Association of Elevated Blood Pressure With Low Distress and Good Quality of Life: Results From the Nationwide Representative German Health Interview and Examination Survey for Children and Adolescents

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Objective: Quality of life is often impaired in patients with known hypertension, but it is less or not at all reduced in people unaware of their elevated blood pressure. Some studies have even shown less self-rated distress in adults with elevated blood pressure. In this substudy of the nationwide German Health Interview and Examination Survey for Children and Adolescents (KIGGS), we addressed the question whether, also in adolescents, hypertensive blood pressure is linked to levels of distress and quality of life. **Methods:** Study participants aged 11 to 17 years ($N = 7688$) received standardized measurements of blood pressure, quality of life (using the Children's Quality of Life Questionnaire), and distress (Strengths and Difficulties Questionnaire). **Results:** Elevated blood pressure was twice as frequent as expected, with 10.7% ($n = 825$) above published age-, sex- and height-adjusted 95th percentiles. Hypertensive participants were more likely to be obese and to report on adverse health behaviors, but they showed better academic success than did normotensive participants. Elevated blood pressure was significantly and positively associated with higher self- and parent-rated quality of life (for both, $p \leq .006$), less hyperactivity (for both, $p < .005$), and lower parent-rated emotional ($p < .001$), conduct ($p = .021$), and overall problems ($p = .001$). Multiple regression analyses confirmed these findings. **Conclusions:** Our observation linking elevated blood pressure to better well-being and low distress can partly be explained by the absence of confounding physical comorbidity and the unawareness of being hypertensive. It also corresponds to earlier research suggesting a bidirectional relationship with repressed emotions leading to elevated blood pressure and, furthermore, elevated blood pressure serving as a potential stress buffer.
Key words: hypertension, blood pressure, health-related quality of life, adolescents.

KiGGS = German Health Interview and Examination Survey for Children and Adolescents (Kinder- und Jugendgesundheitssurvey); **KINDL-R** = Children's Quality of Life Questionnaire (Kinder-Lebensqualitätsfragebogen); **SDQ** = Strengths and Difficulties Questionnaire.

INTRODUCTION

Arterial hypertension is one of the most frequent chronic conditions and a major cause of morbidity and mortality worldwide. Owing to its high prevalence and long-term medical consequences such as myocardial infarction, congestive heart failure, stroke, peripheral vascular, and end-stage renal diseases, hypertension has become a main contributor to disability in adults and places a huge strain on public health spending (1). Unlike many other medical conditions, hypertension frequently remains asymptomatic for many years, especially in mild to moderate stages, although some studies have reported on nonspecific symptoms such as headache, dizziness, tiredness, cognitive changes, and mood alterations (2,3). Several studies have provided evidence that adult hypertension has its onset in childhood, and it is well known that children and adolescents with elevated blood pressure are more likely to become hypertensive adults (4). Arterial hypertension has, therefore, become an increasingly recognized health problem also in adolescents, and its prevalence seems to have been increasing over the last few decades (5–7). To understand the mechanisms behind this increase better, it is of great importance to identify life-style factors, for example, sedentary behavior and faulty dietary habits, including a growing incidence of obesity, as well as psychological factors such as increasing stressor load, associated with elevated blood pressure already in adolescence.

Numerous cross-sectional and population-based studies have suggested that objective measures of stressor exposure may be associated with hypertension in adults and that previously diagnosed or treated hypertension is frequently accompanied by reduced quality of life (3,8–18). In contrast, some studies on adults have yielded inverse associations between self-reported distress and elevated blood pressure (19) (for a review, see Nyklíček et al. (20)). None of these seemingly contradictory studies have been conducted in children or adolescents. In this young age group, hypertension has often not yet been diagnosed and treated, and the extent of hypertension-induced target organ complications must be lower than that in adults. Therefore, we wondered whether, also in a representative population sample of adolescents, hypertensive blood pressure is associated with adverse health behaviors, self- and/or parent-reported distress, and quality of life.

METHODS

Study Design

This study is based on the public use file data from the cross-sectional German Health Interview and Examination Survey for Children and Adolescents (Kinder- und Jugendgesundheitssurvey, or KiGGS), which was conducted by the Robert Koch-Institute, Berlin, from May 2003 to May 2006. The aim of this nationwide survey was to simultaneously collect data on physical, psychological, and social health issues in children and adolescents aged 0 to 17 years. The KiGGS study, which was financed by the German Federal Ministry of Health and the Federal Ministry of Education and Research, took place in 167 selected cities and communities representative for Germany. Participants were randomly chosen from the registry offices at the study locations, and the parents of eligible children and adolescents were contacted by letter and invited to participate in the survey (21,22). The survey comprised physical and medical examinations including a wide range of blood and urine

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tests and psychometric testing using questionnaires filled in by parents as well as parallel questionnaires for adolescents aged 11 years and older. In addition, specifically trained study physicians performed a computer-assisted personal interview with each study participant. Anthropometric data including body height and weight, body mass index, and others were assessed. Detailed information on the medical history and previous use of medication was obtained from accompanying parents and caregivers of the enrolled participants. For the present analysis, we selected all participants from the age group 11 to 17 years because only in this group were self-ratings of quality of life available. All study participants and their accompanying parents gave their informed consent to take part in the survey. The study was approved by the Ethics Committee of the Charité Universitätsmedizin Berlin and the German Federal Office for the Protection of Data.

Blood Pressure Measurements

In the subpopulation of KiGGS participants aged 3 to 17 years, heart rate and blood pressure were assessed using a standardized procedure (23–26). Briefly, systolic, diastolic, and mean arterial blood pressure was noninvasively measured using a sphygmomanometer with a portable monitor (Datascope Accutorr Plus). This automated device provided accurate blood pressure measurements in the brachial artery by collecting oscillometric pulsations during cuff deflation (27). Measurement was performed in a sitting position with the participant's right arm on the desk and the forearm in supination, so that the antecubital fossa was at the level of the heart. Inflatable cuffs of different sizes (6 × 12, 9 × 18, 12 × 23, and 17 × 38.6 cm) were used according to the circumference of the participant's upper right arm. For each participant, two independent readings of the arterial pressure and one reading of heart rate were taken after 5 minutes of rest (22,24,26). The mean of the two blood pressure readings was used for this analysis. According to the manufacturer's instructions, the mean error in blood pressure measurements using the Datascope Accutorr Plus apparatus is less than ±5 mm Hg, with a standard deviation (SD) not exceeding ±8 mm Hg for both systolic and diastolic values. Hypertension was defined as systolic and/or diastolic blood pressure above published age-, sex- and height-adjusted 95th percentiles according to guidelines from the "Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents" as published by the American National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (28). Additional measurements were obtained for heart rate, height, and weight.

Psychometric Assessment

Self- and parent-rated quality of life was measured with the Children's Quality of Life Questionnaire (Kinder-Lebensqualitätsfragebogen, or KINDL-R). This German-language psychometric instrument, originally developed for assessing health-related quality of life in healthy and diseased children and adolescents, had been validated in numerous epidemiological investigations (29). Previous results indicated a sufficient reliability with a Cronbach α of greater than .80 and expected correlations with other instruments measuring similar concepts ($r = 0.70$) (29,30). The questionnaire consists of 24 items covering the following six dimensions of quality of life over the past week: physical well-being, emotional well-being, self-esteem, and everyday functioning at school, in the family, and with friends (31). A total sum score and scores on each of the six subscales were calculated from the answers, which were given in five categories (never, seldom, sometimes, often, always). A proxy version of the KINDL-R questionnaire was filled in by accompanying parents and caregivers. Scores on both versions were transformed so that the range of possible values for the subscores and the total score ranged from 0 (most negative state) to 100 (most positive state). To measure levels of distress, study participants were asked to complete the self-rated Strengths and Difficulties Questionnaire (SDQ). This well-evaluated instrument, which was developed to screen for emotional and behavioral problems in children and adolescents, assesses emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior on different subscales (32–34). For each item of this questionnaire, respondents marked in one of three boxes to indicate whether the item was "not true" (0), "somehow true" (1), or "certainly true" (2). Each of the five subscales is covered by five items, and in addition, an overall problem burden can be calculated by summing up the scores from all subscales except prosocial behavior. Parents independently answered the 25-item SDQ proxy version, which asks about the same problems as the self-rated questionnaires, although the wording is slightly different and more suitable for adults. In addition, participants and their parents answered a number of questions about developmental status and health-related behaviors.

Statistical Analyses

All data obtained from the public use file Robert Koch-Institute, Berlin 2008, and blood pressure status derived from these data were entered into a computerized database and analyzed using the Statistical Package for the Social Sciences (SPSS) software (version 18) running on a personal computer. Individual systolic and diastolic blood pressure status was calculated using normative data, as described earlier. Descriptive statistics with means and SDs for continuous variables and percentages for categorical variables were calculated for each parameter tested. Group comparisons between normotensive and hypertensive probands were performed using χ^2 tests for categorical variables or Student's t tests and Mann-Whitney U tests for continuous measures. To test whether health-rated quality of life was independently predicted by blood pressure, multivariate regression models were calculated based on a hierarchical approach by entering age, sex, body height, and weight on step 1 and school career, perceived physical fitness, and alcohol consumption on step 2, and then adding continuous data on either mean systolic or diastolic blood pressure on step 3. Similar models using the same set of independent variables were calculated from the data obtained with the proxy version of the KINDL-R as well as the self- and proxy-rated SDQ as dependent variables. Sampling weights were used to account for unequal sampling probabilities, as has been described (24). In all tests, statistical significance was defined as $p < .05$.

RESULTS

Prevalence of Hypertensive Blood Pressure in the Study Population

Among the total study cohort, 7697 participants were between 11 and 17 years of age. Of these, data on blood pressure measurements were available for 7688 participants (Table 1). The mean (SD) age of the study population was 14.6 (2.0) years. The number of boys (51.3%) was slightly higher than the number of girls. The mean (SD) heart rate in the entire population was 75.8 (11.7) min^{-1}. The overall mean (SD) systolic blood pressure was 114.7 (10.9) mm Hg, and the mean (SD) diastolic blood pressure was 68.3 (7.6) mm Hg. Elevated systolic blood pressure was found in 9.7% of the adolescents examined, whereas the prevalence of elevated diastolic pressure was 2.7% and systolic and/or diastolic pressure was elevated in 10.7%. Most of the 825 participants classified as hypertensive were male (61.3%, $p < .001$). Boys showed significantly higher rates of elevated blood pressure for both systolic (11.8% versus 7.6%, $p < .001$) and diastolic readings (3.1% versus 2.4%, $p = .033$). Systolic and/or diastolic blood pressure was also elevated more frequently in boys (12.8% versus 8.5%, $p < .001$) than in girls. In boys only, the percentage of elevated blood pressure increased with age from 6% to 18%, whereas in girls, the frequency distribution was relatively stable from puberty to late adolescence (Fig. 1).

Association of Elevated Blood Pressure With Health Indicators and Recreational Behavior

The mean body mass index was higher in the hypertensive group than in the normotensive group (23.7 [5.4] versus 20.8 [3.8], $p < .001$) (Table 1). Socioeconomic status ($p = .578$) and smoking ($p = .486$) did not differ between hypertensive and normotensive participants. In contrast, study participants with

TABLE 1. Clinical Characteristics of the Study Sample

	Total Study Cohort (n = 7688)	Normotensive Participants (n = 6863)	Hypertensive Participants (n = 825)	p
Age, y	14.6 (2.0)	14.6 (2.0)	14.9 (1.9)	<.001
Male sex, no. (%)	3951 (51.3)	3441 (50.1)	506 (61.3)	<.001
Height, cm	164.7 (11.3)	164.3 (11.2)	168.0 (11.5)	<.001
Weight, kg	58.0 (15.1)	56.8 (14.2)	67.7 (19.0)	<.001
BMI, kg/m^2	21.1 (4.1)	20.8 (3.8)	23.7 (5.4)	<.001
Systolic BP, mm Hg	114.7 (10.9)	112.5 (8.8)	133.6 (8.2)	<.001
Diastolic BP, mm Hg	68.3 (7.6)	67.1 (6.7)	77.8 (7.5)	<.001
Heart rate, bpm	75.8 (11.7)	75.2 (11.4)	81.1 (13.5)	<.001
Smoking, %	20.4	20.5	19.5	.486
Alcohol consumption, %	20.1	19.0	25.6	<.001
Low SES, %	27.4	27.3	28.2	.578
Perceived physical fitness (less than good), %	34.6	33.9	39.6	.002
Computer use (>2 h/d), %	11.8	11.3	15.8	<.001
TV, video use (>0.5 h/d), %	74.5	73.8	80.5	<.001
Irregular school career, %	17.0	17.3	14.1	.011

BMI = body mass index; BP = blood pressure; bpm = beats per minute; SES = socioeconomic status; TV = television.
Values are expressed as means and standard deviations of the indicated parameters, including p values from the comparisons between normotensive and the hypertensive subgroups.

elevated blood pressure spent greater amounts of time watching television and playing video games or using the Internet as compared with individuals with normal blood pressure (for both, $p < .001$). Consequently, they reported on lower perceived physical fitness compared with normotensive participants (39.6% versus 33.9%, $p = .002$). Study participants with hypertensive blood pressure levels more often reported on regular alcohol consumption (35.2% versus 26.0%, $p < .001$) as compared with their normotensive counterparts. Unexpectedly, we found that hypertensive adolescents had better academic success than did normotensive adolescents: Although 14.1% of hypertensive participants had to repeat one or more years at school, this was reported by 17.3% of the normotensive participants ($p = .011$). In summary, participants with elevated blood pressure were more likely to be obese, spent significantly more time in front of a screen, reported more often on lower perceived physical fitness, and usually drank higher amounts of alcohol, but experienced less severe problems at school than their normotensive counterparts.

High Blood Pressure in Adolescents is Associated With Better Health-related Quality of Life and Lower Distress

Despite the higher prevalence of adverse health indicators, both self- and parent-reported qualities of life were better in probands with elevated blood pressure as compared with participants with normal blood pressure. In detail, individuals with hypertensive blood pressure reported significantly better quality of life on the KINDL-R dimensions "family life" (83.0 [15.4] versus 81.8 [15.7], $p = .011$), "self-esteem" (59.8 [17.6] versus 58.1 [18.5], $p = .028$), "physical well-being" (72.7 [15.5] versus 70.4 [16.6], $p = .001$), and global quality of life (73.4 [10.0] versus 72.5 [10.4], $p = .006$) compared with participants with normal blood pressure (Fig. 2, **A**). Parent reports confirmed this finding for the same three subscales (dimensions family life: 78.0 [15.3] versus 76.2 [15.1], $p < .001$; self-esteem: 69.1 [15.0] versus 67.1 [15.2], $p = .003$; physical well-being: 75.3 [18.1] versus 74.0 [17.3], $p = .006$) and global quality of life (75.2 [10.3] versus 74.1 [10.3], $p = .002$), whereas no differences (all, $p > 0.1$) were observed on the other subscales (Fig. 2, **B**).

Accordingly, self- and parent-rated assessments on the SDQ revealed significantly lower mean scores on the "hyperactivity" subscale in hypertensive participants as compared with normotensive participants (3.39 [2.02] versus 3.63 [2.02] and 2.58 [2.10] versus 2.83 [2.20], respectively; for both, $p < .005$) (Fig. 2, **C** and **D**). Parent- but not self-rated emotional (1.57 [1.80] versus 1.80 [1.87], $p < .001$), conduct (1.77 [1.53] versus

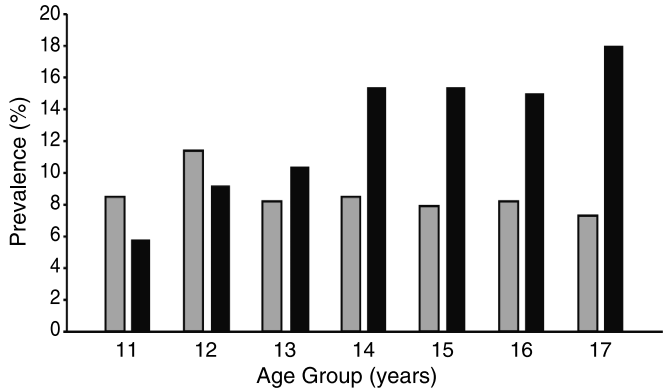

Figure 1. Age-related prevalences of elevated blood pressure measures in male (black columns) and female (gray columns) study participants of the KiGGS survey. KiGGS = German Health Interview and Examination Survey for Children and Adolescents (Kinder- und Jugendgesundheitssurvey).

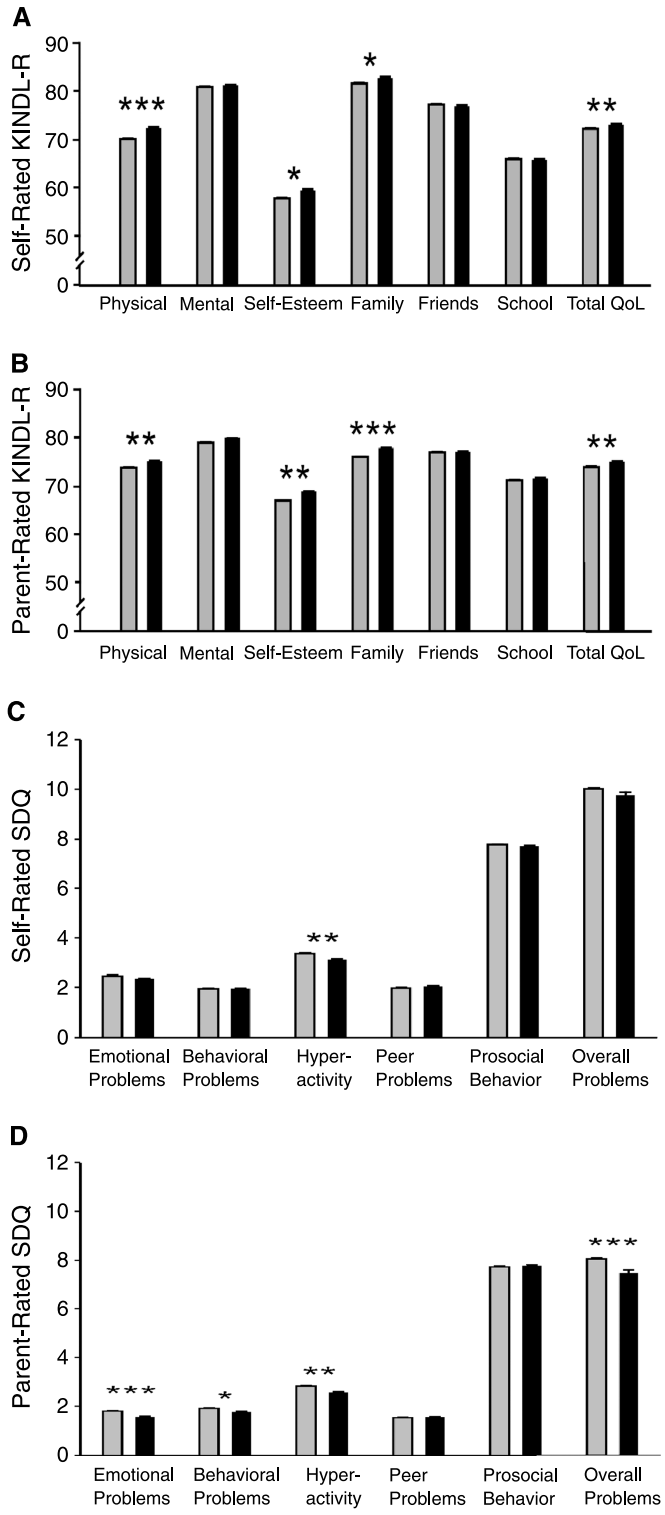

Figure 2. Hypertensive (black columns) and nonhypertensive participants (gray columns) differ in the indicated domains of self-rated (A) and parent-rated (B) KINDL-R as well as self-rated (C) and parent-rated (D) SDQ. Higher scores on the KINDL-R reflect better quality of life, and higher scores on the SDQ indicate more problems. Depicted are the mean scores on each of the indicated subscales and the mean sum scores of each questionnaire including error bars. Significant differences between the two groups are indicated by asterisks (* $p < .05$, ** $p < .01$, *** $p < .001$). KINDL-R = Children's Quality of Life Questionnaire (Kinder-Lebensqualitätsfragebogen); SDQ = Strengths and Difficulties Questionnaire; QoL = quality of life.

1.91 [1.55], $p = .021$), and overall problems (7.47 [5.17] versus 8.06 [5.16, $p = .001$) were also lower in the group of hypertensive adolescents.

Finally, we calculated a series of multivariate regression models with either self- or parent-rated global quality of life (KINDL-R) as dependent variable and blood pressure as predictor, adjusting for age, sex, body height and weight, school career, perceived physical fitness, and alcohol consumption (Table 2). Interestingly, these models identified higher systolic blood pressure as an independent predictor for better self- and parent-rated global quality of life, respectively ($\beta = .080$ [$p < .001$, model $R^2 = 0.123$] and $\beta = .068$ [$p < .001$, model $R^2 = 0.059$]). Furthermore, systolic blood pressure also predicted fewer self- and parent-rated overall problems, independent of the previously mentioned physical and psychosocial variables ($\beta = -.109$ [$p < .001$, model $R^2 = 0.082$] and $\beta = -.097$ [$p < .001$, model $R^2 = 0.111$], respectively). Substituting diastolic for systolic blood pressure in the linear regression models confirmed the predicative role of elevated blood pressure. Similar to systolic pressure, also diastolic blood pressure was a highly significant predictor (in all four models, $p \leq .001$) for both higher quality of life and fewer overall problems, with β coefficients ranging from .061 to .041 (self- and parent-rated KIND-L) and −.075 to −.064 (self- and parent-rated SDQ), respectively.

DISCUSSION

In this substudy of the KiGGS survey, we have examined the association of elevated blood pressure with psychological distress and health-related quality of life in a large, nationally representative sample of German adolescents aged 11 to 17 years. In 825 of 7688 study participants (10.7%), elevated blood pressure levels above published age-, sex-, and height-adjusted 95th percentiles were documented by means of standardized oscillometric measurement, demonstrating twice the rate expected from earlier normative samples (28). Hypertensive blood pressure was independent of socioeconomic status and most frequently found in postpubertal boys.

The central finding of this investigation was that adolescents with elevated blood pressure levels reported significantly better quality of life and lower levels of distress on multiple domains of two well-validated instruments. Moreover, concordant results were observed for both self- and parent-rated versions of the two instruments and for both systolic and diastolic blood pressure as predictors. All associations remained stable when adjusted for a variety of possible confounders in multivariate analyses. These observations in adolescents seem to contradict several reports from adult patients who are aware of having arterial hypertension. The adult patients may already feel concerned about possible long-term health complications, the necessity of regular visits to a physician, and costs and adverse effects of antihypertensive medication. Together with hypertensive end-organ damage present sometimes, this may impair quality of life (1,12,20).

In contrast, our results confirm earlier studies in adult populations showing an inverse association between hypertension and subjectively measured distress (19,20). For example, Winkleby et al. (19) found that hypertension as defined by

TABLE 2. Results From a Set of Linear Regression Models With Self- and Parent-Rated Global Health-Related Quality of Life (Models 1 and 2) and Self- and Parent-Rated Overall Psychological Distress (Models 3 and 4) as Dependent and the Indicated Physical and Psychosocial Parameters as Independent Variables

	Model 1. Dependent Variable: Self-Rated Global Quality of Life		Model 2. Dependent Variable: Parent-Rated Global Quality of Life	
	β Coefficient	Significance	β Coefficient	Significance
Block I				
Age	−.064	<.001	−.013	.488
Sex	−.073	<.001	.006	.635
Body height	.022	.231	.065	.001
Weight	−.046	.007	−.067	<.001
Block II				
School career	−.052	<.001	−.114	<.001
Perceived physical fitness	.261	<.001	.178	<.001
Alcohol consumption	−.113	<.001	−.065	<.001
Block III				
Systolic blood pressure	.080	<.001	.068	<.001
Total model R^2		.123		.059
	Model 3. Dependent Variable: Self-Rated Overall Psychological Distress		Model 4. Dependent Variable: Parent-Rated Overall Psychological Distress	
	β Coefficient	Significance	β Coefficient	Significance
Block I				
Age	−.013	.467	−.139	<.001
Sex	.047	<.001	−.143	<.001
Body height	−.148	<.001	−.136	<.001
Weight	.150	<.001	.153	<.001
Block II				
School career	.110	<.001	.222	<.001
Perceived physical fitness	−.172	<.001	−.121	.018
Alcohol consumption	.083	<.001	.035	<.001
Block III				
Systolic blood pressure	−.109	<.001	−.097	<.001
Total model R^2		.082		.111

elevated office blood pressure and/or current use of antihypertensive medications was negatively related to an index of self-rated job stressors in 1428 San Francisco bus drivers, and the same effect was observed also for continuous blood pressure values. Remarkably, this inverse association was equally found in nonmedicated (and possibly unaware) and medicated (and probably aware) participants.

Most of the hypertensive adolescents identified in the KiGGS study were not aware of their elevated blood pressure, which was only detected by routine screening performed as part of this survey. It is well known that individuals unaware of having high blood pressure usually report less bodily pain and show higher scores in physical functioning and general health than those with known hypertension (1,20,35,36). However, this putative unawareness does not explain why elevated blood pressure was actually associated with better quality of life and lower distress. Several possible explanations might account for this inverse association observed in our sample. a) Some adolescents may be more achievement oriented and, thereby, more successful in their school careers than others. This may occur at the expense of chronic (objective) stress and elevated blood pressure but lead to better self-esteem and quality of life. b) Repression of emotions may lead to better self-ratings of distress and quality of life, and repressed emotions might at the same time lead to elevations in blood pressure, as suggested by a line of research recently summarized by Mann (37). c) Elevations in blood pressure themselves might dampen negative emotions, possibly via vagal afferents. These three possible explanations are not mutually exclusive, and each one merits further discussion. However, the cross-sectional nature of our data does not allow us to draw firm causal conclusions.

In our sample, hypertensive participants performed better at school than did normotensive participants. Better school performance was associated with both better quality of life (data not shown) and elevated blood pressure. However, good quality of life was not mainly driven by better school success because

elevated blood pressure and quality of life remained positively associated even after controlling for irregular school career. School success may, on the other hand, have been achieved at the expense of an increased stressor burden contributing to both high blood pressure and adverse health behaviors.

Our data are also consistent with the emotion repression theory of hypertension. Following that theory, repressed emotions, which could manifest themselves in low self-rated distress, might drive blood pressure up, probably via autonomic arousal (38). Interestingly, however, also parents of hypertensive adolescents rated their children as less distressed, less hyperactive, and more satisfied with their lives than did parents of normotensive adolescents. This indicates that not only hypertensive adolescents themselves but also their close family members perceived them as less distressed. Whether this means that repression of emotion in adolescents leads to distorted perception in their parents via changes in adolescents' expressive behavior or whether these parents are repressors themselves, unable to recognize negative emotional clues in their children, cannot be concluded from our data.

Finally, our data could reflect a repeatedly described stress-dampening effect of hypertension (37,39–41). Arterial mechanoreceptors in the aortic arch and carotid sinus, which are sensitive to changes in systemic blood pressure, function as key elements in the transmission of hemodynamic information to the brain via vagal afferents. From some experimental studies performed almost 20 years ago, it is well documented that elevated blood pressure can thereby have pain- and stress-lowering effects (38–43). Previous reports have suggested the presence of an inhibitory feedback loop for adaption to chronic stressors, in which activation of baroafferent pathways by mechanical stretch caused by elevated blood pressure reduces somatic muscle tone, increases cortical synchronization, and blunts the level of pain and anxiety, all of which may have a beneficial impact on emotional well-being but may also lead to the transition of stress-induced hypertensive reactions to sustained chronic hypertension (38,44). Provided that a rise in blood pressure is involved in the reduction of perceived stress, the endogenous baroreceptor-brain circuitry constitutes a reinforcing mechanism, which rewards phasic elevations of blood pressure in stressful conditions, a reaction that could be learned over time (39). More recently, it has been shown that exogenic stimulation of the vagus nerve may have anticonvulsive and antidepressant properties (45). Interrupting the baroreceptor-brain circuitry by antihypertensive drug therapy, on the other hand, commonly reduces health-related quality of life and, possibly, also may impede adherence to pharmacological treatment (46).

There are some limitations to this study, mainly based on its cross-sectional and post-hoc design, which does not allow a causal interpretation for the observed link between high blood pressure and quality of life. Because the survey was originally not planned to specifically examine associations between blood pressure and well-being, no ambulatory blood pressure monitoring is available. However, the blood pressure readings in KiGGS were obtained under highly standardized conditions by trained physicians and with devices well validated for this age group. They have been published and accepted as new reference values for German children and adolescents (25). Nevertheless, the assignment to the hypertensive group was not based on a medical diagnosis, but on blood pressure levels above previously reported age-, sex-, and height-adjusted 95th percentiles, determined during one complex and potentially demanding diagnostic assessment. They are likely to be biased in the same way as typical office blood pressure recordings are. The unexpectedly high prevalence of elevated blood pressure found in this study cohort should therefore be interpreted with caution. Finally, the effect sizes of systolic and diastolic blood pressure on quality of life were small. However, they were still within the range of other known determinants for health-related quality of life, such as sex, body weight, and alcohol consumption. The small effect sizes may be caused by the relatively small range of blood pressure values and to sample heterogeneity; however, the highly consistent findings across self-rating and parent rating on several dimensions of distress and quality of life suggest a real and epidemiologically relevant association.

Our investigation also has several strengths. Data were available for a large, representative and well-characterized sample, giving sufficient statistical power and generalizability to our observations. Another strength is the well-standardized assessment of blood pressure, quality of life, and distress as well as the use of individual norm-based blood pressure cutoffs rather than one simple threshold. Our analysis was based on the widely accepted reference from the National High Blood Pressure Education Program Working Group on Children and Adolescents (28) because this reference also included overweight individuals, and, moreover, used relatively high cutoff levels (26). The results found for categorized blood pressure data were fully confirmed with continuous readings for both systolic and diastolic blood pressure as predictors in multivariate models, which were adjusted for a variety of possible confounders. Furthermore, we obtained psychometric evaluations by both adolescents and their parents, using instruments that had been well validated beforehand and applied independently of the authors of this substudy, who we were not involved in data collection.

In summary, in this representative sample of German adolescents, we demonstrate a significant and epidemiologically relevant association of hypertensive blood pressure with lower psychological distress and better health-related quality of life. To our knowledge, this is the first report linking elevated blood pressure to quality of life and psychosocial adaptation in a large epidemiological study of adolescents. Besides the absence of confounding from physical comorbidity and a formal diagnosis of hypertension, our cross-sectional assessment may capture a stress-dampening effect of high blood pressure or effects of repressed emotions on blood pressure already at an early stage, not yet fixed by vascular remodeling.

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