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The Correlation between blood pressure and waist circumference,
body mass index, body fat percentage, physical activity and physical
fitness in 1141 8th grade students from northern Germany

Dissertation

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Abbreviations

BMI- bodymass index

BP- blood pressure

WHO- world health organization

NHBPEP- National High Blood Pressure Education Program

MoMo-activity questionnaire- activity questionnaire of motoric module

1. Introduction

In 1946, health was defined, by the World Health Organization as “a state of complete physical, mental and social well-being and not merely the absence of disease”(Grad, 2002). Cardiovascular disease is the leading cause of death worldwide and accounts for approximately 30 per cent of all deaths. In 2010 the three leading risk factors for development of cardiovascular disease were arterial hypertension, tobacco smoking and household air pollution from solid fuels. It is known that, an increased blood pressure contributes to the development of heart failure, myocardial infarction and stroke. Santulli writes in his article of epidemiology of cardiovascular disease in the 21st century, that 16.5 per cent of all deaths are attributed to arterial hypertension. Of those 51 per cent are due to stroke and 45 per cent due to coronary heart disease. (Santulli, 2013).

The prevalence of hypertension rises with age. Of people aged 60 to 65 more than 50 per cent are affected, while in age groups 70 years of age and older three-fourth are affected. (Chobanian et al, 2003)

In children hypertension has become more and more prevalent in recent years. Elevated blood pressure values in childhood commonly lead to the development of hypertension in adulthood. In children secondary hypertension is more likely than in adults. Most often secondary hypertension in children is associated with renal parenchymal disease and renovascular diseases. (Riley and Bluhm, 2012)

With the development of hypertension starting as early as childhood it is of paramount importance to start prevention as early as possible. An active and healthy life-style should be promoted and enforced in children.

Physical activity and physical fitness play an important role in achieving and maintaining health, since physical inactivity is considered the 4th leading risk factor for global mortality (2010). Recent studies have shown that as much as 12.2 per cent of all myocardial infarctions in the world’s population can be attributed to physical inactivity (Carnethon et al., 2005). It was proven that a sedentary lifestyle increases the risk of development of cardiovascular disease, type 2 diabetes and breast and colon cancer (Lee et al., 2012).

Multiple studies have established that physical inactivity is strongly positively associated with hypertension. Intervention studies have ascertained that increased physical activity is an effective treatment of high blood pressure in a variety of populations (Warburton et al., 2006). Thus to prevent the development of said diseases one should start prevention as early as possible. It is henceforth of paramount importance to establish and promote a healthy and active life-style early in life.

With the development of new technologies and an increasing amount of schoolwork, it has become more and more difficult for young children and adolescents to lead a healthy life. A study with 16.918 children age 11-15 years in Germany from 2002-2010 showed, that only 14 per cent of the girls and 19.9 per cent of the boys achieved the amount of recommended moderate-to-vigorous physical activity. It was also shown, that in adolescence there is a steady decline in physical activity and an increase in TV- and PC-screen-time (Bucksch et al., 2014). Another study evaluated the effect of physical exercise on mental health of children. The study showed that physical activity had a positive effect on depression, anxiety, psychological distress and emotional disturbance in children. It showed furthermore that the higher the intensity of the workout is, the greater the positive effect on mental health. Ahn et al. recommend a mix of high-intensity aerobic and resistance training exercises for optimum mental health of our children (Ahn and Fedewa, 2011).

The European Youth Heart Study determined that to prevent the development of insulin resistance and thereby cardiovascular risk factor clustering, at least 90minutes of moderate-to-vigorous physical exercise is required in children (Andersen et al., 2006).

The WHO currently recommends at least one hour of moderate to intense physical activity per day (2010).

A study published in the Journal of Paediatrics in 2005 by Strong et al. reviewed the effects of physical activity on health and behaviour outcomes, by doing a systematic literature review of 850 articles. The study discovered, using evidence-based data, that physical activity has strong beneficial effects on musculoskeletal health, cardiovascular health, adiposity and blood pressure in mildly hypertensive children. The authors came to the conclusion that children should perform at least 60minutes of moderate-to-vigorous physical activity every day, to achieve beneficial effects (Strong et al., 2005).

Another study proved that total physical activity was significantly and inversely associated with waist circumference, fasting insulin and triglycerides. Furthermore the study found significantly lower values of waist circumference, fasting insulin, fasting triglycerides and systolic blood pressure in individuals with higher levels of moderate-to-vigorous physical activity. In the study waist circumference was measured and showed up to 5,6cm difference in between the top and bottom percentiles for moderate-to-vigorous physical activity in children (Ekelund et al., 2012). Another study by T. Pischon et al. from 2008 found that an increase of 5cm in waist circumference in adults increases the relative risk for all cause-mortality in men and women by 17 per cent and 13 per cent (Pischon et al., 2008).

In today's society chronic diseases such as diabetes, arterial hypertension and cancer are more and more prevalent. It is thus important to identify the risk factors associated to chronic illnesses to prevent the development or progression. There are multiple hypotheses that speculate that chronic illness starts in childhood.

We therefore conducted a study to find out if there is a correlation between blood pressure and cardio-vascular risk factors, such as physical activity, BMI, body fat percentage in 8th grade students in northern Germany.

2. Literature Review

2.1 Physiology of blood pressure

Blood pressure regulation is required to ensure sufficient blood flow to organs and tissues during various states of physical activity.

Arteries deliver the oxygen-rich blood to organs and tissues, while veins transport the oxygen-depleted blood from organs and tissues to the right atrium of the heart.

The contraction of the left ventricle of the heart generates a pressure gradient in the circulatory system of the body; the elastic vascular system modulates this pressure gradient thus ensuring sufficient supply of all tissues and organs.

The function of the human heart is to pump oxygen-rich blood to the tissues and organs of the body and delivering oxygen-depleted blood to the lungs for gas exchange.

The heart pumps blood by means of rhythmical contractions.

The cardiac cycle consists of systole (contraction phase) and diastole (dilatation phase). Due to systole and diastole the arterial blood pressure is pulsatile in character.

The maximum increase in pressure wave is called systolic, minimal increase in pressure wave is called diastolic blood pressure.

During diastole the ventricles of the heart fill with blood. Closing of the pulmonic and aortic valve, and dilatation of the ventricular muscle mark the beginning of diastole. During the end of diastole the atrio-ventricular valves (mitral and tricuspid valves) close and aortic and pulmonic valve reopen.

During systole the ventricular muscle begins to contract. The pressure in the ventricle rises above the pressure in the surrounding vascular system thus opening the aortic and pulmonic valve. The blood is being ejected from the ventricles into the pulmonary circulation and the circulatory system of the body. The end of systole is marked by closing of aortic and pulmonic valve and beginning of dilatation of the ventricles.

Systolic blood pressure is determined by myocardial contraction speed, elasticity of arterial vessels close to the heart (windkessel function) and stroke volume.

The peripheral resistance of the blood vessels mainly determines the diastolic blood pressure.

Arterial blood pressure is the product of cardiac output and total peripheral resistance.

A change in arterial blood pressure is therefore either the result of a change in cardiac output or peripheral resistance.

Vasoconstriction and an increase in cardiac output lead to an increase in blood pressure, whereas vasodilatation and a decrease in cardiac output lead to decreased blood pressure.

Hypertension is thus the result of a shift of balance between cardiac output/ stroke volume and modified elasticity of the peripheral blood vessels.

Regulation of blood pressure is achieved via nervous, humoral and renal mechanisms. The goal is to maintain a constant basal blood pressure, thus ensuring adequate perfusion (Stimpel, 2001).

2.2. Measurement of blood pressure

There are invasive and non-invasive techniques for the measurement of blood pressure.

The maximum pulsatile pressure is the systolic blood pressure, while the minimum pulsatile pressure is being defined as diastolic blood pressure. During non-invasive blood pressure measurement an artery, usually the brachial artery, is being occluded by a mercury sphygmomanometer. This sphygmomanometer usually consists of a pneumatic cuff, which is connected to a column of mercury next to a scale.

The external pneumatic cuff is being inflated until the pressure in the cuff exceeds the pressure inside the artery and the artery collapses. The pressure inside the pneumatic cuff is then slowly reduced, until the blood in the artery can flow again. This occurs when the pneumatic cuff pressure is lower than the systolic pressure in the artery. With the recurrence of the blood flow in the arteries the Korotkoff sounds appear. This sound can be auscultated and gives you the systolic blood pressure value in millimetre quicksilver. When the Korotkoff sounds disappear the blood flow in the artery is continuous again, this is an estimate of the diastolic blood pressure value. This method of blood pressure measurement is still the gold standard for blood pressure measurement. Blood pressure is commonly measured in millimetre quicksilver (mmHg).

To achieve an accurate measurement using this technique proper training is necessary. The outcome during this procedure greatly depends on the correct selection of cuff size for the individual, furthermore it is important that the examiner has an adequate cognitive competency and is able to use his/her eye/hand/ear coordination accordingly.

The American Heart Association has specific guidelines for non-invasive blood pressure measurement. The patient should be comfortable seated with back supported, legs uncrossed and bare right arm. The cuff bladder is supposed to encircle at least 80 per cent of the patients' arm circumference. Furthermore the American Heart Association recommends that the arm of the patient should be supported at heart level (Pickering et al., 2005). Blood pressure should be measured in both arms while the child is in sitting position and in one leg while the child is in prone position. In both arms the blood pressure should be approximately

the same. While the blood pressure in legs is normally 10 to 20 mmHg higher(Riley and Bluhm, 2012).

Another non-invasive widely used technique is the use of automated oscillometric devices. This method uses the oscillations at cardiac frequency. “These oscillations in cuff pressure increase in amplitude as cuff pressure falls between systolic and mean arterial pressure. The oscillations then decrease in amplitude as cuff pressure falls below mean arterial pressure. The corresponding oscillation envelope function is interpreted by computer aided analysis to extract estimates of blood pressure.” (Babbs, 2012).

Invasive blood pressure measurement techniques are most commonly used in the clinical setting in intensive care units or in the operating theatre. The indication for use is very narrow due possible complications, such as infection and arterial embolism. For ambulatory blood pressure measurement invasive technique is not recommended.

During invasive blood pressure monitoring the mean arterial pressure is measured by insertion of a cannulised needle into an artery. The needle is connected to a fluid filled system and an electronic patient monitor. This allows a constant measurement of the mean arterial blood pressure.

2.3 Blood pressure in children and adolescents

In general children have lower blood pressure values than adults. Systolic and diastolic blood pressure rises with age and height. In children not only age and gender must be considered during evaluation of blood pressure but also the height of the child.

Blood pressure values usually rise more significantly within the first 10 years of life.

The American heart association defines hypertension in adults as a systolic blood pressure above 140 mmHg and diastolic blood pressure above 90 mmHg (Pickering et al., 2005).

In children a rigid definition like this is not applicable, since height, age and developmental stage of the child must be taken into consideration.

The Working Group on High Blood Pressure in Children and Adolescents defined hypertension as blood pressure in the 95th percentile or greater. Prehypertension was defined as blood pressure measurement over 120/80mmHg or between the 90th and 95th percentile for age, height and gender (Falkner and Daniels, 2004). In Hansen et al. study about the underdiagnosis of hypertension in children and adolescents the prevalence of hypertension in children age 3-18 was 3.6 per cent, while the prevalence of prehypertension in this age group was 3.4 per cent (Hansen et al., 2007).

Hypertension in children and adolescents is, after the diagnosis is being made, further divided into stage I and stage II hypertension. Stage I hypertension is defined by the National High Blood Pressure Education Program (NHBPEP) as systolic or diastolic blood pressure from the 95th percentile to <99th percentile plus 5mmHg, whereas stage II is classified as >99th percentile plus 5 mmHg (Riley and Bluhm, 2012).

2.4 Cardiovascular risk factors

A study about the prevalence of hypertension and pre-hypertension among high-school students by McNiece et al done in 2007 found that the prevalence of pre-hypertension and hypertension was more than 30 per cent in the obese male study population and 23-30 per cent in the obese female study population (McNiece et al., 2007).

Falkner et al. analysed the data collected in the National Childhood Blood Pressure database of adolescents who underwent blood pressure measurement at 2 and 4 year intervals. The analysis showed that 14 per cent of adolescents with pre-hypertension had developed hypertension 2 years later. Of the adolescents with a high-risk blood pressure measurement 68 per cent of the male and 43 per cent of the female population progressed to pre-hypertension or hypertension within 2 years. This data indicates that adolescents with pre-hypertension continue to have elevated blood pressure or even progress to hypertension (Falkner et al., 2008).

Falkner et al found that being overweight and obesity correlate strongly with primary hypertension in children. Other risk factors found were maternal smoking during pregnancy, male gender and a family history of cardiovascular disease (Falkner et al., 2006).

Atherosclerotic disease is one of the major causes of death in adults in Western society. The Bogalusa Heart study proved that the development of atherosclerotic disease begins in early childhood (Berenson et al., 1998).

The occurrence of type 2 diabetes in adolescence is rising. It is the most common form of diabetes in the world (>90 per cent). It is associated with an increased risk of cardiovascular disease.

2.5 Physical activity

The WHO defined physical activity as “any bodily movement produced by skeletal muscles that requires energy expenditure“. Physical inactivity is estimated to cause 3.2 million deaths globally and has been identified as the fourth leading risk factor for global mortality (2010). According to WHO 31 per cent of adults didn’t meet the global recommendations for physical activity. This is partly due to an increase in the use of motorized modes of transportation as well as due to sedentary lifestyle during occupational and domestic activities. A study conducted by the WHO in 2008 showed that in the Americas and Eastern Mediterranean Region 50 per cent of women didn’t meet the recommended amount of physical activity.

2.6 Guidelines for physical activity

The current guidelines of the WHO recommend at least 60 minutes of moderate-to-vigorous exercise daily for the age group of 5-17 years. Furthermore it is advised that most physical activity should be aerobic in nature. Vigorous-intensity workouts that strengthen the muscles and bones should be additionally performed at least 3 times per week. The guidelines are independent of gender, race or ethnicity and can be applied to all children. Children who do not meet these criteria should be encouraged to gradually increase their daily physical activity until the criteria are met. According to WHO being physically active less than the global recommendation is still more beneficial than not being active at all (2010).

2.7 Effect of physical activity on cardio-metabolic risk

In 2010 Janssen et al. published the results of a systematic literature review about the health benefits of physical activity and fitness in school-aged children. The data collected showed that physical activity has beneficial effects on adiposity, musculoskeletal health and fitness, as well as several components of cardiovascular health. The evidence-based data furthermore illustrated that physical activity has beneficial effects on adiposity levels in children with normal body weight. Physical activity has, furthermore, a positive effect on blood pressure in normotensive children, as well as on plasma lipid and lipoproteins levels. The study also analysed the effect of physical activity on non-traditional cardiovascular risk factors, such as inflammatory markers, endothelial cell function as well as heart rate variability. A positive correlation between these factors and physical activity could be confirmed (Janssen and Leblanc, 2010).

Meyer et al conducted a study with 96 obese children in Germany. The aim of the study was to assess the effect of a 6-month interventional exercise program in obese children on flow-mediated vasodilatation, thickness of the intima-media as well as cardiovascular risk factors. In this study the exercise regime significantly improved intima-media thickness of the carotid artery and showed an improvement of endothelium-dependant vasodilatation of the radial artery. Furthermore a significant reduction of body weight, blood pressure, insulin resistance and waist/hip ratio was found. The authors suggested that exercise could have an immediate effect on vascular condition, which is of paramount importance for the pathogenesis of early atherosclerosis. Additionally the data found in this study showed a reduction in systolic blood pressure and left ventricular mass after 6 month of exercise. This, so the authors hypothesized, could be due to a reduction in arterial stiffness, thereby promoting an improvement of vascular response and by weight reduction a reduction in blood volume in obese children. The size of the left atrium is known to be a risk factor for cardiovascular outcome. Meyer et al further found that there is an increase in inflammatory markers in obese children. A positive correlation between inflammatory markers and BMI, body fat percentage, insulin resistance and blood pressure is well known. It has been suggested that inflammation might disturb the endothelial cell function and promotes thickening of intima-media. This would affirm that inflammation is involved in the early stages of pathogenesis of atherosclerosis (Meyer et al., 2006).

2.8 Physical fitness

VO₂ max is defined as the highest rate of oxygen consumption attainable during maximal or exhaustive exercise. It is the measure of the maximum volume of oxygen that an individual can use. It is measured in millilitres per kilogramme of body weight per minute (ml/kg/min)(Bassett and Howley, 2000).

The point at which oxygen consumption plateaus defines the VO₂ max, maximal aerobic capacity. It is generally considered the best indicator of cardiorespiratory endurance and aerobic fitness. Higher VO₂ max is indicative for more favourable cardiorespiratory fitness. Part of physical fitness is attributed to genetics, such as large chest size in relation to body size and strong respiratory muscles. According to Guyton and Hall maximal exercise results in an increase of heart rate and stroke volume to ca. 95 per cent of their maximal levels. Cardiac output reaches 90 per cent of the maximum that a person can achieve during maximum exercise. But this equals only 65 per cent of the maximum pulmonary ventilation a person can achieve. This shows that the cardiovascular system is more limiting on VO₂max,

than the respiratory system is. The body can only utilize oxygen at the rate at which the cardiovascular system transports it. This in turn means, that athletic performance depends much more on the performance capability of the heart (Guyton and Hall, 2011).

There are multiple factors affecting VO_2 max. Factors can be divided into demand and supply. For one we have the transport of oxygen to the lungs and from there to mitochondria (supply). This pathway includes factors, such as stroke volume, blood volume and lung diffusion. Demand on the other hand would be the ability of mitochondria to convert oxygen into energy. There are additional other factors, such as age, sex, pulmonary diffusion capacity, oxygen carrying capacity and capillary density (Bassett and Howley, 2000).

3. Objectives

The main objective of this study was to analyse the correlation between blood pressure and physical fitness in 8th grade students.

The aims were to determine a correlation between blood pressure and physical activity, determine a correlation between waist circumference and blood pressure. Further aims were the determination of a correlation between body mass index and blood pressure and a determination of a correlation between body fat percentage and blood pressure.

4. Materials and Methods

The data collection was conducted from January 2014 till February 2014 at 29 schools in the federal state of Schleswig-Holstein, northern Germany.

4.1 Participants and Design

This study was part of the “läuft”-study-program. The “läuft”- program is a 12-week physical activity program, designed by a team of psychologists, sports medicine specialists, as well as nutritional scientists, sport scientists and teachers, for teenagers in 8th grade to promote physical activity in children. Part of the “läuft”-study-program was to evaluate the effect of an interventional physical activity program for students. In the context of the “läuft”-study, baseline data was acquired (Suchert et al., 2015). The baseline data was subsequently used for this cross-sectional study.

For the “läuft”-study the data was collected at baseline as well as 3month and 1 year after the 12weeks intervention-period. Our study only uses the baseline data collected.

During the “läuft” project students were divided into control and intervention group. For the intervention group a 12-week physical activity program was realized. The activity program consisted of pedometer (Omron Walking Style One 2.1) use for evaluation of daily physical activity. Furthermore classes received four educational lessons during which ideas how to be more physically active were created. The students participated in two class competitions. One competition involved collection of the most steps during 3 given weeks, in the other competition the most creative class project to assimilating the most steps was awarded. Also all teachers and parents received information material.

Prior to data collection invitation letters and information sheets about the study were sent to all secondary schools from 6 selected districts in Schleswig-Holstein and informed consent for the storage and collection of the data was collected from the parents. Schools for disabled students were not included in the study. In total 134 schools were invited to participate. 29 secondary schools with 69 classes and 1489 students were willing to participate. The target were 8th grade classes, with students aged 12 to 17 (Suchert et al., 2013).

The data of a total of 1296 students was collected. 193 students had to be excluded due to missing data. 136 students missed the parental consent, another 52 were absent during data collection and 5 students left the school in the following month.

52.23 per cent of the study population was male. The mean age was 13,71 years, the youngest participant was 12 years old, whereas the oldest was 17 years of age. The mean age for the

female and male study population was almost identical at 13.71 years of age. 57.06 per cent of the students went to community school and 42.94 per cent went to secondary school.

The study was approved by the Ministry of School and Professional Education of the Land Schleswig-Holstein, as well as the ethics committee of the German Psychological Society.

4.2 Outcomes and analysed items

The items collected for this study were blood pressure, gender, age, weight, height, body mass index, body fat and waist circumference. Additionally students were asked to participate in a 20m-Shuttle-Run-Test to assess physical fitness. A self-administered questionnaire was used to assess the daily physical activity of each student.

Standing height was determined by use of a portable stadiometer (Seca 213, Basel, Switzerland). Bioelectrical impedance analysis (Omron BF-511, Omron Healthcare, Mannheim, Germany) was used for determination body fat. For weight measurement an electrical scale (Omron BF-511, Omron Healthcare, Mannheim, Germany) was used.

The students' body mass index was calculated and converted into gender- and age-specific percentiles using the Kromeyer-Hauschild-percentiles as reference (Suchert et al., 2013, Suchert et al., 2015).

Blood pressure was being measured prior to physical exercise using an automated oscillometric device (M5-Professional, Omron Healthcare, Mannheim, Germany). The blood pressure was measured twice for each individual. We calculated the mean systolic and diastolic blood pressure from the two blood pressure measurements. For further analysis of minimum and maximum blood pressure values, the lower blood pressure was used. Blood pressure percentiles were adjusted according to NHBPEP (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents).

For determination of waist circumference a flexible measuring-tape was used. Waist circumference was measured at the medial axillary line halfway between iliac crest and lowest rib (2000).

The 20m-Shuttle-run test was conducted to measure cardiorespiratory fitness and obtain VO_2 max. The 20m-Shuttle-run-test is a progressive running test, in which subjects must run back and forth between two lines on a 20m course. The subjects must cross each line in a given time. For this a pre-recorded sound signal is emitted. The initial running speed is 8.0 km/h. The frequency of the sound signal is increased by 0.5km/h every minute. When the subject fails to cross the line in time for the sound signal twice the test is stopped and the last stage announced is used to determine the aerobic capacity.

Maximal oxygen uptake is calculated using the following formula: $VO_{2max}=31.025+3.238x-3.248a+0.1536ax$, where x is speed in km/h and a is age in years.

Using the 20m shuttle run test allows a validated estimation of maximal oxygen uptake as indicator for cardiovascular fitness (Leger et al., 1988, Mahar et al., 2011).

For the self-administered questionnaire items of the MoMo-activity questionnaire (Falkner and Daniels, 2004) were used (Fig. 22-33). The questionnaire gave an insight into physical activity of a regular week in the child' life. The questionnaire asks, among other things, about how students spent their time during recess, how they commuted to school, what household-chores students had to do at home, as well as participation in sports club outside of school. The determination of physical activity in the students' life was achieved by using a two-item screening (Hansen et al., 2007). Most recent school day and Sunday were evaluated for physical activity during leisure time (Suchert et al., 2015).

All data collection was conducted under the supervision of a physician. Children with pathological results were informed by the participating physicians and received a letter for their parents. A check-up was suggested for those students.

4.3 Statistical analysis

All statistical analyses were conducted with Stata 14 (Stata Corp, College Station, TX).

Multilevel mixed-effects regression analyses were applied to evaluate effects of physical activity, body mass index, waist circumference, physical fitness and body fat percentage on blood pressure.

Multilevel mixed-effects regression analyses describe the directed correlation of a characteristic against various other variables. Thereby, the specific influence of each variable in relation to the characteristic is measured.

The two-sample t-test (Snedecor and Cochran, 1989) was used to determine gender differences in body fat, waist circumference, blood pressure, physical activity, body mass index and cardiorespiratory fitness.

Cohen's d was calculated for physical activity, body mass index, waist circumference, physical fitness and body fat percentage to evaluate effect strength on blood pressure. Like Cohen suggested in 1988 d=0.2 meant small effect, d=0.5 meant medium effect and d=0.8 meant large effect. Cases with missing data were excluded from the analysis.

5. Results

5.1 Study population

In this study 1141 individuals were analysed. Males made up 52.23 per cent of the study population (Fig.1). The mean age of the study population was 13,71 years, the youngest participant was 12 years old, whereas the oldest was 17 years of age (Fig.2). The mean age for the female and male study population was almost identical at 13.71 years of age (SD +/- 0.669).

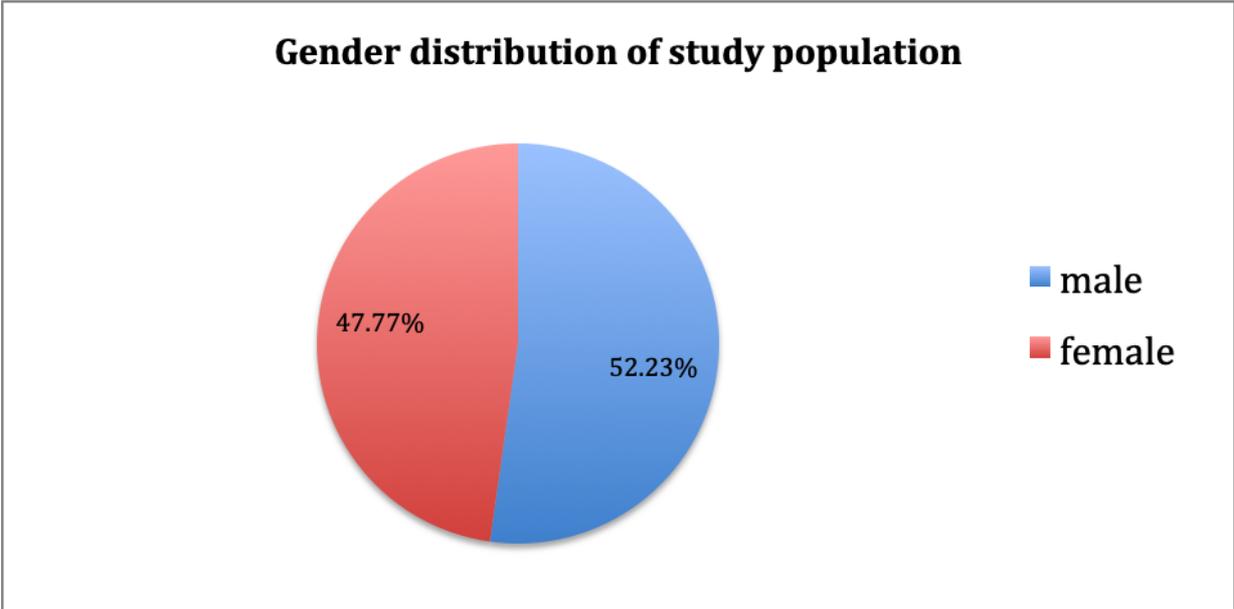


Figure 1: shows the gender distribution of the study population made up of 1141 individuals

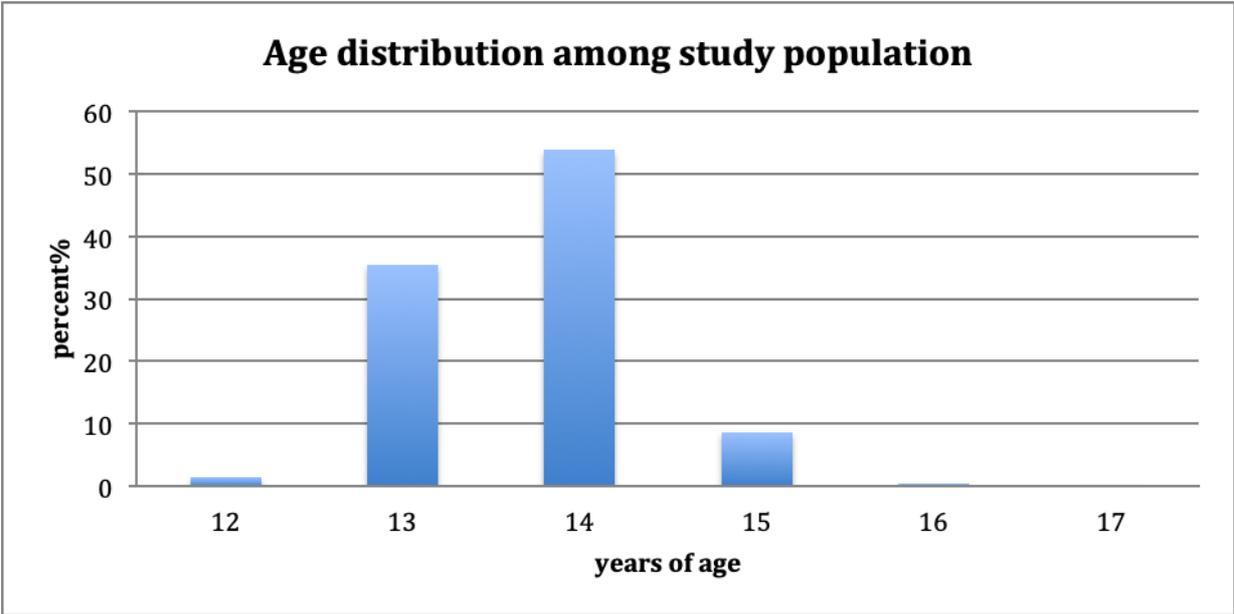


Figure 2: shows age distribution among study population of 1141 students in percentage

Of the 1141 individuals 57.06 per cent went to community school and 42.94 per cent went to secondary school.

5.2. Waist circumference

1138 students had their waist circumference measured. The mean circumference was 71.62 cm, the smallest circumference measured 39.2cm, the biggest 122.2cm. Of the students who had their waist circumference measured 594 were boys, here the mean circumference was 73.10cm. For the 544 girls the mean waist circumference measured was 69.99cm. There was a significant statistical difference between the waist circumference of male and female students ($p < 0,001$) (Tab. 1).

	n	Mean	Std. dev.
Boys	594	73.10774	9.74212
Girls	544	69.99044	9.236569*
Combined	1138	71.61757	9.626531

* $p < 0.0001$

Table 1: Two-sample t-test with equal variance for gender and waist circumference

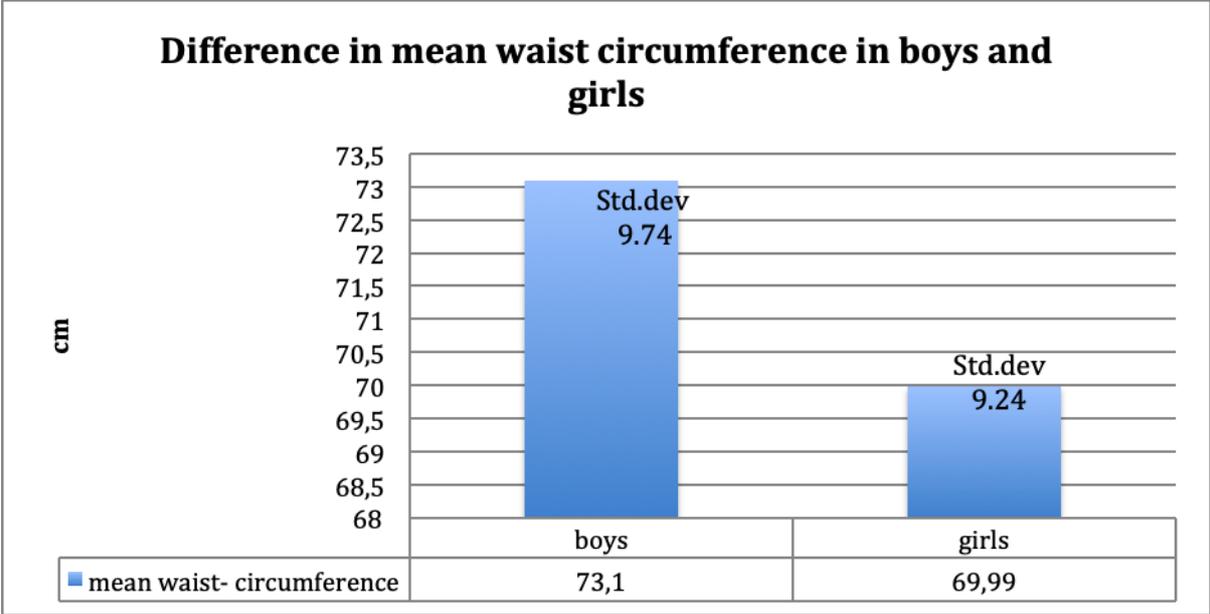


Figure 3: shows the gender difference in mean waist circumference

5.3. Body mass index

For those 1138 students who were measured the body mass index was also calculated. The mean body mass index was 20.98 kg/ m², the minimum value for body mass index was 12.6 and maximum was 47.03kg/ m².

The statistical analysis showed no significant difference between the body mass index of boys and girls (p=0.8305).

Using the chi-square-Test it was found that pathological or normal blood pressure values (mean systolic and mean diastolic values) are dependant on body mass index-percentile (p<0.0001)(Table 2 and 3).

Mean diastolic blood pressure	BMI <10th percentile	BMI 10th-90th percentile	BMI >90th percentile	Total
Normal blood pressure	45	841	174	1060*
Elevated blood pressure	3	37	36	76*
Total	48	878	210	1136

*p<0.0001

Table 2: chi-square-Test for dependency of diastolic blood pressure and BMI-percentile

Mean systolic bp	BMI <10th percentile	BMI 10th-90th percentile	BMI >90th percentile	Total
Normal bp	43	753	136	932*
Elevated bp	5	125	74	204*
Total	48	878	210	1136

*p<0.0001

Table 3: chi-square-Test for dependency of systolic blood pressure and BMI-percentile

5.4. Body fat percentage

The body fat percentage of 1096 students was obtained. The minimum percentage measured was 5 per cent, the maximum 49.5per cent; the mean body fat percentage of the students was 20.25 per cent. Of those 1096 students 540 were girls, the girls mean body fat percentage was 24.52 per cent, the boys mean body fat percentage on the other hand was 16.09 per cent. There was a significant statistical difference between the body fat percentage of male and female students with $p < 0,001$ (Fig. 4).

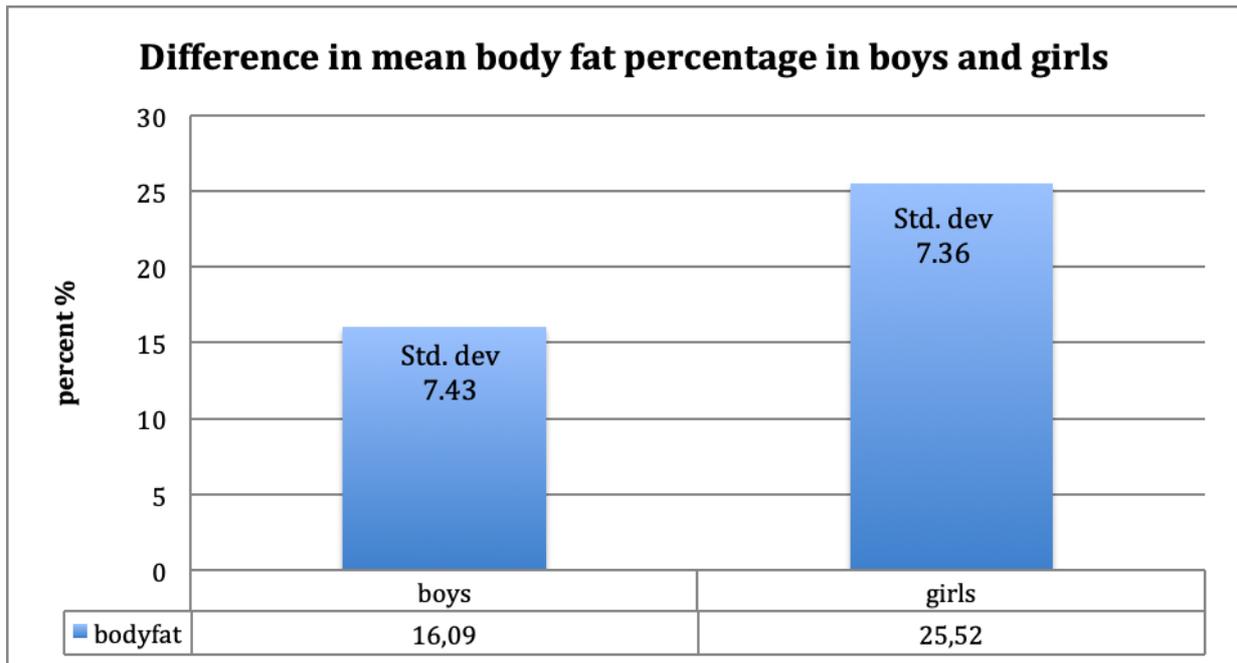


Figure 4: shows difference in mean body fat percentage in boys and girls

5.5. Weekly physical activity

By using the aforementioned questionnaire it was possible to obtain data concerning the physical activity of the participating students. In total 1141 were analysed for weakly physical activity. 20 individuals had to be excluded for not answering the questionnaire sufficiently. The mean weekly physical activity of the remaining 1121 students was 4,07 days per week. The mean weekly activity for boys was 4.21 days per week, whereas girls were less active with a mean weekly physical activity of 3.91 days of moderate to vigorous exercise per week (Tab. 3). The data showed a significant difference in weekly physical activity amongst boys and girls ($p=0,0028$). A statistical significance was being defined as $p<0,05$. Physical activity was defined as at least 60 minutes of moderate to vigorous exercise per day.

	n	Mean	Std. dev.
Boys	587	4.214651	1.72907
Girls	534	3.91573	1.599254*
Combined	1121	4.072257	1.674426

* $p= 0.0028$

Table 3: Two-sample t-test with equal variance for weekly physical activity in boys and girls

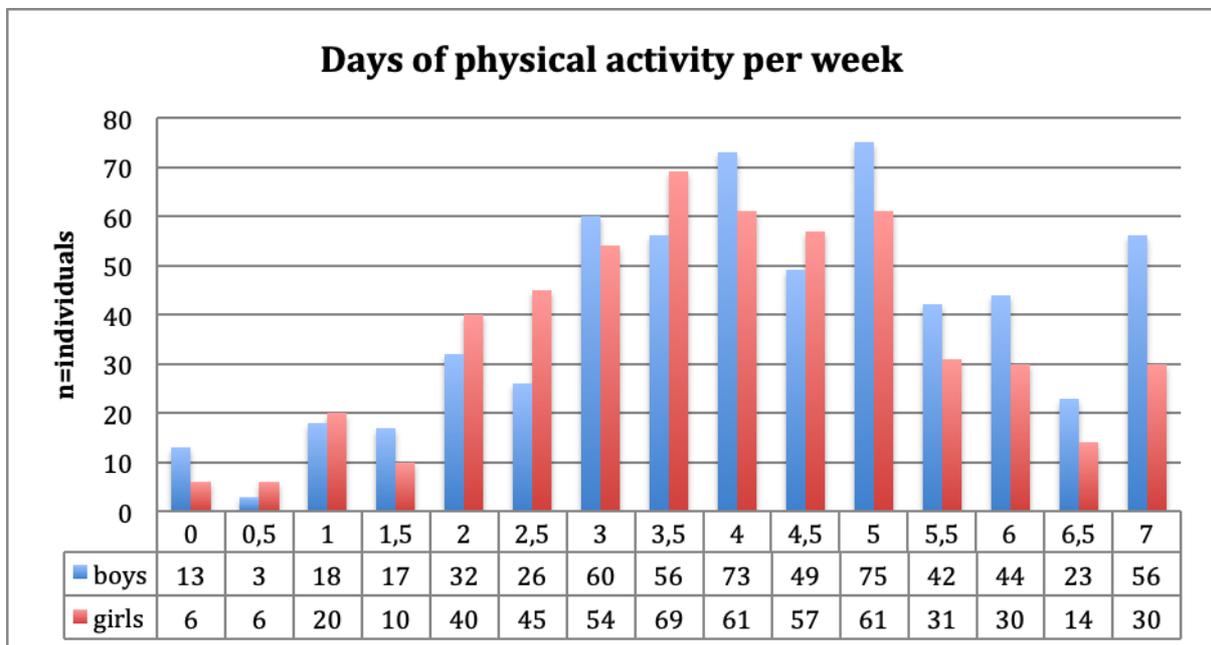


Figure 5: days of physical activity (at least 60 min of moderate/vigorous activity per day) per week divided by gender

5.6. Systolic blood pressure

1225 students had their blood pressure taken. The systolic blood pressures' mean value was 120.28 mmHg, ranging from 70mmHg to 164.5mmHg. For 1139 students (595 boys, 544 girls) a systolic mean value was calculated. For 86 students the mean systolic blood pressure could not be calculated because only one measurement was taken. Of those 1139 students with calculated mean systolic blood pressure 205 students showed elevated systolic blood pressure for their age and height. Of those 205 students with elevated systolic blood pressure 124 were male. Two-sample-T-Test-analysis showed that there was a statistically significant ($p < 0.003$) difference between the male and female study population when analysing the mean systolic blood pressure values.

Using the chi-square-Test it was established that there is a dependence of normal and pathological mean systolic blood pressure values and gender ($p < 0.009$).

Mean systolic blood pressure	Boys	Girls	Total
Normal blood pressure	471	463	934
Elevated blood pressure	124	81	205*
Total	595	544	1139

* $p = 0.009$

Table 4: chi-square-Test for dependency of systolic blood pressure in boys and girls

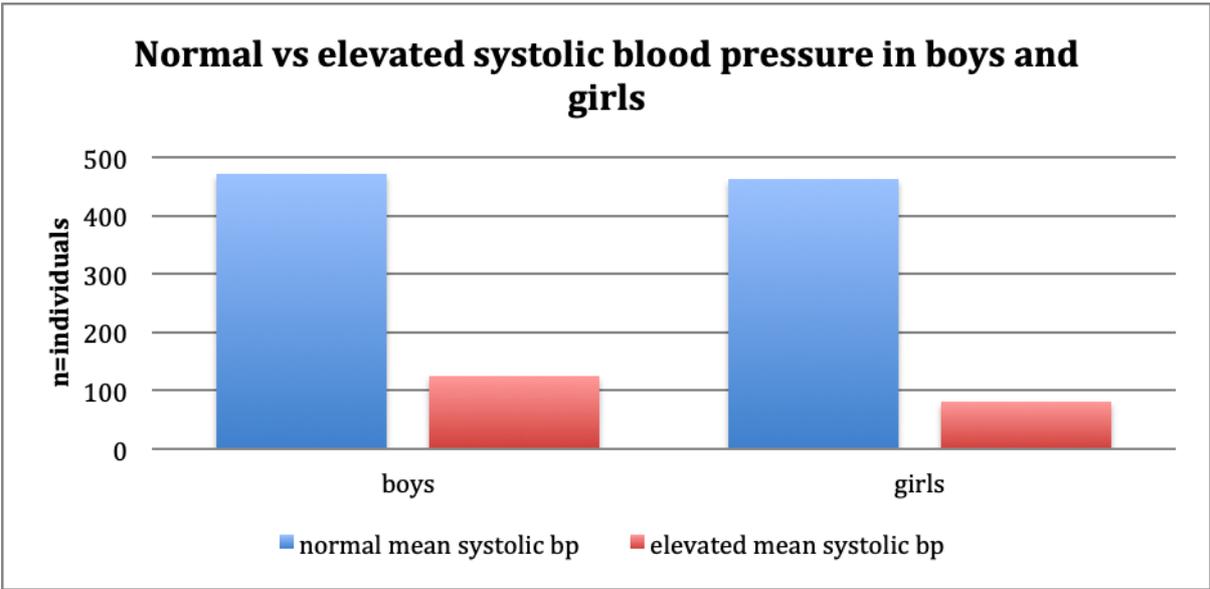


Figure 6.: shows difference of normal and elevated mean values in boys and girls

5.7. Diastolic blood pressure

For the diastolic blood pressure 2 students had to be excluded due to failure of obtaining a value. For the remaining 1223 students the mean diastolic blood pressured ranged from 32mmHg to 107mmHg with an average 68.15mmHg calculated. For 84 students the mean diastolic blood pressure could not be calculated since only one measurement was taken. Hence the mean value of diastolic blood pressure of 1139 students was obtained. Of those mean values 76 were elevated, 43 of the elevated values were from girls.

Two-sample-T-Test-analysis showed that there was a statistically significant ($p < 0.001$) difference between the male and female study population when analysing the mean diastolic blood pressure values.

Using the chi-square-Test it was established that there is no dependence of normal and pathological mean diastolic blood pressure values and gender ($p = 0.111$).

Diastolic blood pressure	Boys	Girls	Total
Normal blood pressure	562	501	1063
Elevated blood pressure	33	43	76*
Total	595	544	1139

* $p = 0.111$

Table 5: chi-square-Test for dependency of diastolic blood pressure and BMI-percentile

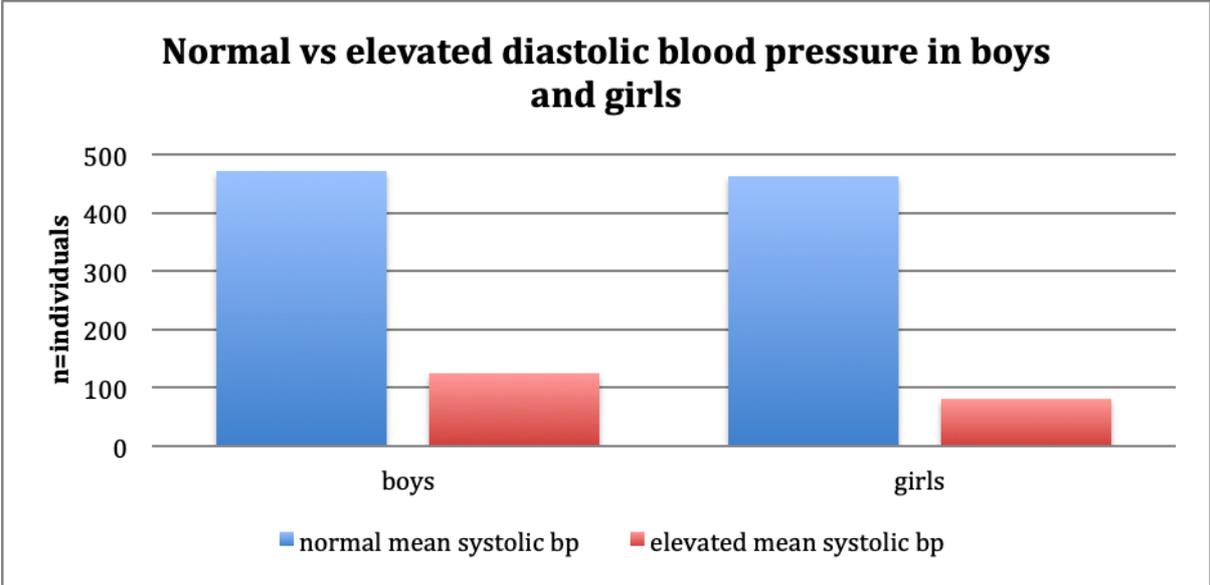


Figure 7: distribution of normal and elevated systolic blood pressure in boys and girls

5.8. Physical fitness

The physical fitness (VO₂max) was obtained after the shuttle-run-test by using the model of Maher et al (2011) for calculation. 1067 students participated in the shuttle-run-test and were therefore analysed. The mean physical fitness of the total study population was 47.73 ml O₂/min, the minimum was 17.43 ml O₂/min and the maximum 58.19 ml O₂/min. Of the 1067 students who were analysed 559 were boys, the mean VO₂ max for this group was 51.36ml O₂/min. 508 girls were analysed, the mean physical fitness was calculated to be 43.73ml O₂/min. There is a highly significant difference between physical fitness in the male and female study population, p<0.001.

	n	Mean VO₂max	Std. dev.
Boys	559	51.35941	4.897157*
Girls	508	43.72875	5.250884*
Combined	1067	47.72644	6.340664

*p<0.0001

Table 6: Two-sample t-test with equal variance for VO₂max

5.9 Regression analysis

The regression analysis showed a statistically significant ($p < 0.001$) negative relation between mean diastolic blood pressure and weekly physical activity (regression coefficient = $-1,7272$). Meaning that for a one unit change in physical activity the mean diastolic blood pressure would change by $-1,7272$ mmHg.

There was no statistically significant relation ($p = 0.807$) by regression analysis found between the mean systolic blood pressure and weekly physical activity.

In Figure 8 the regression line of physical activity and diastolic blood pressure is seen.

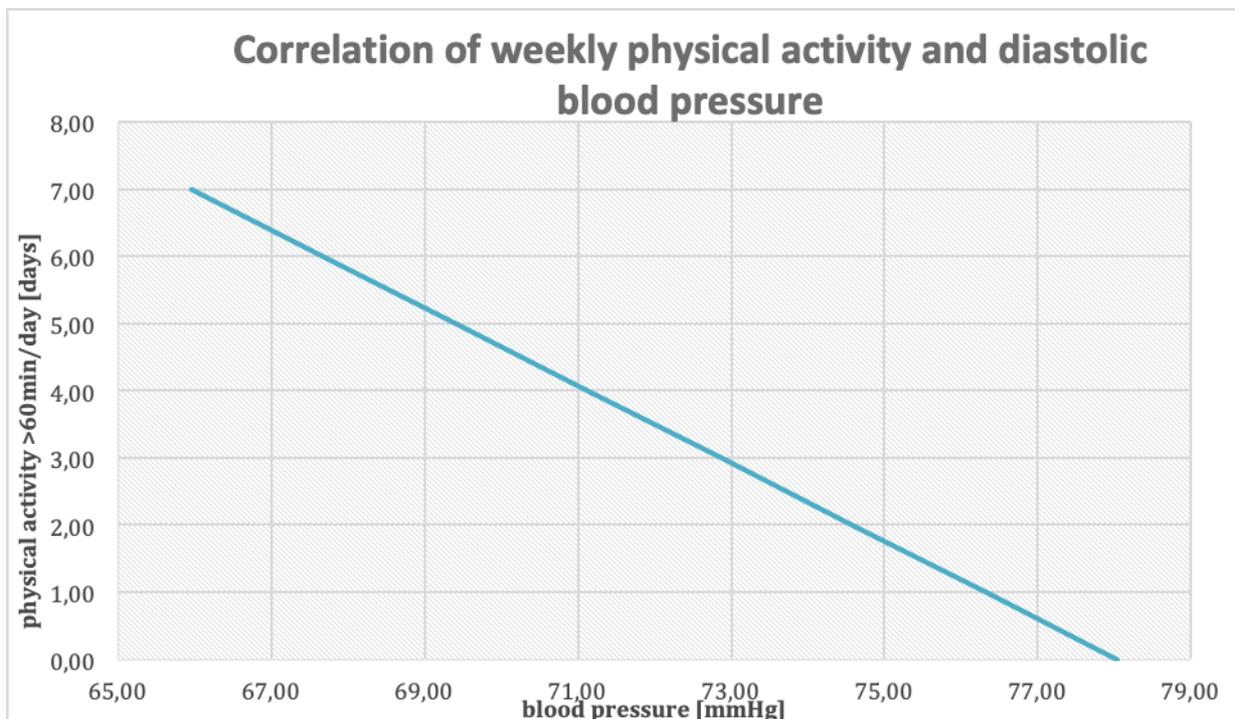


Figure 8: correlation of physical activity and mean diastolic blood pressure

Regression analysis for waist circumference and mean systolic blood pressure showed a statistically significant positive relation ($p < 0.001$, regression coefficient = 0.6974). Additionally the regression analysis for mean diastolic blood pressure and waist circumference showed a statistically significant positive relation ($p < 0.001$, regression coefficient = 0.5925). In Figure 9 and 10 regression line of waist circumference and mean systolic and diastolic blood pressure is shown.

For a one-unit change in waist circumference the mean diastolic blood pressure would change 0.5925 mmHg, whereas the mean systolic blood pressure would change by 0.6974 mmHg.

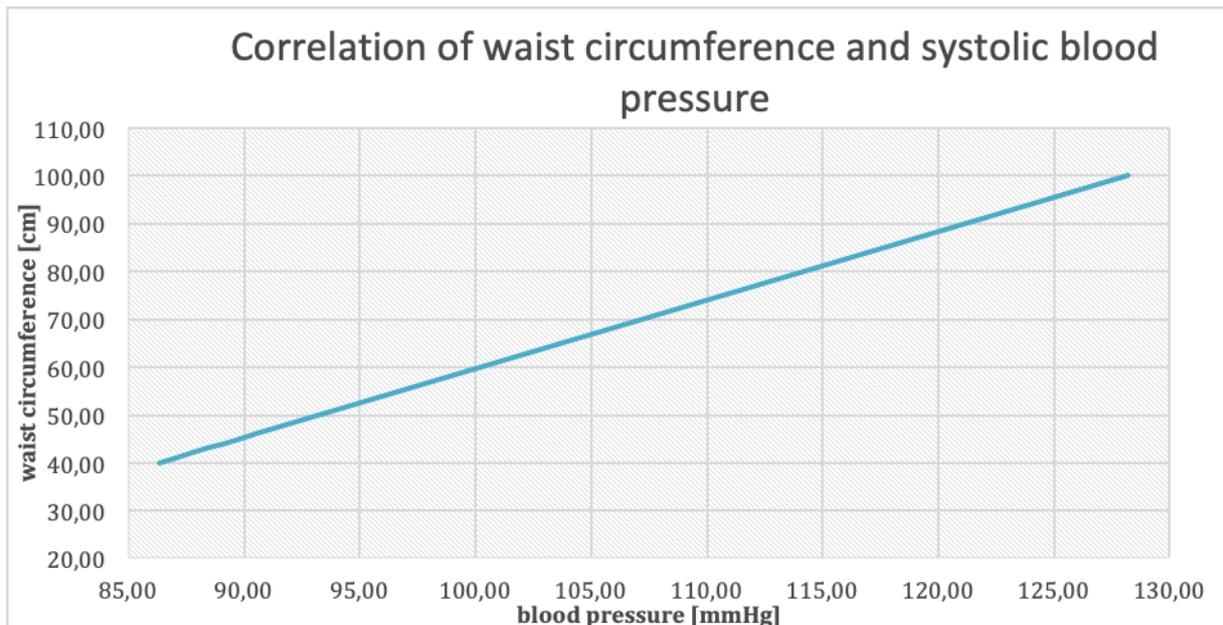


Fig. 9: correlation of waist circumference and mean systolic blood pressure

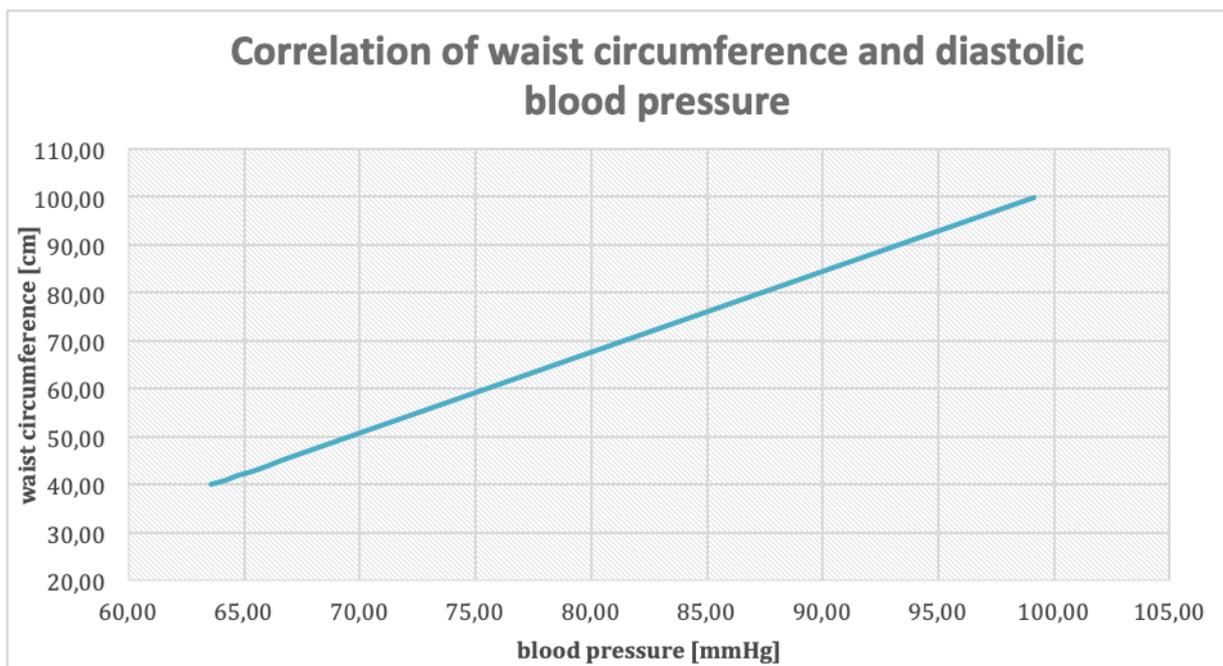


Figure 10: correlation of waist circumference and mean diastolic blood pressure

For mean systolic and mean diastolic blood pressure and BMI percentile, the regression analysis showed a statistically significant positive relation, $p < 0.001$.

For one unit change in body mass index percentile, the mean diastolic blood pressure would change 0.1340mmHg, while the systolic mean blood pressure would change 0.2668mmHg, the regression coefficient for mean diastolic blood pressure being 0.1340, and the coefficient for systolic mean blood pressure being 0.2668.

Figure 11 and 12 show the regression line of BMI percentile and mean systolic and diastolic blood pressure.

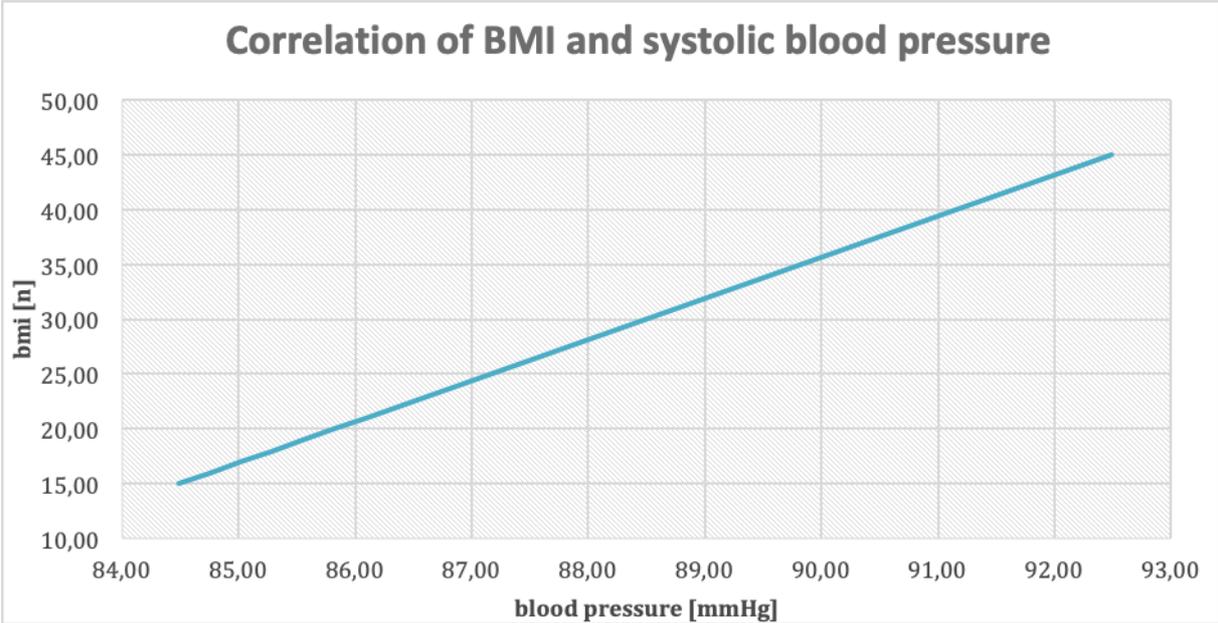


Figure 11: correlation of BMI percentile and mean systolic blood pressure

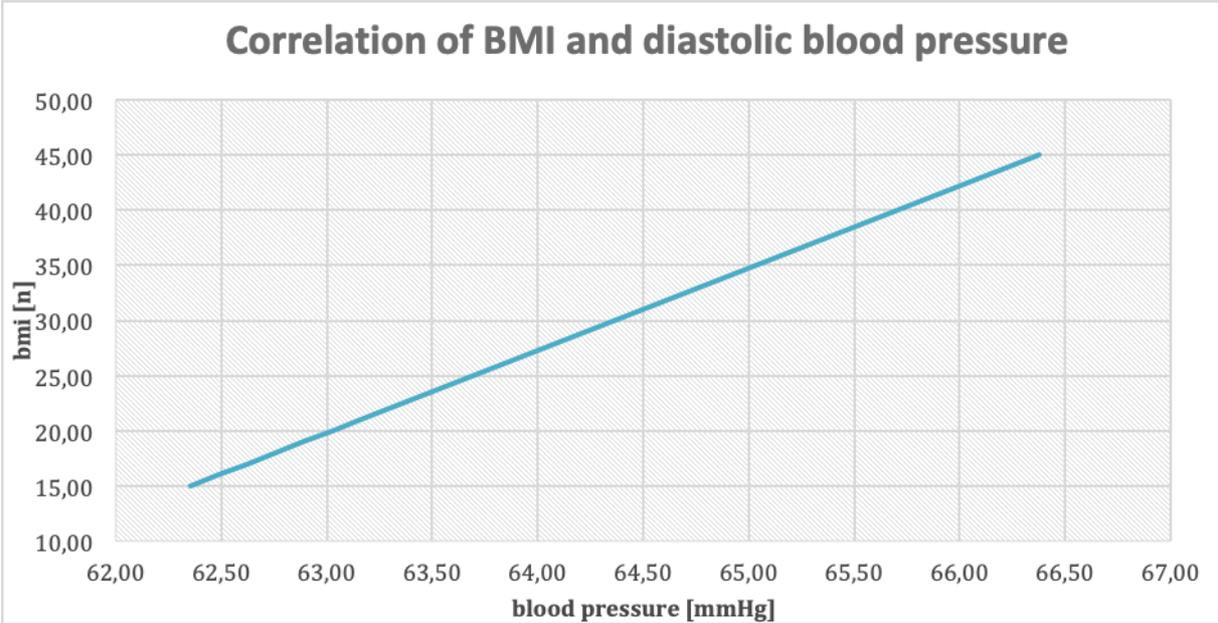


Figure 12: correlation of BMI percentile and mean diastolic blood pressure

During analysis of body fat percentage and blood pressure the regression analysis proved a statistically significant relation between mean diastolic blood pressure and body fat percentage, as well as between mean systolic blood pressure and body fat percentage ($p < 0.001$). In Figure 13 and 14 the regression line of body fat percentage and mean systolic and diastolic blood pressure is seen.

The regression coefficient for mean diastolic blood pressure and body fat percentage was 0.9173. For one unit of change in body fat percentage the mean diastolic blood pressure would change 0.9173mmHg.

The regression coefficient for mean systolic blood pressure and body fat percentage was 0.7429.

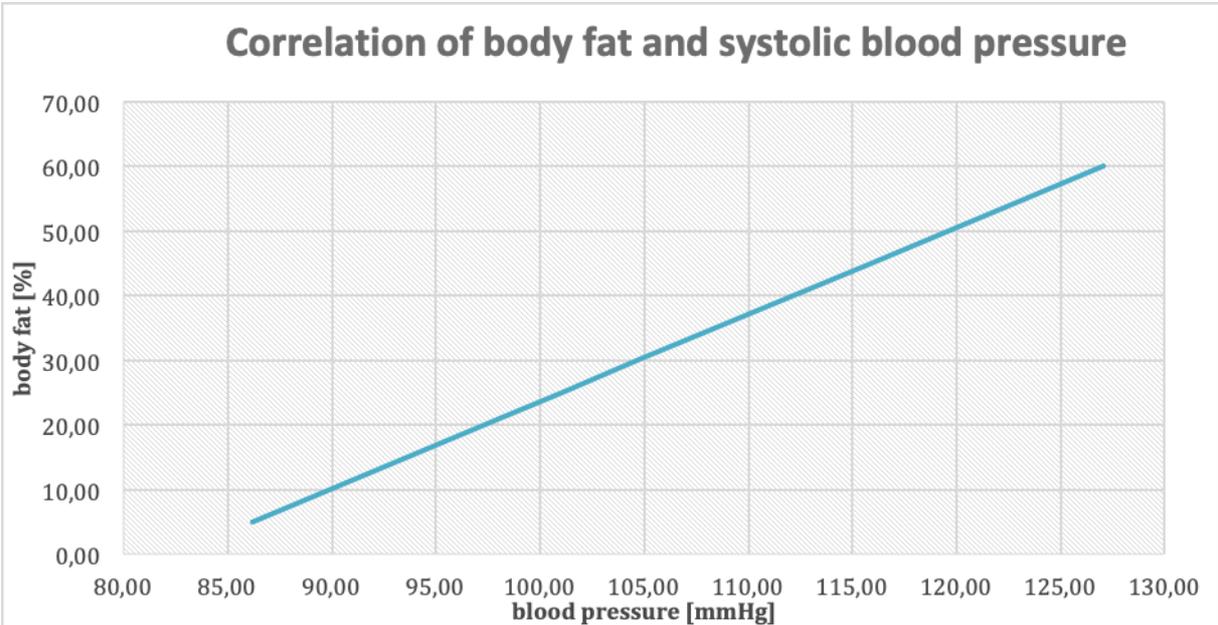


Figure 13: correlation of body fat percentage and mean systolic blood

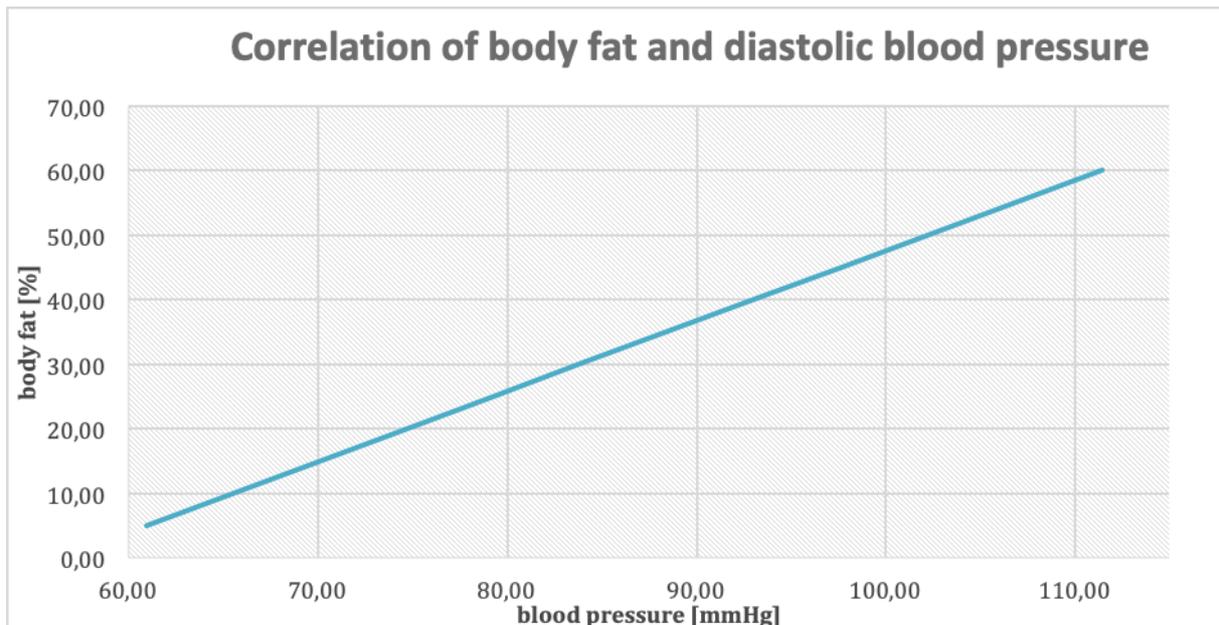


Figure 14: correlation of body fat percentage and mean diastolic blood pressure

Additionally the regression analysis showed a statistical significant relation ($p < 0.001$) between physical fitness and mean systolic blood pressure. The regression coefficient was -0.9423 , meaning for a one-unit change in $VO_2\text{max}$ the systolic blood pressure decreased by 0.9423 mmHg. In conclusion the higher the physical fitness, the lower the mean systolic blood pressure.

Similar results were found for the mean diastolic blood pressure. There was a statistical significant relation found between physical fitness and mean diastolic blood pressure ($p < 0.001$). The regression coefficient was -1.1579 , meaning for a one-unit change in $VO_2\text{max}$ the diastolic mean blood pressure changes by -1.1579 mmHg. In Figure 15 and 16 the regression line of physical fitness and mean systolic and diastolic blood pressure is seen.

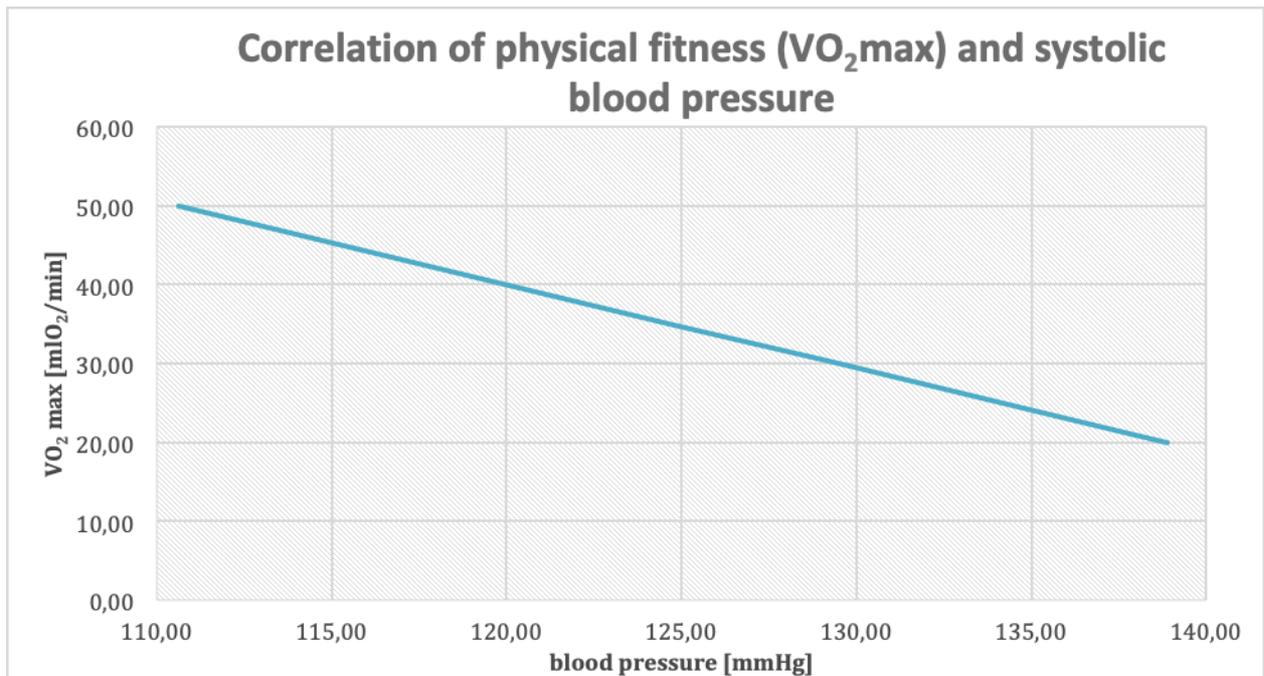


Figure 15: correlation of physical fitness and mean systolic blood pressure

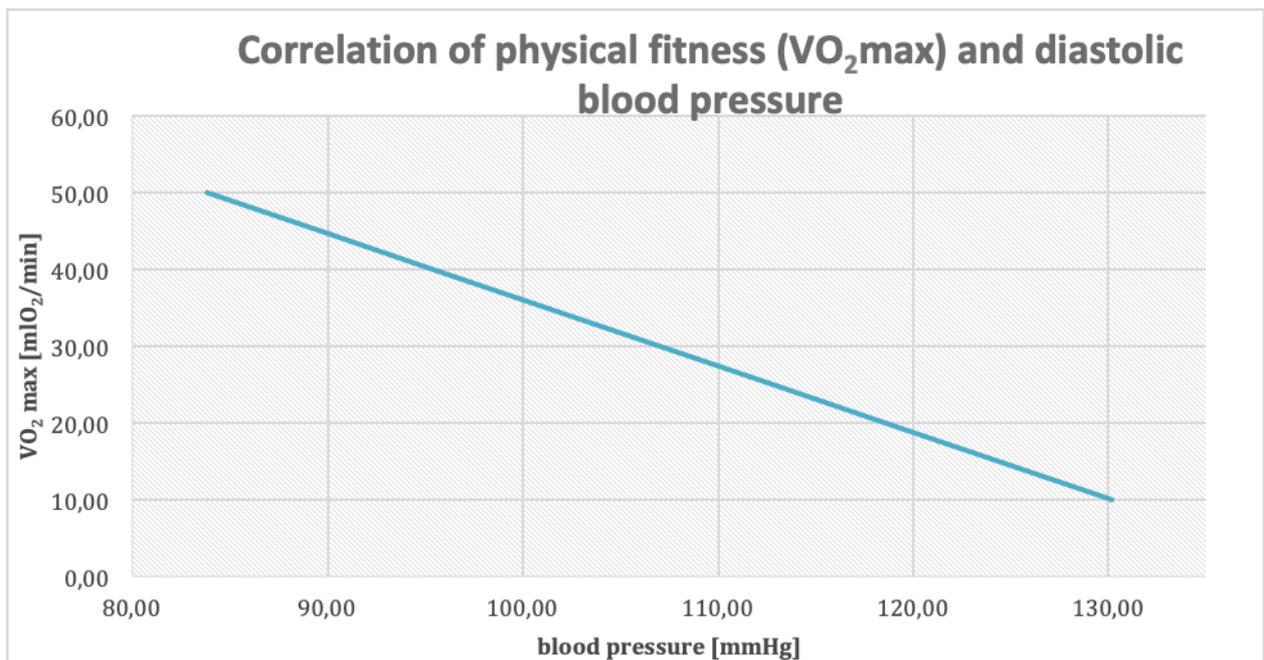


Figure 16: correlation of physical fitness and mean diastolic blood pressure with regression line

5.10 Correlation analysis of mean blood pressure and co-variants

The statistical analysis showed no correlation between physical activity and mean systolic blood pressure ($p=0.8214$), but a correlation between mean diastolic blood pressure and physical activity was found ($p<0.001$).

The statistical analysis showed that there is a strong correlation between waist circumference and systolic blood pressure, as well as waist circumference and mean diastolic blood pressure ($p<0.001$). See Figure 10 and 11 for the correlation graph of mean systolic and mean diastolic blood pressure and waist circumference with regression line.

There is a strong correlation between mean systolic and diastolic blood pressure and BMI percentile ($p<0.001$)

The statistical analysis showed a strong correlation between mean systolic and diastolic blood pressure and body fat percentage (mean systolic blood pressure and body-fat percentage $p=0.0178$; mean diastolic blood pressure and body fat percentage $p<0.001$).

There was no correlation found between mean systolic blood pressure and physical fitness ($p=0.381$), but the statistical analysis showed a strong correlation between the mean diastolic blood pressure and physical fitness ($p<0.001$).

	VO₂max	Weekly PA	Waist	Body-fat	BMI-percentile	Mean diastole	Mean systole
VO₂max	1.0000						
p							
Weekly PA	0.2772	1.0000					
p	0.0000						
Waist	-0.4656	-0.0818	1.0000				
p	0.0000	0.0046					
Body-fat	-0.8196	-0.1767	0.5559	1.0000			
p	0.0000	0.0000	0.0000				
BMI-percentile	-0.2565	-0.0420	0.7435	0.6449	1.0000		
p	0.0000	0.1470	0.0000	0.0000			
Mean diastole	-0.2418	-0.1179	0.2318	0.2675	0.1583	1.0000	
p	0.0000	0.0000	0.0000	0.0000	0.0000		
Mean systole	-0.0256	0.0065	0.3473	0.0694	0.3015	0.5142	1.0000
p	0.3891	0.8214	0.0000	0.0178	0.0000	0.0000	

Table 7: correlation matrix with p

5.11 Effect strength of the different variables on mean systole and diastole

We calculated the effect strength of physical fitness, physical activity, BMI percentile, body fat and waist circumference on mean diastolic and systolic blood pressure using the Cohen's-formula of efficacy.

The effect strength measures the strength of a relationship between variables on a numeric scale. The greater the effect strength, the more influence a variable has.

The analysis shows that physical activity has no significant effect on mean systole and diastole. BMI percentile and waist circumference have the most significant effect on mean systole, whereas physical fitness and body fat show the most significant effect on mean diastole.

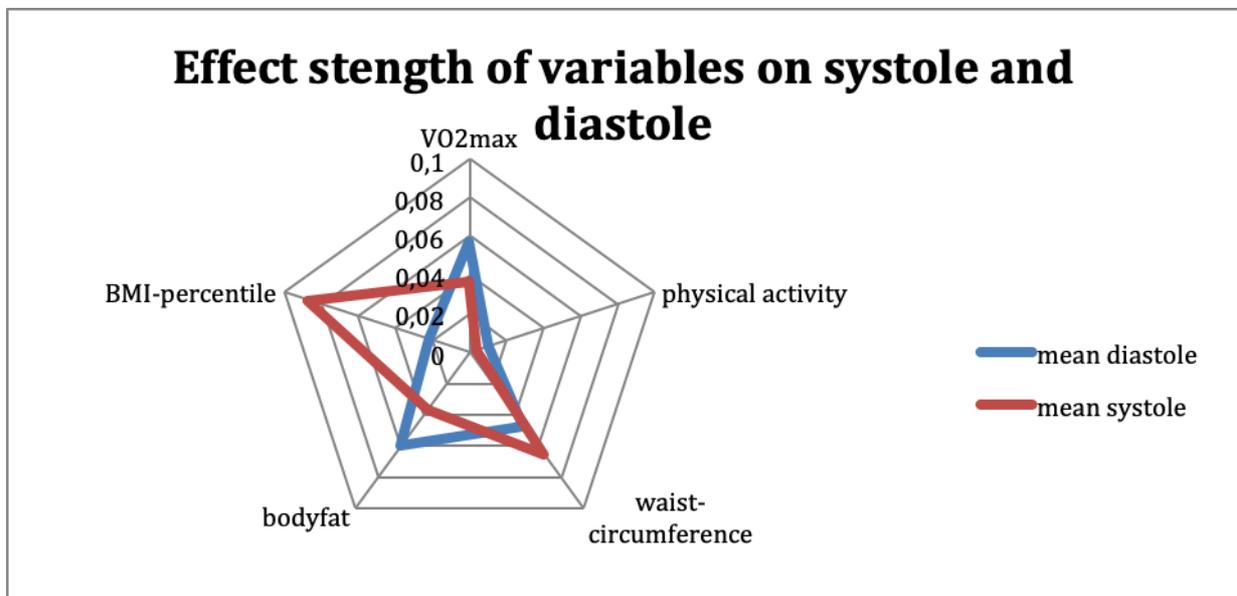


Figure 17: effect strength f2 for co-variants on mean systolic and diastolic blood pressure

	Mean systolic blood pressure	Mean diastolic blood pressure
Physical fitness	f2= 0.037	f2= 0.057
Weekly physical activity	f2= 0.004	f2= 0.010
Waist circumference	f2= 0.065	f2= 0.047
Body fat percentage	f2= 0.036	f2= 0.060
BMI-percentile	f2= 0.087	f2= 0.022

Table 8: effect strength f2 for co-variants on mean systolic and diastolic blood pressure

6. Discussion

The objective of this study was to determine, amongst others, a correlation between blood pressure and body fat percentage. The analysis of the data showed, that there is a strong correlation between mean systolic blood pressure and body fat percentage, as well as between mean diastolic blood pressure and body fat percentage. This corresponds with the findings of most studies. In one study from 1988, Rocchini et al. found a strong correlation between blood pressure values and fat weight in obese adolescents. After an intervention period of 20-weeks it was shown that a reduction in body weight, and thereby reduction of body fat percentage, lead to a significant reduction of both the systolic and diastolic blood pressure. The study divided the interventional groups in diet and exercise group. The exercise group showed a significantly higher reduction in blood pressure (Rocchini et al., 1988). It is commonly known, that a diet regimen with moderate to vigorous physical exercise has a positive effect on body composition, the reduction of body fat percentage is higher using this method (Janssen and Leblanc, 2010). Silva and Lopes showed that there is a significant correlation between excess body fat and high blood pressure, thus confirming our results. Obesity often results in insulin resistance, vascular dysfunction and an over-activity of the sympathetic nervous system. This can explain the correlation between elevated body fat percentage and the development of arterial hypertension (Souza et al., 2010). Children with obesity are at a higher risk for the development of atherosclerosis later in life and consequently the development of arterial hypertension. Our study demonstrated, using regression analysis, that an increase in body fat leads to an increase in both systolic and diastolic blood pressure. The effect strength analysis showed a strong effect of body fat percentage on systolic and diastolic blood pressure. One can thus stipulate that there is a strong correlation between elevated body fat percentage and elevated blood pressure. The treatment of arterial hypertension in children should therefore, amongst other variables, aim at the reduction of body fat percentage.

During data-acquisition the height and weight of the children was taken, and the body mass index was calculated. The body mass index is dependant on age and gender. Our data was then divided into reference groups/percentiles according to Kromeyer-Hauschild. Children that were above the 90th percentile were considered overweight. The “Arbeitsgemeinschaft Adipositas im Kindes- und Jugendalter” defined nationwide uniform percentile limits for adiposity. According to this definition children in the 90th-97th BMI percentile are considered

overweight, adiposity starts in the 97th-99.5th BMI percentile, and extreme adiposity is defined as BMI percentile above 99.5th (Wabitsch et al., 2002).

Our results furthermore proved that pathological or normal blood pressure is dependant on BMI percentile ($p < 0.0001$) and that there is a strong correlation between mean systolic and diastolic blood pressure and BMI percentile ($p < 0.001$). By using regression analysis, a statistically significant positive relation between blood pressure and BMI percentile was found. Our findings largely reflect the current literature and are in accordance with our findings concerning body fat percentage and waist-circumference.

He et al. systematically examined, in their study, the association between obesity and blood pressure in preschool children in China. They found that the body mass index was positively related to blood pressure in non-obese as well as obese children. They furthermore found that an increase in one body mass index unit was associated with an increase of 1mmHg in both systolic and diastolic blood pressure and that the body mass index effect was twice as strong in the non-obese group as in the obese study population. This further proofs our conclusion that a decrease in body mass index, weight and body-fat percentage, leads to a decrease in blood pressure and improvement of body composition (He et al., 2000).

The body mass index is a cheap and easy to use tool in the assessment of adiposity. Paediatric doctors should try to obtain the body mass index of their patients to better monitor the risk of development of cardiovascular diseases, such as arterial hypertension. If a child has a body mass index over the 90th percentile or is gaining weight and in risk of becoming obese, dietary measures as well as a physical exercise regimen should be implemented. In today's fast paced world, doctors only have minutes to tend to their patients, the body mass index can be an easy, cheap tool in screening of patients' which need extra attention. The body mass index could be easily obtained after a patient enters the practice of a paediatric doctor, since no trained personnel is needed, this could be done during the waiting period, thus saving the physicians' time. The body mass index would also facilitate the identification of patients with pathological body mass index values and could be used to monitor the course of the body mass index of a patient this would make an early intervention possible.

In this study we furthermore found a strong positive correlation between waist circumference and systolic and diastolic blood pressure. It was shown, that waist circumference has a strong effect on blood pressure. We were able to demonstrate, that the bigger the waist circumference, the higher the blood pressure. This is consistent with the results in current literature. Choy et al. found that elevated blood pressure was associated with waist circumference. In their study 26.8 per cent of the children in the highest waist circumference

quartile had elevated blood pressure. This shows that waist circumference is a risk factor for the development of hypertension. A big waist circumference is associated with abdominal obesity, this in turn is strongly associated with insulin resistance and the development of metabolic syndrome (Choy et al., 2011). As Hirschler et al. showed waist circumference is a strong predictor of insulin resistance and thus the development of metabolic syndrome (Hirschler et al., 2005).

There is an undeniable connection between childhood cardiovascular risk factors and metabolic syndrome (Reis et al., 2006). Analysing the results of this study it becomes clear that weight reduction or prevention of development of obesity is of utmost importance in the prevention of development of hypertension in childhood or earlier in life. Regular screening of waist circumference could become a cost-effective, fast and easy to perform examination by general practitioners. We recommend the measurement of waist circumference on a regular basis since one can easily assess the patients body composition and predict the total fat content (Sarria et al., 2001). This would help physicians to evaluate the risk of a patient to develop metabolic syndrome, high blood pressure or any other disease associated with adiposity.

Another aim of this study was to analyse the correlation between blood pressure and physical fitness in 8th grade students. Our statistical analysis could not find a correlation between mean systolic blood pressure and physical fitness ($VO_2\text{max}$). For mean diastolic blood pressure a significant correlation was found. The regression analysis was able to prove that there is a strong positive relation between mean systolic and diastolic blood pressure and physical fitness. The effect strength of physical fitness on mean systolic and mean diastolic blood pressure was found to be strong.

Physical fitness does not seem to influence the arterial blood pressure directly. But, as Carnethon et al., showed, adolescents with low physical fitness are 2 to 4 times more likely to be overweight or obese. They found a strong association between low physical fitness and obesity and other cardio-vascular risk factors. So, even though, physical fitness might not directly correlate with systolic blood pressure, it is still a risk factor for the development of heart disease later in life (Carnethon et al., 2005).

In 1988 Fraser et al. studied the relationship of physical fitness and blood pressure in 228 school children. They found that students with above average physical fitness exhibited lower systolic and diastolic blood pressures. Their analysis showed a relationship between maximal oxygen uptake ($VO_2\text{max}$) and blood pressure. Increased physical fitness was associated with

lower systolic blood pressure values. A dynamic relationship could not be found (Fraser et al., 1983). This correlates with the findings in this study.

We obtained physical fitness ($VO_2\text{max}$) by 20meter shuttle-run test. Obtaining an unbiased result is difficult since this test depends largely on the motivation of the study subject. During the performance of said test it was visible that some of the students did not try to give their best or were not motivated enough to push themselves to the limit. Furthermore the class dynamics play a big role during this test. Some classes pushed themselves more, while in other classes it was obvious that students only did the minimum. In some cases students stopped the shuttle-run test because they were the last one running. One was able to see that some of the students stopped running, when their friends stopped. Some students did not take the shuttle-run test seriously or had problems following the instructions, e.g. they ran too fast in the beginning. Since the $VO_2\text{max}$ is predicted by use of multiple regression analysis from the number of laps completed, gender, age and body mass index, the prediction is strongly dependant on the motivation of the children. Ergo the test-results for $VO_2\text{max}$ are not necessarily objective or accurate in all individuals. Another problem with the estimation of $VO_2\text{max}$ using the 20-meter shuttle-run test is underestimation of values at high performance levels. This is due to the fact that the regression coefficient for the squared term is negative, so after a certain number of completed laps, estimated $VO_2\text{max}$ decreases (Mahar et al., 2011).

This can explain that we were no able to find a correlation between systolic blood pressure and physical fitness. In further studies one should perhaps analyse the dynamics of each study group and build different teams to run together as to not discourage children to give their best. In this study we additionally analysed the data to determine a correlation between blood pressure and physical activity. Of the 1121 students that were being analysed for weekly physical activity only 86 students met the recommendation of at least 60minutes of vigorous to moderate exercise per day.

Weekly physical activity was obtained by self-administered questionnaire. Students were asked how much time they spent with different activities including household chores and active commuting to and from school, participation in sports clubs and how students spent their recess time. The questionnaire thus gave an insight into physical activity of a regular week in the child' life. The determination of physical activity in the students' life was then achieved by using a two-item screening (Hansen et al., 2007).

The most recent school day and Sunday were evaluated for physical activity during leisure time (Suchert et al., 2015).

Our statistical analysis showed no correlation between physical activity and mean systolic blood pressure. A significant correlation between diastolic blood pressure and physical activity could be found. The regression analysis proved that there is a negative relation between mean diastolic blood pressure and weekly physical activity, meaning the more physically active a child is the less the diastolic blood pressure was. No such relation could be found for the systolic blood pressure.

The correlation between mean diastolic blood pressure and physical activity and between diastolic blood pressure and physical fitness could be explained, due to the fact that, the diastolic blood pressure is mainly determined by the peripheral resistance of the blood vessels. The peripheral resistance rises with loss of elasticity, e.g. due to thickening of intima-media, or the inability to perform vasodilation, due to endothelial dysfunction. Meyer et al showed in their study on improving vascular risk in obese children, that an 8-week exercise regimen positively influenced endothelial-dependant vasodilation independent of weight-reduction. This suggests that physical activity beneficially affects the vasculature condition. The study further suggested that due to inflammatory processes in overweight children, the endothelial function is disturbed and intima-media thickening is promoted. Even though our study could not find a significant correlation between physical activity and systolic blood pressure, it is still advisable to adhere to the recommendation 60 minutes of vigorous-to-moderate exercise per day, since this physical activity is proven to influence the peripheral resistance of blood vessels thus decreasing the risk of development of atherosclerosis and arterial hypertension later in life. Physical activity furthermore promotes weight loss and has a therefore a beneficial influence on body composition thus indirectly influencing the systolic blood pressure (Meyer et al., 2006, Andersen et al., 2006, Ekelund et al., 2012, Reinehr and Andler, 2004). The results of our study concerning physical activity have to be seen critically since a self-administered questionnaire is only a subjective method. Some students might tend to over- or under-estimate their daily physical activity, thus distorting their actual physical activity. In further studies an objective method of obtaining the physical activity children should be used to purify the results.

To come to a conclusion there is a strong correlation between blood pressure and body mass index, body fat percentage and waist circumference. It is thus advisable for paediatricians to obtain these data during each visit of a patient and to monitor the course. By monitoring the course of a patients' history the physician is able to recognize trends and intervene before the vicious cycle beings. Furthermore school could also monitor these parameters and try to motivate children by teaching them about healthy eating habits and a healthy life-style as

early as primary school. Thereby the development of chronic diseases such as arterial hypertension could be diminished. This would in turn decrease the burden that chronic diseases put on the public health care system.

7. Conclusions

- I. There is a strong correlation between body mass index, body fat percentage, waist circumference and blood pressure
- II. There is a correlation between physical activity and diastolic blood pressure
- III. There is a correlation between VO_2 max and diastolic blood pressure, but not systolic blood pressure
- IV. Paediatricians should regularly monitor body mass index and waist circumference, since these parameters are easy to assess and show a high risk for the development of arterial hypertension later in life
- V. Children with elevated body mass index or waist circumference should aim at losing weight and thereby controlling their risk of development of arterial hypertension
- VI. Physical exercise can help, as an instrument, to influence hypertension in overweight children by aiding at weight loss, but the main emphasis lies on losing weight and improving body composition
- VII. Weight control is more important than physical fitness and physical activity in children with elevated blood pressure
- VIII. By monitoring of parameters, such as weight, body mass index and waist circumference trends can be visualized and an early intervention could be initiated, thus limiting the risk of development of chronic diseases
- IX. Teaching children about healthy lifestyle and food choices one could, by preventing the development of chronic diseases, diminish the burden put on the public health care system by chronic diseases, such as arterial hypertension

8. Abstract/ Summary

Background:

Hypertension is one of the leading causes of mortality worldwide. Studies have shown that its' development is associated with obesity, a sedentary life-style and stress.

Obesity, one of the main risk factors for the development of hypertension, has become more and more prevalent in todays' society. It is associated with the development of metabolic syndrome, cardiovascular diseases and chronic illnesses, such as diabetes. Even children and adolescents are nowadays more often obese. This might be due to the fact that a sedentary lifestyle and a lack in physical exercise have become more common. Studies theorize that the development of arterial hypertension starts as early as childhood. Thus the aim of this study was to find a correlation between high blood pressure and body mass index, body fat percentage and waist circumference in 1141 8th grade school children in northern Germany.

Objective: The objective of this study was to analyse the correlation between blood pressure and waist circumference, body mass index and between body fat percentage. Another aim of this study was to find a correlation between blood pressure and physical activity and physical fitness.

Materials and Methods: The data collection was conducted from January 2014 till February 2014 at 29 selected schools in the federal state of Schleswig-Holstein, northern Germany. The data was analysed using the Stata 14 (Stata Corp, College Station, TX). The students' blood pressure was taken, BMI was calculated and body fat percentage and waist circumference were measured. To obtain data concerning physical activity and physical fitness, the school children were required to fill out a self-administered questionnaire with information about their weekly physical activity. Furthermore students participated in the 20m shuttle run test to obtain VO_2max .

Results: 1141 students were analysed. It was found that pathological or normal blood pressure values (mean systolic and mean diastolic values) are dependant on body mass index percentile ($p < 0.0001$). 210 children out of 1136 had a body mass index value above the 90th percentile and were therefore obese. The statistical analysis proved that there is a strong correlation between waist circumference, body fat percentage ($p = 0.0178$), as well as BMI percentile and blood pressure ($p < 0.001$). Using regression analysis for blood pressure and waist circumference, as well as body fat percentage and BMI percentile, a statistically significant positive relation ($p < 0.001$) between those factors and blood pressure were found.

Body mass index percentile and waist circumference had the most significant effect on mean systole, whereas body-fat percentage showed the most significant effect on mean diastole. Our analysis additionally showed, that the amount of weekly physical activity had no significant effect on blood pressure.

Conclusion: We found a strong correlation between body mass index, body fat percentage, waist circumference and blood pressure. Paediatricians should regularly monitor body mass index and waist circumference, since these parameters are easy to assess and show a high risk for the development of arterial hypertension later in life. Children with elevated body mass index or waist circumference should aim at losing weight and thereby controlling their risk of development of arterial hypertension. Physical exercise can help, as an instrument, to influence hypertension by aiding at weight loss, but the main emphasis should lie on losing weight and improvement of body composition. Weight control is more important than physical fitness and physical activity in children.

9. Appendix

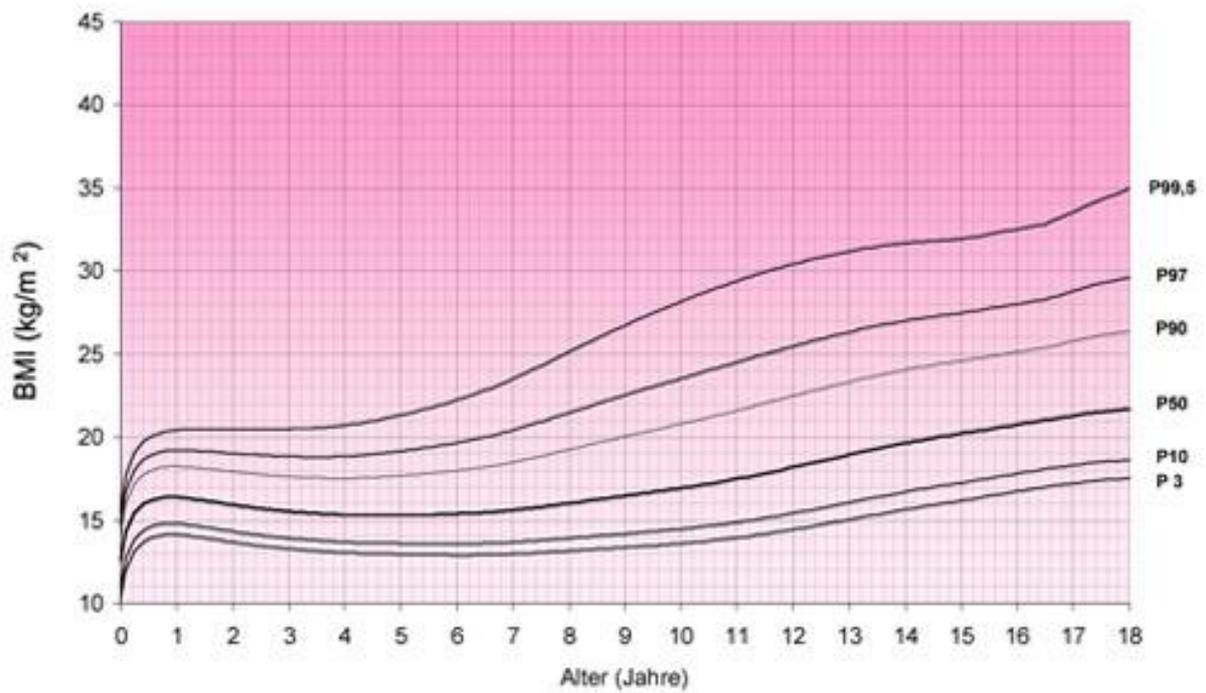
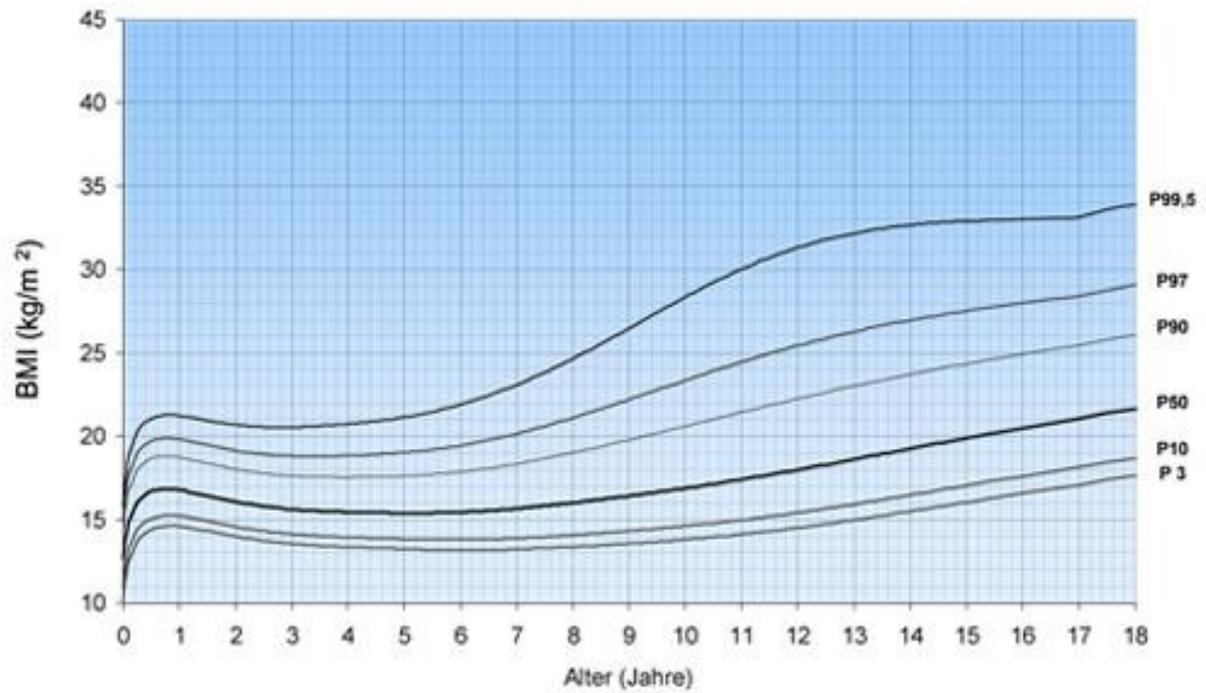


Figure 18: percentile curve for BMI for boys and girls after Kromeyer-Hauschild et al., 2001

Alter (Jahre)	BMI-Perzentile Jungen		BMI-Perzentile Mädchen	
	Adipositas P97,0	Extreme Adipositas P99,5	Adipositas P97,0	Extreme Adipositas P99,5
0,0 bis < 0,5	18,9	20,2	18,0	19,0
0,5 bis < 1,0	19,9	21,3	19,1	20,3
1,0 bis < 1,5	19,6	21,1	19,2	20,5
1,5 bis < 2,0	19,3	20,8	19,1	20,5
2,0 bis < 2,5	19,0	20,6	19,0	20,5
2,5 bis < 3,0	18,9	20,5	18,9	20,5
3,0 bis < 4,0	18,8	20,6	18,8	20,6
4,0 bis < 5,0	18,9	20,9	19,0	21,0
5,0 bis < 6,0	19,2	21,5	19,4	21,7
6,0 bis < 7,0	19,8	22,4	20,0	22,8
7,0 bis < 8,0	20,6	23,8	20,9	24,3
8,0 bis < 9,0	21,6	25,5	22,0	26,0
9,0 bis < 10,0	22,8	27,3	23,0	27,5
10,0 bis < 11,0	23,9	29,2	24,0	28,8
11,0 bis < 12,0	25,0	30,6	25,0	29,9
12,0 bis < 13,0	25,9	31,7	25,9	30,8
13,0 bis < 14,0	26,6	32,5	26,7	31,5
14,0 bis < 15,0	27,3	32,8	27,3	31,8
15,0 bis < 16,0	27,8	33,0	27,8	32,2
16,0 bis < 17,0	28,2	33,1	28,3	32,8
17,0 bis < 18,0	28,8	33,6	29,3	34,3
18,0 bis < 19,0	29,4	34,2	30,0	35,5
19,0 bis < 20,0	30,0	34,7	30,6	36,7
20,0 bis < 21,0	30,5	35,2	31,2	37,8
21,0 bis < 22,0	31,0	35,7	31,7	38,9
22,0 bis < 23,0	31,5	36,1	32,3	40,0

Table 10: percentile for BMI for boys and girls after Kromeyer-Hauschild et al., 2001

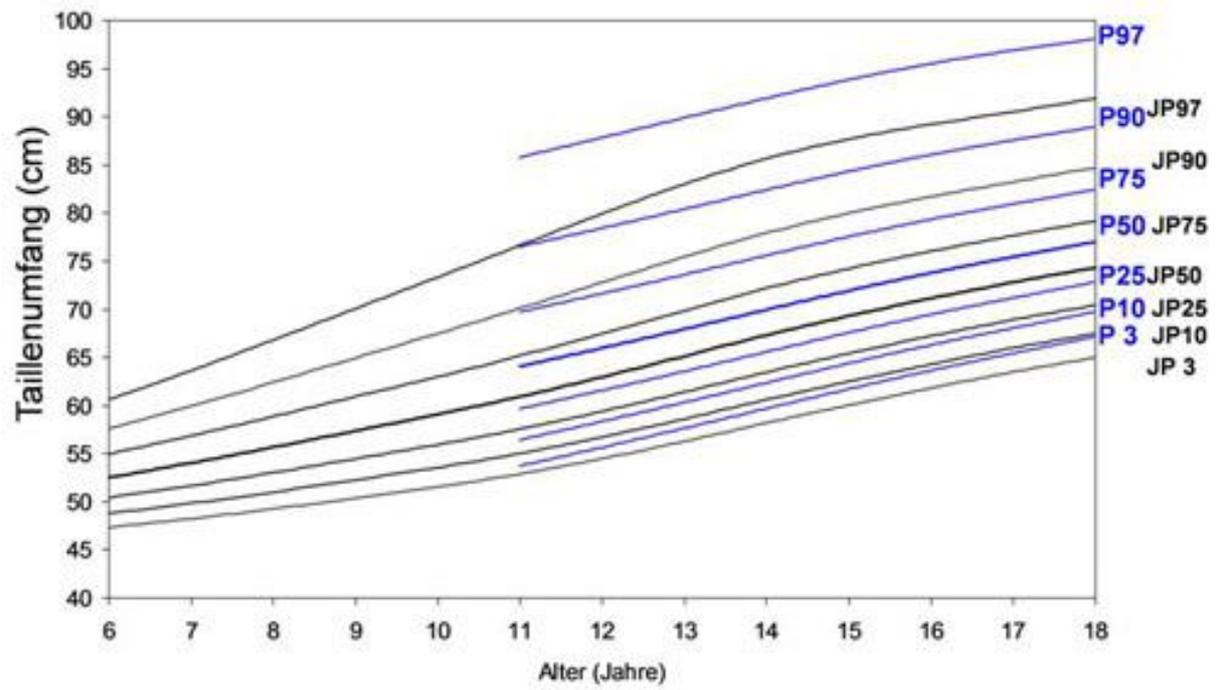


Figure 19: percentile curve of waist circumference for European children age 6-18

Blood Pressure Levels for Boys by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		← Percentile of Height →							← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50th	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50th	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50th	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90

Table 10: percentile of blood pressure for boys age 1-10 according to NHBPEP (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004, p12-13)

Blood Pressure Levels for Boys by Age and Height Percentile (Continued)

Age (Year)	BP Percentile ↓	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		← Percentile of Height →							← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50th	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50th	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50th	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

BP, blood pressure

* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

For research purposes, the standard deviations in Appendix Table B-1 allow one to compute BP Z-scores and percentiles for boys with height percentiles given in Table 3 (i.e., the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28%; 95% = 1.645) and then computed according to the methodology in steps 2-4 described in Appendix B. For children with height percentiles other than these, follow steps 1-4 as described in Appendix B.

Table 11: percentile of blood pressure for boys age 11-17 according to NHBPEP (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004, p12-13)

Blood Pressure Levels for Girls by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		← Percentile of Height →							← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88

Table 12: percentile of blood pressure for girls age 1-10 according to NHBPEP (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004, p12-13)

Blood Pressure Levels for Girls by Age and Height Percentile (Continued)

Age (Year)	BP Percentile ↓	Systolic BP (mmHg)							Diastolic BP (mmHg)						
		← Percentile of Height →							← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

BP, blood pressure

* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

For research purposes, the standard deviations in Appendix Table B-1 allow one to compute BP Z-scores and percentiles for girls with height percentiles given in Table 4 (i.e., the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28%; 95% = 1.645) and then computed according to the methodology in steps 2-4 described in Appendix B. For children with height percentiles other than these, follow steps 1-4 as described in Appendix B.

Table 13: percentile of blood pressure for girls age 11-17 according to NHBPEP (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004, p12-13)

FRAGEBOGEN FÜR SCHÜLERINNEN UND SCHÜLER

Bogen für die Erstellung des anonymen Codes

Dein Nachname

Dein Vorname

Dein Geburtstag

Tag / Monat / Jahr

Vorname deiner Mutter

Vorname deines Vaters

Liebe Schülerin, lieber Schüler,

vielen Dank, dass du an der Befragung teilnimmst.

Beachte bitte:

Dies ist kein Test. Es gibt keine richtigen und falschen Antworten.

Deine Antworten bleiben geheim. Du kannst ganz ehrlich und frei antworten.

Es erfährt niemand, welcher Fragebogen von dir kommt und was du geantwortet hast. Diese erste Seite behältst du nach Erstellung des Codes und kannst sie vernichten.

Das Ausfüllen des Fragebogens ist freiwillig.

Wenn du Fragen hast, melde dich bitte.

Figure 19: self-administered questionnaire after Suchert et al

Zuerst ein paar allgemeine Fragen zu dir

1.) Ich bin ein Junge Mädchen und Jahre alt.

2.) Welche Sprache sprecht ihr normalerweise zuhause?

Deutsch

Andere Sprache, und zwar:

3.) Welchen Schulabschluss hat deine Mutter/dein Vater?

Bitte kreuze in jeder Spalte ein Kästchen an.

	Deine Mutter	Dein Vater
Sie/Er hat keine Schule besucht.	<input type="checkbox"/>	<input type="checkbox"/>
Sie/Er ist ohne Abschluss von der Schule abgegangen.	<input type="checkbox"/>	<input type="checkbox"/>
Abschluss einer Sonderschule/Förderschule	<input type="checkbox"/>	<input type="checkbox"/>
Abschluss der Polytechnischen Oberschule nach der 8. Klasse	<input type="checkbox"/>	<input type="checkbox"/>
Hauptschulabschluss/Volksschulabschluss	<input type="checkbox"/>	<input type="checkbox"/>
Realschulabschluss/mittlere Reife/Abschluss der Polytechnischen Oberschule nach der 10. Klasse	<input type="checkbox"/>	<input type="checkbox"/>
Fachhochschulreife	<input type="checkbox"/>	<input type="checkbox"/>
Hochschulreife/Abitur	<input type="checkbox"/>	<input type="checkbox"/>
Sonstiger Schulabschluss (z. B. im Ausland)	<input type="checkbox"/>	<input type="checkbox"/>
Weiß ich nicht.	<input type="checkbox"/>	<input type="checkbox"/>

4.) Hier findest du ein paar Aussagen zu dir: Wie sehr stimmst du ihnen zu?

Bitte kreuze in jeder Zeile ein Kästchen an.

	Stimmt nicht	Stimmt kaum	Stimmt eher	Stimmt genau
Die Lösung schwieriger Probleme gelingt mir immer, wenn ich mich darum bemühe.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
In unerwarteten Situationen weiß ich immer, wie ich mich verhalten soll.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Schwierigkeiten sehe ich gelassen entgegen, weil ich meinen Fähigkeiten immer vertrauen kann.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wenn eine neue Sache auf mich zukommt, weiß ich, wie ich damit umgehen kann.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wenn ein Problem auftaucht, kann ich es aus eigener Kraft meistern.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 20: self-administered questionnaire after Suchert et al

Jetzt geht es darum, wie du dich und deinen Körper einschätzt.

5.) Wie sehr treffen folgende Aussagen auf dich zu?

Bitte kreuze in jeder Zeile ein Kästchen an.

	Stimmt nicht	Stimmt kaum	Stimmt eher	Stimmt genau
Bei den meisten Sportarten bin ich gut.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Die meisten Sportarten fallen mir leicht.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ich bin besser im Sport als die meisten meiner Freunde.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Andere Leute denken, dass ich gut im Sport bin.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ich habe gute sportliche Fähigkeiten.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ich fühle mich in meinem Körper zu Hause.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ich bin mit meinem Körper zufrieden.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ich bin stolz auf meinen Körper.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wenn ich mich vom Aussehen her mit anderen vergleiche, bin ich der Meinung, dass ich mich sehen lassen kann.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ich bin mit meinem Aussehen zufrieden.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6.) Wie beurteilst du die folgenden Aussagen?

Bitte kreuze in jeder Zeile ein Kästchen an.

	1 Keines- falls	2	3	4	5	6	7 Ganz sicher
Ich beabsichtige, in der nächsten Woche an den meisten Tagen für mindestens 60 Minuten körperlich aktiv zu sein.	<input type="checkbox"/>						
Ich plane, in der nächsten Woche an den meisten Tagen für mindestens 60 Minuten körperlich aktiv zu sein.	<input type="checkbox"/>						
Ich erwarte, dass ich in der nächsten Woche an den meisten Tagen für mindestens 60 Minuten körperlich aktiv sein werde.	<input type="checkbox"/>						

7.) Glaubst du, dass du ...

... viel zu dünn bist?

... ein bisschen zu dünn bist?

... genau das richtig Gewicht hast?

... ein bisschen zu dick bist?

... viel zu dick bist?

Nun folgen einige Fragen zu deinem Freizeitverhalten

8.) Wie oft machst du gefährliche Sachen, um Spaß zu haben?

Überhaupt nicht

Gelegentlich

Manchmal

Oft

Sehr oft

9.) Wie oft machst du aufregende Sachen, auch wenn sie gefährlich sind?

Überhaupt nicht

Gelegentlich

Manchmal

Oft

Sehr oft

Figure 21: self-administered questionnaire after Suchert et al

10.) Die beiden folgenden Fragen beziehen sich auf die gesamte Zeit, die du jeden Tag körperlich aktiv bist.

Körperliche Aktivitäten schließen alle Tätigkeiten ein, bei denen das Herz schneller schlägt und für einige Zeit die Atmung erhöht ist. Zu den körperlichen Aktivitäten zählen beispielsweise Sport (Basketball, Fußball, Schwimmen, ...), Spielen mit Freunden oder das Fahrradfahren zur Schule.

Zähle die gesamte Zeit zusammen, die du jeden Tag mit körperlicher Aktivität verbringst.

An wie vielen Tagen der **letzten sieben Tage** warst du für mindestens 60 min am Tag körperlich aktiv?

0 Tage 1 Tag 2 Tage 3 Tage 4 Tage 5 Tage 6 Tage 7 Tage

An wie vielen Tagen **einer normalen Woche** bist du für mindestens 60 min am Tag körperlich aktiv?

0 Tage 1 Tag 2 Tage 3 Tage 4 Tage 5 Tage 6 Tage 7 Tage

11.) Bei dieser Frage geht es um sportliche Aktivitäten im Verein.

Wie viele Stunden in **einer normalen Woche** betreibst du Sport im Verein?

Rechne alle Trainingszeiten und Wettkämpfe/ Punktspiele zusammen. Wenn du Mitglied verschiedener Sportvereine bist, zähle die Zeit aller Sportarten zusammen.

Stunden pro Woche

Wie sehr strengst du dich dabei in der Regel an? *(Bitte kreuze nur eine Antwort an)*

- Ohne zu schwitzen und ohne Kurzatmigkeit/Schnaufen
- Etwas Schwitzen und etwas Kurzatmigkeit/Schnaufen
- Viel Schwitzen und viel Kurzatmigkeit/Schnaufen

12.) Bei dieser Frage geht es um sportliche Aktivitäten in deiner Freizeit, denen du außerhalb eines Vereins unregelmäßig und/ oder regelmäßig nachgehst (z. B. Inline Skaten, Joggen, Fußball spielen oder Trampolin springen).

Wie viele Stunden in **einer normalen Woche** betreibst du Sport in deiner Freizeit?

Rechne alle Zeiten und Gelegenheiten zusammen, die mindestens 15 Minuten gedauert haben.

Stunden pro Woche

Wie sehr strengst du dich dabei in der Regel an? *(Bitte kreuze nur eine Antwort an)*

- Ohne zu schwitzen und ohne Kurzatmigkeit/Schnaufen
- Etwas Schwitzen und etwas Kurzatmigkeit/Schnaufen
- Viel Schwitzen und viel Kurzatmigkeit/Schnaufen

Figure 22: self-administered questionnaire after Suchert et al

- 13.) Die folgenden Fragen beziehen sich auf den **vergangenen Schultag**, in der Regel also auf gestern. (Ausnahme: Falls heute Montag ist, beziehen sich die Fragen auf den letzten Donnerstag.)

Zusammengerechnet, wie viel Zeit hast du mit den folgenden Aktivitäten verbracht?
(Wenn du keine Zeit mit einer bestimmten Aktivität verbracht hast, trage bei dieser „0“ ein)

Fernsehen und/ oder DVD anschauen	_____ Stunden und _____ Minuten
Spiele auf dem Computer, der Spielekonsole oder dem Handy (keine Bewegungsspiele wie z. B. Wii™ Sports)	_____ Stunden und _____ Minuten
Andere Freizeitaktivitäten mit dem Computer (z. B. soziale Netzwerke, im Internet surfen)	_____ Stunden und _____ Minuten
Sitzen im Auto, Bus oder Zug	_____ Stunden und _____ Minuten
Hausaufgaben machen (sowohl mit als auch ohne Computer) oder Nachhilfe	_____ Stunden und _____ Minuten
Lesen (nicht für die Schule)	_____ Stunden und _____ Minuten
Sitzen oder Liegen während du Musik hörst	_____ Stunden und _____ Minuten
Kreative Hobbys im Sitzen oder Liegen (z. B. Malen, Basteln, Stricken, Musikinstrument spielen)	_____ Stunden und _____ Minuten
Sitzen oder Liegen während du telefonierst oder mit anderen redest (z. B. mit Freunden)	_____ Stunden und _____ Minuten
Andere sitzende oder liegende Beschäftigungen (außer Schlafen, Essen und Schule)	_____ Stunden und _____ Minuten
Wege zu Fuß zurückgelegt (z. B. zu Freunden, zur Schule, mit dem Hund spazieren gehen)	_____ Stunden und _____ Minuten
Wege mit dem Fahrrad zurückgelegt (z. B. zu Freunden, zur Schule oder zum Einkaufen)	_____ Stunden und _____ Minuten
Aufgaben im Haushalt und Garten (z. B. Zimmer aufräumen, Küchendienst, Rasen mähen)	_____ Stunden und _____ Minuten
Sport im Verein (auch Punktspiele, Wettkämpfe oder Turniere)	_____ Stunden und _____ Minuten
Sportliche Aktivitäten in der Schule (Schulsport oder Sport-AG)	_____ Stunden und _____ Minuten
Sportliche Aktivitäten in der Freizeit (z. B. Inline Skaten, Fußball spielen, Joggen)	_____ Stunden und _____ Minuten
Andere Beschäftigungen (nicht im Liegen oder Sitzen)	_____ Stunden und _____ Minuten

Warst du an diesem Tag krank oder verletzt?

Nein

Ja

Figure 23: self-administered questionnaire after Suchert et al

14.) Die folgenden Fragen beziehen sich auf den **letzten Sonntag**.

Zusammengerechnet, wie viel Zeit hast du mit den folgenden Aktivitäten verbracht?
(Wenn du keine Zeit mit einer bestimmten Aktivität verbracht hast, trage bei dieser „0“ ein)

Fernsehen und/ oder DVD anschauen	_____ Stunden und _____ Minuten
Spiele auf dem Computer, der Spielekonsole oder dem Handy (keine Bewegungsspiele wie z. B. Wii™ Sports)	_____ Stunden und _____ Minuten
Andere Freizeitaktivitäten mit dem Computer (z. B. soziale Netzwerke, im Internet surfen)	_____ Stunden und _____ Minuten
Sitzen im Auto, Bus oder Zug	_____ Stunden und _____ Minuten
Hausaufgaben machen (sowohl mit als auch ohne Computer) oder Nachhilfe	_____ Stunden und _____ Minuten
Lesen (nicht für die Schule)	_____ Stunden und _____ Minuten
Sitzen oder Liegen während du Musik hörst	_____ Stunden und _____ Minuten
Kreative Hobbys im Sitzen oder Liegen (z. B. Malen, Basteln, Stricken, Musikinstrument spielen)	_____ Stunden und _____ Minuten
Sitzen oder Liegen während du telefonierst oder mit anderen redest (z. B. mit Freunden)	_____ Stunden und _____ Minuten
Andere sitzende oder liegende Beschäftigungen (außer Schlafen und Essen)	_____ Stunden und _____ Minuten
Wege zu Fuß zurückgelegt (z. B. zu Freunden, Einkaufen, mit dem Hund spazieren gehen)	_____ Stunden und _____ Minuten
Wege mit dem Fahrrad zurückgelegt (z. B. zu Freunden oder Einkaufen)	_____ Stunden und _____ Minuten
Aufgaben im Haushalt und Garten (z. B. Zimmer aufräumen, Küchendienst, Rasen mähen)	_____ Stunden und _____ Minuten
Sport im Verein (auch Punktspiele, Wettkämpfe oder Turniere)	_____ Stunden und _____ Minuten
Sportliche Aktivitäten in der Freizeit (z. B. Inline Skaten, Fußball spielen, Joggen)	_____ Stunden und _____ Minuten
Andere Beschäftigungen (nicht im Liegen oder Sitzen)	_____ Stunden und _____ Minuten

Warst du an diesem Tag krank oder verletzt? Nein Ja

Figure 24: self-administered questionnaire after Suchert et al

Jetzt noch einmal ein paar Fragen zu dir

15.) Wie häufig hast du dich in der letzten Woche folgendermaßen gefühlt?

Bitte kreuze in jeder Zeile ein Kästchen an.

In der letzten Woche ...	Nie	Selten	Manchmal	Oft	Immer
... mochte ich mich selbst leiden.	<input type="checkbox"/>				
... fühlte ich mich wohl in meiner Haut.	<input type="checkbox"/>				
... war ich stolz auf mich.	<input type="checkbox"/>				
... habe ich mich allein gefühlt.	<input type="checkbox"/>				
... habe ich viel gelacht und Spaß gehabt.	<input type="checkbox"/>				
... habe ich mich ängstlich oder unsicher gefühlt.	<input type="checkbox"/>				

16.) Wie beurteilst du die folgenden Aussagen?

Bitte kreuze in jeder Zeile ein Kästchen an.

Ich bin mir sicher, eine geplante körperliche Aktivität (z. B. Joggen, mit dem Fahrrad zur Schule fahren oder zum Training im Sportverein gehen) **auch dann noch auszuüben, wenn ...**

	Gar nicht sicher	Wenig sicher	Vielleicht	Ziemlich sicher	Ganz sicher
... ich müde bin.	<input type="checkbox"/>				
... ich mich niedergeschlagen fühle.	<input type="checkbox"/>				
... ich Sorgen habe.	<input type="checkbox"/>				
... ich mich über etwas ärgere.	<input type="checkbox"/>				
... ich mich angespannt fühle.	<input type="checkbox"/>				
... ich niemanden finde, der mit mir Sport treibt.	<input type="checkbox"/>				
... schlechtes Wetter ist.	<input type="checkbox"/>				
... ein interessantes Fernsehprogramm läuft.	<input type="checkbox"/>				

Nun folgen ein paar Fragen zur Schule

17.) Wie viele Unterrichtsstunden in **einer normalen Woche** betreibst du Sport in der Schule?
Rechne alles zusammen, das heißt, sowohl Schulsport als auch Sport-AGs.

Unterrichtsstunden (je 45 Min.) pro Woche

Wie sehr strengst du dich dabei in der Regel an? (Bitte kreuze nur eine Antwort an.)

- Ohne zu schwitzen und ohne Kurzatmigkeit/Schnaufen
- Etwas Schwitzen und etwas Kurzatmigkeit/Schnaufen
- Viel Schwitzen und viel Kurzatmigkeit/Schnaufen

Figure 25: self-administered questionnaire after Suchert et al

18.) Wie häufig hast du die Schulpausen **der letzten Woche** mit den folgenden Aktivitäten verbracht?

Bitte kreuze in jeder Zeile ein Kästchen an.

	Nie	Selten	Manchmal	Oft	Immer
Durch die Schule/Über das Schulgelände gehen.	<input type="checkbox"/>				
Stehen oder Sitzen (während du dich z. B. unterhältst)	<input type="checkbox"/>				
Sportliche Aktivität (z. B. Fußball oder Tischtennis spielen)	<input type="checkbox"/>				

19.) Wie bist du in den **letzten 4 Wochen** meistens zur Schule gekommen? (Bitte kreuze nur eine Antwort an.)

- Zu Fuß**
Wie viele Minuten brauchst du insgesamt für Hin- und Rückweg? Minuten
- Mit dem Fahrrad**
Wie viele Minuten brauchst du insgesamt für Hin- und Rückweg? Minuten
- Mit dem Bus oder der Bahn**
Von zu Hause zur Haltestelle und von der Haltestelle zur Schule gehe ich zu Fuß.
Wie viele Minuten brauchst du insgesamt für die gelaufene Strecke von Hin- und Rückweg? Minuten
- Mit dem Auto**

Nachfolgend geht es kurz um Rauchen und Alkohol

20.) Wie viele Zigaretten hast du in deinem Leben geraucht?

- Keine
- Nur ein paar Züge
- 1 bis 19 Zigaretten (weniger als eine Packung)
- 20 bis 100 Zigaretten (ein bis fünf Packungen)
- Mehr als 100 Zigaretten (mehr als fünf Packungen)

21.) Wie häufig rauchst du zur Zeit?

- Ich rauche nicht
- Weniger als einmal im Monat
- Mindestens einmal im Monat, aber nicht jede Woche
- Mindestens einmal die Woche, aber nicht jeden Tag
- Jeden Tag

22.) Hast du schon einmal Alkohol getrunken?

- Nein Ja

+

+

Figure 26: self-administered questionnaire after Suchert et al

23.) Wie häufig hast du schon einmal **fünf oder mehr alkoholische Getränke** bei einer Gelegenheit getrunken?

- Noch nie Einmal 2- bis 5-mal Mehr als 5-mal

24.) Wie häufig trinkst du **zur Zeit** Alkohol?

- Gar nicht
 Weniger als einmal im Monat
 Mindestens einmal im Monat, aber nicht jede Woche
 Mindestens einmal die Woche, aber nicht jeden Tag
 Jeden Tag

Nun geht es darum, wie gut dir bestimmte Freizeitbeschäftigungen gefallen

25.) Wie sehr stimmst du den folgenden Aussagen zu?

Bitte kreuze in jeder Zeile ein Kästchen an.

Mich zu bewegen ...	Stimme überhaupt nicht zu	Stimme eher nicht zu	Teils/teils	Stimme eher zu	Stimme voll und ganz zu
... macht mir Freude.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... genieße ich.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... gibt mir Energie.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... ist sehr angenehm.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... bedeutet, dass mein Körper sich gut anfühlt.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... gibt mir etwas.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... ist sehr aufregend.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... gibt mir ein starkes Erfolgserlebnis.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... fühlt sich gut an.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... gibt mir das Gefühl, dass ich lieber etwas anderes machen würde.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

26.) Wie sehr stimmst du den folgenden Aussagen zu?

Bitte kreuze in jeder Zeile ein Kästchen an.

Fernsehen oder Beschäftigungen am Computer (z. B. Spielen, Chatten, in sozialen Netzwerken unterwegs Sein oder im Internet Surfen) ...

Fernsehen oder Beschäftigungen am Computer (z. B. Spielen, Chatten, in sozialen Netzwerken unterwegs Sein oder im Internet Surfen) ...	Stimme überhaupt nicht zu	Stimme eher nicht zu	Teils/ teils	Stimme eher zu	Stimme voll und ganz zu
... machen mir Freude.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... fühlen sich gut an.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... genieße ich.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... geben mir das Gefühl, dass ich lieber etwas anderes machen würde.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 27: self-administered questionnaire after Suchert et al

27.) Wie sehr stimmst du den folgenden Aussagen zu?

Bitte kreuze in jeder Zeile ein Kästchen an.

Andere sitzende oder liegende Tätigkeiten wie Lesen, kreative Hobbys, Telefonieren oder sich mit anderen zu unterhalten ...

	Stimme überhaupt nicht zu	Stimme eher nicht zu	Teils/ teils	Stimme eher zu	Stimme voll und ganz zu
... machen mir Freude.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... fühlen sich gut an.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... genieße ich.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
... geben mir das Gefühl, dass ich lieber etwas anderes machen würde.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Jetzt folgen ein paar Fragen zu deinem Umfeld

28.) Wie viele deiner Freunde sind regelmäßig körperlich aktiv?

Keine Wenige Einige Die meisten Alle

29.) Wie viele deiner Freunde sind in einem Sportverein?

Keine Wenige Einige Die meisten Alle

30.) Wie wichtig ist körperliche Aktivität in deinem Freundeskreis?

Nicht wichtig Kaum wichtig Eher wichtig Sehr wichtig

31.) Wenn ich Sport treiben will, fehlen mir Geräte und Einrichtungen.

Nie Selten Gelegentlich Oft Immer

32.) In meiner näheren Wohnumgebung gibt es viele Möglichkeiten, um körperlich aktiv zu sein (z. B. Parks, Fahrradwege, frei zugängliche Sportplätze).

Stimmt gar nicht Stimmt wenig Stimmt teils/teils Stimmt ziemlich Stimmt völlig

33.) In der **letzten Woche**, wie häufig ...

Bitte kreuze in jeder Zeile ein Kästchen an.

	Gar nicht	1-mal	2- bis 3-mal	4- bis 5-mal	Mehr als 5-mal
... haben dich deine Eltern zum Sport oder einen Ort gefahren, an dem du körperlich aktiv sein konntest?	<input type="checkbox"/>				
... haben dir deine Eltern bei körperliche Aktivität oder beim Sport zugesehen?	<input type="checkbox"/>				
... waren deine Eltern selbst (ohne dich) körperlich aktiv?	<input type="checkbox"/>				

Figure 28: self-administered questionnaire after Suchert et al

38.) In einer **normalen Woche**: Wie häufig isst bzw. trinkst du die folgenden Nahrungsmittel?

Bitte kreuze in jeder Zeile ein Kästchen an.

	Mindestens einmal täglich	Mehrmals wöchentlich, aber nicht täglich	Höchstens wöchentlich
Frisches Obst und Gemüse bzw. Salat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Schokolade, Süßigkeiten	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cola oder Limonade	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fast Food (z. B. Döner, Pizza, Hamburger, Pommes)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wasser	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

39.) **An Wochentagen** (Montag bis Freitag): Wie viele Stunden (und Minuten) schläfst du normalerweise?

Stunden und

Minuten

40.) **An Wochenendtagen** (Samstag und Sonntag): Wie viele Stunden (und Minuten) schläfst du normalerweise?

Stunden und

Minuten

Super, du hast es geschafft!

Vielen Dank für deine Teilnahme!

Figure 30: self-administered questionnaire after Suchert et al

Trikotnummer:

Ruhepuls

1. Messung: Schläge

2. Messung: Schläge

Blutdruck

1. Messung: / mmHg

2. Messung: / mmHg

Alter

Jahre und Monate

Körpermaße

Größe: , cm

Gewicht: , Kg

Körperzusammensetzung: %

BMI:

Taillenumfang: , cm

20 Meter Shuttle-Run Test

Gelaufene Zeit: : Minuten

Belastungspuls: Schläge

Erholungspuls: Schläge



Figure 31: evaluation card after Suchert et al

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Erklärung

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbstständig und ohne fremde Hilfe angefertigt und keine anderen als die angegebenen Quellen und Hilfsmittel verwendet habe. Ferner versichere ich, dass diese Arbeit noch nicht zum Zwecke der Erlangung der Doktorwürde an anderer Stelle vorgelegen hat.

Ort, Datum

Anja Höhn