could partly be the result of the booster sessions provided after the intervention. As mentioned before, our results show a decrease in blood pressure during the intervention, however in the period after the intervention the blood pressure levels start rising again. Booster sessions could have possibly played a role in preventing this rise from happening.

We earlier showed that the intervention studied had a positive trend towards a lower BMI-z at 52 weeks after the start of Kids4Fit, and a significant reduction in waist circumference (4). These results, in combination with a significantly improved CRF immediately after the intervention period, which is a stronger predictor for all-cause mortality than BMI (5-7), and a positive effect on blood pressure during the intervention period, indicate that a multidisciplinary intervention in deprived areas for overweight and obese children has potential to improve different health outcomes. However, more attention should be paid to maintain the effects of intervention programs right after the intervention and throughout children's life.

Providing booster sessions in the period following an intervention may be one option to maintain the positive effects of an intervention program. However, this may only postpone the deterioration of health outcomes until after the booster sessions, when the participants become completely dependent on their own decisions. Besides focusing on improving intervention programs, it is also important to consider environmental factors that can either facilitate or hinder maintenance of health benefits of such interventions. People have personal responsibilities for their health, but environmental factors, such as increasing the accessibility to safe and secure playgrounds, and promoting the consumption of healthy food, can affect the ability of people to make healthy choices (24, 25). Therefore it could be argued that, in addition to the personal guidance as in multidisciplinary intervention programs, it is especially the environmental factors that should be tackled in order to maintain the health benefits of an intervention.

Strength and limitations

A strength of this study is that we made use of an existing intervention program in deprived areas, and therefore did not intervene with existing health pathways. As a consequence, we did not apply a randomized controlled trial design, but applied an observational study design. By using the waiting list period before the intervention, children formed their own controls.

The number of children included in our analyses was 129 at baseline, and 89 at follow up. Since at follow-up only a small number of children was labeled as unfit, we lacked power to test for statistical differences in blood pressure status between the unfit and fit children. If our sample size would have been larger, the non-statistical trend that unfit children have a higher blood pressure than fit children, which we saw in our data, may have become statistically significant.

Children (and their parents) admitted to the Kids4Fit intervention had to be highly motivated for the intervention program in order to be eligible to participate. As a consequence, the results of this study are applicable to a selected group of children.

Conclusions

A local multidisciplinary intervention program for overweight and obese children in deprived areas had a significant positive effect on cardiorespiratory fitness, but this effect diluted after the intervention. SBP and DBP percentiles improved during the intervention-period. However, over the whole study period (i.e. waiting-, intervention-, and follow-up period) , SBP percentiles did not change, while DBP percentiles slightly increased.

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