Physical activity and blood pressure: A cross-sectional study

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Preface

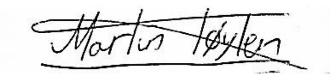
The purpose of this study was to look at the relationship between physical activity and blood pressure in a population in the north of Norway. The study was done as a master thesis as part of the educational program Medical profession at the University of Tromsø during 2015-2017. The project was based on data collected from the 6th Tromsø study, Tromsø 6 which was performed in 2007-2008. The project received no funding.

I have always been interested in physical activity and the effects it has on the human body, and studying the preventive effects of physical activity was appealing to me. The idea of looking at physical activity and blood pressure in a cross-sectional study was developed through cooperation between me and my supervisor.

The study was done by me, and was supervised by Bente Morseth whom I would like to give a huge thank you to for her tremendous help and guidance during the process.

Tromsø 06.06.17

Martin Støyten



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1.0 Summary

Background

Hypertension is known as a major risk factor for cardiovascular disease, and the world-wide prevalence of hypertension is expected to rise to 30 % by the end of 2025. Physical activity has been shown to be a major part of the conservative treatment of hypertension, although the nature of the dose-response relationship is not known. The purpose of this study was to examine the associations between physical activity and blood pressure in the sixth survey of the Tromsø Study.

Methods

Tromsø 6 is a population study performed during 2007-08 in northern Norway. The study included 12981 participators, and we analyses 9913 cases after removing cases with missing data. We used ANOVA and ANCOVA analyses to examine associations between blood pressure and physical activity using SPSS 24.

Results

The unadjusted analyses showed a statistically significant inverse relationship between total physical activity and systolic blood pressure. These associations disappeared when adjusting for potential confounders. The same analyses provide no significant findings for diastolic blood pressure.

Conclusion

Systolic and diastolic blood pressure was not associated with total physical activity level. Although unadjusted analyses showed an inverse relationship between systolic blood pressure and total physical activity, the significant association disappeared when adding BMI to the model, suggesting that some of the differences in mean systolic blood pressure seems to be due to lower BMI or other risk factors, rather than physical activity level.

2.0 Introduction

2.1 Purpose of the study

The aim of this cross-sectional study was to investigate the association between physical activity and systolic and diastolic blood pressure (SBP and DBP) in a cohort of adults who participated in the sixth Tromsø Study (Tromsø 6).

The primary goal was to examine if there is a significant difference in mean SBP and DBP between groups of different levels of total volume of leisure time activity. The main hypothesis was that mean SBP and DBP, and thus the prevalence of hypertension, is inversely related to physical activity level. A secondary goal was to examine the association between intensity, frequencies, and duration of physical activity and SBP and DBP.

2.2 Background

With the estimation that approximately 1 billion of the world's adult population has hypertension, and the worldwide prevalence of hypertension is believed to increase to 30 % by the end of 2025, prevention of hypertension is becoming a public health issue (1). In Norway, the prevalence of hypertension has been shown by Klouman et al (2) to be approximately 30 %. The etiology of hypertension seems to be complex, and may involve several risk factors. Physical inactivity is linked to hypertension, and several meta-analyses of RCTs show that regular exercise may decrease blood pressure (3-5). Diaz et al (6) found that physical activity has a big part in the prevention of hypertension, but that the appropriate mode, intensity, duration and frequency is still unclear. Population-based studies are more modest, suggesting that there is a relationship between physical activity and incident hypertension(7, 8), but that the type and level of activity still is unclear. The participation in vigorous, physical activity has been shown to predict a low risk of hypertension in men compared to those being inactive (7). Other cross-sectional studies (9-11) have found few or small associations between physical activity and blood pressure when adjusting for confounders. BMI has in some studies been shown to be the more important confounder, and that some of the inverse relationship between physical activity and blood pressure is instead related to BMI (9, 12)(please see attached GRADE forms).

2.3 Physiology of blood pressure regulation

A normal blood pressure is defined as less than 120/80 mmHg. Hypertension is defined as SBP ≥ 140 mmHg and DBP ≥ 90 mmHg (13). This is a direct result of a higher mean arterial pressure (MAP), which can be determined as cardiac output (CO) multiplied with total peripheral resistance (TPR) (i.e. MAP = CO x TPR). Maintaining arterial pressure is crucial for ensuring organ perfusion and sustaining the need for oxygen and nutrients, and removal of waste products like CO2. Blood pressure will change in reaction to a variety of conditions in the internal environment in the body, and the main factors regulating blood-pressure is the Renin-Angiotension-Aldosteron system, the sympathetic nervous system, and the plasma volume which in turn is mainly regulated by the kidneys (14). These factors are to different degrees responsible for both the necessary changes in blood-pressure one can see when increasing the metabolic activity when being physically active, and the abnormal changes in patients with hypertension.

2.4 Pathophysiology and risk factors for hypertension

The pathogenesis of essential hypertension is not yet fully understood, but is likely to develop due to a combination of different risk factors. Primary hypertension, also called essential hypertension, includes 95 % of the patients with high blood pressure, and has no single cause which can be identified. It is often a collection of factors that over time will add up and lead to the development of hypertension. Age, overweight (9, 15, 16), physical inactivity (17, 18), family history, race (14) (being black is associated with a higher prevalence of hypertension), resting BP, high-sodium diet, excessive alcohol consumption, diabetes, and dyslipidemia, are some of the risk factors (14). Secondary hypertension, being hypertension derived from other medical conditions or treatment, can occur due to many different causes. Medication (oral contraceptives, NSAIDS, antidepressants, glucocorticoids, erythropoietin cyclosporine) (19), narcotic drugs such as cocaine and metampehtamine, primary renal disease, renovascular hypertension, primary aldosteronism, cushings syndrome, coarctation of the aorta, and pheochromocytoma are some of the causes for secondary hypertension (19). The blood pressure of this type of patients will often normalize after the primary cause has been corrected (20, 21).

Cardiac output, which is the amount of blood pumped by the heart per minute, is a product of heart rate and stroke volume, and will usually increase in combination with increased systemic vascular resistance when a person develops hypertension. Given time, these changes can become manifest and develop into chronic hypertension. Subjects with chronic hypertension can have decreased endothelial function in blood-vessels, stiffer walls, hypertrophy of the left ventricle, and lastly albumin-leakage from the kidneys (22, 23).

Ito, K. et al (24) recently discovered through a 10-year follow-up study that healthy individuals with a normal resting BP but who has an excessive increase in BP during exercise will have an elevated risk of having increased BP at rest 10 years later. This means that abnormal increases of BP during exercise is another independent variable and determinant for future rise of resting BP.

2.5 Complications

There are many complications of hypertension, some being more serious than others. The chance of developing some of these complications increase together with the increase in hypertension. When blood pressure rises above 115/75 mmHg there is an increased risk of complications in all age groups (22).

Hypertension is said to be the most important risk factor for developing cardiovascular disease (CVD)(25) and left ventricular hypertrophy (26). It is more common than cigarette smoking, diabetes and dyslipidemia, and hypertension is estimated to account for 54 % of all strokes and 47 % of all ischemic heart disease in the world (27). Hypertension is a major risk factor for atherosclerosis (28), and cardiovascular disease due to atherosclerosis is in turn the most common cause of death in older people in European countries and North-America (29). For example, veins moved from a low-pressure system to a high-pressure system, like the arterial side of the circulation, will develop atherosclerosis within months (22).

Patients surviving myocardial infarction or stroke will often be disabled or have handicaps requiring care for the rest of their lives, and thus have a large economic impact on the public health care systems.

It also increases the risk for atrial fibrillation, peripheral heart disease, and heart failure (30). Levy D et al. (31) concluded in a during a 20-year follow-up study that hypertension is the most common risk factor for Congestive heart failure (CHF), and the most efficient preventive strategies are more aggressive and earlier blood pressure control. Hypertension is also the most important risk factor for intracerebral hemorrhage (32), and one of the most important risk factors for chronic kidney disease and end-stage kidney disease, both as a direct harm to the interstitial kidney tissue, and as a mediator for progression of other renal diseases (33, 34).

2.6 Treatment of hypertension and the role of physical activity

The first line of treatment is lifestyle changes, and these changes may include weight reduction, sodium restrictions, increased physical activity and reduced alcohol consumption. Pharmacological treatment of hypertension is well established as the second line of treatment after life-style changes has been implemented. Depending on the success of these changes, a physician might add medication like ACE inhibitors, Angiotension II blockers, and thiazid diuretics, if the goal isn't reached with conservative treatment. Treatment goals are usually 140/90 mmHg independent of age and sex, but if the patient has diabetes or nephropathy the physician will normally be aiming for a lower goal of 130/80 mmHg (29).

Guidelines for conservative treatment of hypertension has for a long period of time focused on physical activity (35). A review of the latest evidence for physical activity to prevent development of hypertension concluded that there is a strong association between physical activity and hypertension, and the review strongly supports the role of physical activity in the prevention of hypertension in non-hypertensives (4). As much as 5-13 % of the risk for developing hypertension is assumed to be due to physical inactivity. However, the optimal mode, duration and intensity is still unclear (4, 21). Cornelissen et al (4) looked at the effect of specific types of exercise on blood pressure in a large meta-analysis from 2013. They included endurance exercise, dynamic resistance (weight training), isometric resistance and combined endurance and dynamic resistance exercise, and reviewed 93 trials with a total of 5223 participants. The authors concluded that endurance, dynamic resistance and isometric resistance training lower both SBP and DBP, and that combined exercise will lower DBP, but not SBP. Strasser et al performed a meta-analysis to look at the effects physical exercise has on metabolic syndrome (36) in patients with abnormal glucose-metabolism. They concluded that resistance training reduces HbA1c, fat mass and SBP, but does not have an effect on cholesterol, triglycerides and DBP.

Recent studies suggest that functional and structural changes in the heart happen at an earlier stage in the development of hypertension than expected (21, 26), and more than a quarter of individuals with normal or high-normal blood pressure have left ventricular hypertrophy (22). These structural changes are amongst other things stimulated by increased daytime BP, and contribute to the development of left ventricular myopathy. Individuals with a low level of physical fitness have shown a higher BP during routine activity compared to individuals with a high level of physical fitness. Since increased physical activity is associated with lower BP at medium and low workloads, this suggests that activities like fast walks of half an hour might lower BP and reduce the risk of LVH (37). Changes in fitness-levels have been shown to be in reverse association with hypertension, meaning that increased fitness is associated with a decrease in blood pressure, and a decrease is associated with an increase in blood-pressure (6).

Differences in occupational activity and leisure time activity and their relation to daily SBP was examined by Clays et al (11). They found that workers reporting a high level of static occupational activity and work with their arms in awkward, static positions had a higher daily SBP, and that those with a high level of leisure time activity had lower daily SBP. Knowing that moderate and vigorous leisure time activity is documented to reduce the risk of cardio vascular disease, and that high occupational activity is associated with an increase in risk, more studies are needed to be able to give a more exact understanding of the relationship between SBP, CVD and occupational and leisure time physical activity, and how to prescribe physical activity as a conservative treatment (38).

A reduction in blood pressure will correspond with a reduction of cardiovascular events, and according to a meta-analysis including 1 million subjects, one can expect a 7 % reduction of coronary heart disease and a 10 % reduction of stroke per 2 mmHg reduction in blood pressure. Knowing that most hypertensive cases has not been discovered, treated or have reached the treatment goals, there is a large potential for improvement of both pharmacological and conservative treatment (39, 40).

3.0 Methods

3.1 Data Collection

Data was retrieved from the sixth survey of the Tromsø Study, Tromsø 6, which was conducted during 2007-2008. Invitations to Tromsø 6 were sent to 4 different groups of inhabitants in Tromsø: The participants in the second round of an earlier study, Tromsø 4, were invited to participate again. A 10 % random selection in the age group of 30-39 years of age of those living in the Tromsø-region, all between 40-42 and 60-87 years of age, and a 40% random selection in the age-group of 43-59 as also invited. In total, 19762 men and women between 30-87 years of age were invited to participate in the survey and examinations (Figure 1).

3.2 Questions regarding physical activity

The invited inhabitants were given an information leaflet and a 4-page long questionnaire that included questions regarding general health condition, own diseases, diseases in the family, muscular pain, mental issues, nutrition, alcohol, smoking, physical activity, education, and so on. All questions were presented with alternative answers, and participants were asked to tick the most correct box.

There were 5 questions regarding physical activity:

a.) If you have paid or unpaid work, which statement describes your work best?

1 : Mostly sedentary work? (e.g. office work, mounting)

2 : Work that requires a lot of walking? (e.g. shop assistant, light industrial work, teaching)

3 : Work that requires a lot of walking and lifting? (e.g. postman, nursing, construction)

4 : Heavy manual labour? (e.g. forestry, heavy farmwork, heavy construction)

b.) Exercise and physical exertion in leisure time. If your activity varies much, for example between summer and winter, then give an average. The question refer only to the last twelve months.

1 : Reading, watching TV, or other sedentary activity?

2 : Walking, cycling, or other forms of exercise at least 4 hours a week? (including walking or cycling to place of work, Sunday-walking, etc.)

3 : Participation in recreational sports, heavy gardening, etc.? (note: duration of activity at least 4 hours a week).

4 : Participation in hard training or sports competitions, regularly several times a week?

c.) How often do you exercise (i.e walking, skiing, swimming or training/sports)?

1 : Never

2 : Less than once a week

3 : Once a week

4 : 2-3 times a week

5 : Approximately every day

d.) If you exercise - how hard do you exercise?

1 : Easy - you do not become shortwinded or sweaty

2 : You become shortwinded and sweaty

3 : Hard - you become exhausted

e.) For how long time do you exercise? (give an average)

1 : Less than 15 minutes

2 : 15-29 minutes

3 : 30-60 minutes

4 : More than 1 hour

This study chose to define question B as a measure of total level of physical activity the last 12 months: “Exercise and physical exertion in leisure time. If your activity varies much, for example between summer and winter, then give an average. The question refers only to the last twelve months.” The participants were divided into 4 groups of different level of total physical activity corresponding to their answer in the questionnaire. Groups being 1: “No activity”, 2: “recreational activity”, 3: “Exercising”, and 4: “Hard exercise.”

Questions C, D, and E were treated as a measurement for frequency, intensity and duration of physical activity, respectively. All questions were analyzed in relation to differences in SBP. These questions gave of 5, 3 and 4 groups of different levels of frequency, intensity and duration of physical activity, respectively.

We chose to ignore question A because heavy labor at work cannot be subscribed as a "lifestyle-change" by a general practitioner, and therefore is not applicable as a treatment.

3.3 Measurements

The participants underwent a physical examination consisting of measuring height, weight, hip and stomach circumference with standardized measurement equipment and weight scale. Blood pressure was measured 3 times by a physician using a standardized automatic sphygomamometer, and the results given as a mean of reading 2 and 3. All values were listed as mmHg. Weight was measured in kilograms (kg) to the nearest kilogram wearing light clothes, and height measured to the nearest centimeters (cm). Blood-samples were analyzed at the laboratory at the University hospital of Northern-Norway in Tromsø.

3.4 Variable selection and case exclusion

The following variables were included in the analyses: Age, sex, height, weight, mean SBP (as a mean of reading 2 and 3), mean DBP (as a mean of reading 2 and 3), heart attack (ever experienced a heart attack), angina (ever experience angina), stroke (ever had a stroke), diabetes, blood pressure treatment (currently, used to, or never), exercise in leisure time, exercise frequency, exercise intensity, exercise duration, smoke daily (currently or ever smoked 6 cigarettes a day), total serum cholesterol, and total triglycerides. All variables with more than 2 categories was treated as categorical variables, and the others as continuous variables.

One computed these variables for the analysis:

Cardio vascular disease (CVD): Yes on either heart attack, angina or stroke.

Body mass index (BMI): Weight in kilograms divided by height in meters, squared.

A total of 19762 inhabitants were invited, of which 12981 patients participated. After selecting the variables, there were 12981 cases with valid data for the variable Age. We then decided to remove cases with missing data for: Sex, mean SBP, mean DBP, diabetes, exercise in leisure time, exercise frequency, exercise intensity, exercise duration, smoke daily, total triglycerides, total cholesterol, cardiovascular disease, and body mass index (BMI). The final dataset thus included 9913 cases. In a sub-cohort with additional adjustments for blood pressure lowering drugs, the total number of cases was reduced to 9842 (Figure 1).

3.5 Analyzes

SPSS version 24 was used with permission and license from the University of Tromsø, and the data was analyzed using this software. For the main analyzes we used ANOVA and ANCOVA with mean SBP as the dependent variable and total physical activity in leisure time as fixed factor, to examine if there was a statistically significant difference in means between the 4 different groups of total physical activity.

Similar analyses were performed for the variables "How often do you exercise," "How hard do you exercise," and "How long do you exercise."

The ANCOVA model included the following covariates: Age, sex, smoking, BMI, CVD, triglycerides, cholesterol, diabetes, and blood pressure treatment. We did a sub-analysis with pregnancy as an additional covariate.

The results are given as means and the statistical level was set at p = 0,05 (Confidence interval (CI) 95%).

3.6 Ethics

The Tromsø Study has been approved by the Regional Norwegian Data Protection Authority and recommended by the Regional Committee of Medical and Health Research Ethics in Norway (REC North). Each participant signed a written informed consent. Consent to use the data in future research was also obtained. There were no conflicts of interest.

4.0 Results

4.1 Total physical activity and SBP

Descriptive statistics for mean SBP in relation to the total level of exercise (Exercise in leisure time) are presented in Table 1. There are more participants in the group *Recreational activity* (n=6137, 61,9%), than in the other groups (N group 1=1622, 16,4%; N group 3=1974, 19,9%; N group 4=180, 1,8%). Unadjusted mean SBP showed a decreasing trend with increasing physical activity level (Table1).

There was a difference in unadjusted mean SBP between the physical activity groups. *No Activity* had a 3.23 mmHg (95% CI; 1.75-4.71, p<0.001) higher mean SBP than *Recreational Activity*, and a 6.61 mmHg (95% CI; 3.14-10.08, p<0.001) higher mean than the *Hard exercise* group. *Recreational activity* had a 2.77 mmHg (95% CI; 1.63-3.91, p<0.001) higher mean than the *Exercising group* and a 6.15 mmHg (95% CI; 2.81-9.49, p<0,001) higher mean than *Hard Exercise* group. There was no statistically significant difference in mean SBP between *No Activity* and *Recreational activity* and between *Exercising* and *Hard exercise* (Table 2, Figure 2).

4.2 Intensity, frequency, and duration of physical activity and SBP

When examining frequency of physical activity (as defined by the variable How often do you exercise), there was no significant difference in SBP amongst *Less than once a week* (group 2), *Once a week* (group 3), *2-3 times a week* (group 4), and *Approximately every day* (group 5) in the unadjusted analyses. There was however a statistically significant difference between *Never* and the other groups; *Less Than Once A Week* had a 10.61 mmHg (95% CI; 4.49-16.63, p<0,01) higher mean SBP compared to the *Never* group. *Once A Week* had a 10.05 mmHg (95% CI; 4.06, 16.03, p<0,01) higher mean SBP compared to *Never*, and *2-3 Times A Week* had a 10.09 mmHg (95% CI; 4.14-16.04, p<0,01) higher mean SBP compared to *Never*. The *Approximately Every Day* group had a 9.81 mmHg (95% CI; 3.82-15.80, p<0,01) higher mean SBP compared to *Never* (Table 2, Figure 3).

Intensity of physical activity (as defined by the variable How hard do you exercise) showed statistically significant differences in mean SBP between all the groups. The *Medium* group had 6.16 mmHg (95% CI;5.26-7.06, p<0,001) higher SBP than the *Easy* group 1, *Hard* was

9.85 mmHg (95% CI;7.39-12.30, p<0,001) higher than *Easy*, and the *Hard* group had 3.68 mmHg (95% CI; 1.14-6.13, p<0,01) higher SBP than the *Medium* (Table 2, Figure 4).

Exercise duration (as defined by the variable For how long do you exercise) showed statistically significant differences in mean SBP between all groups except group 2 and 4. *Less than 15 minutes* (group 2) had 3.28 mmHg (95% CI;0,63-5.93, p<0,05) higher mean SBP than *15-29 minutes* (group 3), *Less than 15 minutes* (group 1) had a 5.08 mmHg (95% CI; 2.65-5-93, p<0,001) higher mean SBP than *30-60 minutes* (group 4), *Less than 15 minutes* had a 3.56 mmHg (95% CI; 1.03-6.09, p<0,01) higher mean SBP than *More than 60 minutes* (group 5), *15-29 minutes* had a 1.80 mmHg (95% CI;0,47-3.14, p<0,01) higher mean SBP than *30-60 minutes*, and *More than 60 minutes* had a 1.52 mmHg (95% CI; 0.44-2.60, p<0,01) higher mean SBP than *30-60 minutes* (table 2, Figure 5).

4.3 Total physical activity and DBP

Descriptive statistics for mean DBP in relation to the total level of exercise (Exercise in leisure time) are presented in Table 1. In unadjusted ANOVA analyses, we found no statistically significant association between total, frequency, duration and intensity of exercise and mean DBP (Table 3), and there was no trend for mean DBP in relation to physical activity.

4.4 Intensity, frequency, and duration of physical activity and DBP

In the unadjusted analyses with duration of the exercise *as outcome*, participants reporting *30-60 minutes* duration had a 1.34 mmHg (95% CI; 0.20-2.48, p<0.05) lower mean DBP than the *Less than 15 minutes* group, and a 0.95 mmHg (95% CI; 0.45-1.46, p<0.001) lower mean DBP than the *More than 60 minutes* group.

For intensity of the exercise, participants performing *Hard exercise* (Hard) had a 1.23 mmHg (95% CI; 0.07-2.40, p<0.05) lower mean DBP than participants in the *Easy* exercise group.

Regarding frequency of the exercise, the group *Approximately every day* had a 1.74 mmHg (95% CI; 1.03-2.44, p<0.001) lower mean DBP than *Less than once a week*, and a 1.11 mmHg (95% CI; 0.47-1.76, p<0,01) lower mean DBP than *Once a week*. The group *2-3 times a week* had a 1.57 mmHg (95% CI;0.95-2.20, p<0.001) lower mean DBP than *Less than once a week*, and a 0.95 mmHg (95% CI; 0.40-1.50, p<0.05) lower mean DBP than *Once a week* (Table 2).

4.4 The adjusted association between physical activity and SBP

When adjusting for the covariates BMI, CVD, smoking, age, sex, cholesterol, triglycerides, diabetes, and blood pressure treatment in the ANCOVA analysis with total physical activity as the dependent variable, there was no longer any statistically significant differences in mean SBP between the physical activity groups at the p<0,05 level. The same was true for the variables Frequency of exercise and Intensity of exercise. The only difference that remained significant at the p<0,05 level was Duration of exercise, where the group More than 60 minutes had a 1.56 mmHg (95 % CI; 0.64-2.46, p<0,05) higher mean systolic blood pressure than 30-60 minutes, and More than 60 minutes had a 1.34 (95% CI; 0.07-2.61, p<0.05) higher blood pressure than 15-29 minutes.

4.5 The adjusted association between physical activity and DBP

When adjusting for possible confounders, we saw that there was a statistically significant difference in mean DBP between *Recreational activity* and *Exercising*. *Exercising* had a 0.75 mmHg (95% CI; 0.25–1.25, p<0.01) higher mean DBP than *Recreational activity*. For duration of exercise, *More Than 60 Minutes* had a 0.48 mmHg (95% CI; 0.17-0.95, p<0.05) lower mean DBP than *30-60 minutes*. For intensity of exercise, *Hard* had a 1.23 mmHg (95% CI; 0.17-2.29, p<0.05) lower mean DBP than *Medium*. For frequency of exercise, *Almost Every Day* had a 0.51 mmHg (95% CI; 0.001-1.03, p=0.05) lower mean DBP than *2-3 Times A Week*.

4.6 SBP and other risk factors

The group who never had used blood pressure lowering drug had a 14.14 mmHg (95%; 11.34-16.93, p<0,001) lower mean than those who had been using previously, but not now, and a 7.99 mmHg (95% CI; 6.94 – 9.06, p<0,001) lower mean than those who were currently using blood pressure lowering drugs.

The group who did not smoke daily had a 1.21 mmHg (95% CI; 0.37-2.05, p<0,01) higher mean SBP than those who previously had been smoking daily, and a 2.82 mmHg (95% CI; 1.76-3.87, p<0,001) higher mean than those was smoking daily.

There was a statistically significant increase in mean SBP of 0.80 mmHg (95% CI; 0.76-0.83, p<0,001) with increasing age, with 0,80 mmHg increase SBP per 1 year.

Males had a 4.54 mmHg (95% CI;3.76-5.32, p<0,001) higher mean SBP than females.

There was no statistically significant difference in mean SBP between those who had diabetes or not.

There were statistically significant differences in mean SBP between the different BMI groups. SBP increased by 0.70 mmHg (95% CI;0,61.0,80, p<0,001) per BMI level.

The mean SBP was 3.61 mmHg (95% CI; 2.10-5.11, p<0,001) lower for the participants who had experienced a cardiovascular event such as heart attack, angina or stroke or a combination of these, than those who did not.

For the different measurements of total serum cholesterol there was significant higher mean SBP accounting for 2.12 mmHg (95% CI; 1.74-2.51, p<0,001) for each mmol/L increase. For total triglycerides the difference in mean SBP for each mmol/L increase was 0.59 mmHg (95% CI; 0.18-1.01, p<0.01. This means that 1 unit (mmol/L) higher measurement of total cholesterol or total triglycerides equaled a 2.12 mmHG and 0.59 mmHg higher mean SBP, respectfully.

4.7 DBP and other risk factors

The group who never have used blood pressure lowering drug had a 7.35 mmHg (95%; 5.92-8.78, p<0,001) lower mean DBP than those who had been using previously, but not now, and a 3.25 mmHg (95% CI; 2.71-3.79, p<0,001) lower mean DBP than those who were currently using blood pressure lowering drugs.

The group who did not smoke daily had a 0.76 mmHg (95% CI; 0.21-1.30, p<0,01) higher mean DBP than those who were smoking daily.

There was a statistically significant increase in mean DBP of 0.07 mmHg (95% CI; 0.05-0.08, p<0,001) with increasing age, with 0,07 mmHg increase DBP per 1 year.

Males had a 6.36 mmHg (95% CI; 5.96-6.75, p<0,001) higher mean DBP than females.

Those with diabetes had a 2.02 mmHg (95% CI; 1.05-2.99, p<0.001) lower mean DBP than those who didn't have diabetes.

Mean DBP increased by 0.35 mmHg (95% CI; 0.30-0,40, p<0,001) per BMI level.

The mean DBP was 2.57 mmHg (95% CI; 1.80-3.34, p<0,001) lower for the participants who had experienced a cardiovascular event such as heart attack, angina or stroke or a combination of these, than those who had not.

For the different measurements of total serum cholesterol there was significant higher mean DBP accounting for 1.31 mmHg (95% CI; 1.11-1.50, p<0,001) for each mmol/L increase. For total triglycerides, the difference in mean DBP for each mmol/L increase was 0.31 mmHg (95% CI; 0.10-0.53, p<0.01. This means that 1 unit (mmol/L) higher measurement of total cholesterol or total triglycerides equaled a 2.12 mmHg and 0.59 mmHg higher mean DBP, respectfully.

5.0 Discussion

5.1 Summary

There was an inverse association between mean SBP and total physical activity in unadjusted analyses. This association was no longer significant when adjusting for potential confounders. Unadjusted analyses also showed an inverse association between mean SBP and frequency, intensity and duration. As for total physical activity, the association disappeared when adjusting for potential confounders, except for an association between duration of exercise and SBP.

There was no association between mean DBP and total physical activity in unadjusted analyses. However, when adjusting for potential confounders we saw that there was a small, inverse association for mean DBP and frequency of exercise, a small favorable association for the intensity-group *Hard,* and a small favorable association with the duration-group *30-60 minutes.* The differences were small and probably of little clinical significance

5.2 Total physical activity and SBP

The goal of this study was to examine mean SBP and DBP in relation to different levels of leisure time physical activity. The main difference in SBP was seen between those being at *Recreational activity* or lower, and those *Exercising* and higher. The unadjusted results suggest that physical activity may contribute to lower SBP, but only when the total activity level reaches *Exercising* or "walking, cycling and other light activities around 4 hours a week." Assuming that the observed unadjusted associations are true, this can possibly be explained by the fact that many people with high-normal (120-139 mmHg) or High (>140 mmHg) blood pressure already have been prescribed increased physical activity as conservative treatment by their physician, and therefore has an increased activity level even though their blood pressure is high.

However, the relation was no longer significant when adjusting for potential confounders, and the observed associations between mean SBP and physical activity may be due to one or more confounders. In the present analyses, stepwise ANCOVA revealed that while sex and age did not affect the relationship between physical activity and SBP, adding BMI to the model changed the association so that physical activity was no longer significantly associated with SBP, suggesting that BMI may explain some of the effects of physical activity seen in unadjusted analyses. This result is interesting because it may seem that the positive effect of physical activity on reducing hypertension might be due to losing weight in the process (41). When implementing a life-style change aimed at hypertension, it should include increased physical activity, eating healthier, loose more weight and stop smoking, and it seems that the losing weight might be an important factor depending on your starting BMI. Thorogood et al (42) showed that weight loss can be accomplished through physical activity, and that physical activity in itself might reduce blood pressure, but that it should be combined with a diet to make it an effective means for weight reduction.

All of the groups had a mean SBP within 120-139 mmHg, previously described as pre-hypertension, but there was a clear tendency that those having a lower level of physical activity was closer to the definition of systolic or diastolic hypertension. After adjustment for covariates, the mean SBP remained within the ranges of prehypertension for all groups. It has been shown that aerobic exercise especially, and also resistance training, over a longer period of time can have a beneficial effect on blood pressure. Hernelahti et Al (7) conclude in their cohort-study from 1975 to 1990 that persistent vigorous activity in healthy, young adults predicts a low risk of hypertension. They specify that the activity needs to be continued over a longer period of time to be a significant preventive factor. They also observed that the other important factors for predicting hypertension are consistent or increased use of alcohol, overweight, and gaining a lot of weigh. Heavy drinking and gaining weight can be interpreted both as a result of a change in lifestyle, and in association with less physical activity.

5.3 Intensity, frequency, and duration of physical activity and SBP

In the unadjusted analyses for Frequency of exercise, only SBP in the group *Never* was significantly different from the other. Among those who report to be physically active, there was no difference in mean blood pressure regarding how often the participants exercise. There were very few participants who responded with *Never* to the question of frequency (n=56, 0,6%). Not being physically active at all is likely to be part of a lifestyle who includes more risk factors like smoking, excessive drinking, overweight, diabetes and unhealthy food high in cholesterols and triglycerides.

The intensity of the activity showed statistically significant differences in mean SBP between all the groups in the unadjusted analysis. The largest difference was found between those not becoming short-winded and those who exercise until exhaustion, and the participants spending enough energy to be sweaty and out of breath when exercising had the lowest blood pressure. Assuming that the observed differences are real, this can be interpreted both as a sign that exercising at increased intensity is associated with a lower SBP, and that those having a normal SBP are having a life-style that allows for high-intensity activities. High intensity training has been shown to be effective, but that medium intensity is recommended for lowering blood pressure (37). 60-85 % of age-predicted maximum heart was the most effective. Since this study looks at intensity as a self-reported variable with only 3 alternatives, it is difficult to assess a percentage of max heart rate. However, we interpreted that a heart rate of 60-85 % of maximum is at such a level that you become sweaty and short-winded (alternative 2), and depending on the duration, it is not uncommon to become exhausted if you are approaching 85 % maximum HR (37).

The unadjusted analysis for duration of the exercise showed a statistically significant difference in SBP means between all groups except between *15-29 minutes* and *Over 60 minutes*. The fact that blood pressure is greater in the group who exercises the longest than in the group who exercises between 30 and 60 minutes might be due to the same reason as for total physical activity; They might have been given a prescription for lifestyle change, and thus are exercising at more than 1 hour each time. The lowest level of blood pressure is found in the group who exercises between *30 and 60 minutes*, and that makes an interesting result combined with the fact that there is no difference in mean SBP when looking at frequency above *Never* exercising, and that the cut-off for total physical activity is between those doing light exercise minimum 4 hours a week and those doing harder exercise and recreational sports minimum 4 hours a week. Knowing that the Norwegian national recommendations for physical activity is medium to hard exercise (out of breath and sweating) for minimum 30 minutes, 5 days a week, it is natural to see that those in effect reporting to be following the recommendation had a lower blood pressure than those who didn't. It is on the other hand more probable that a young, healthy individual is following the recommendations than an elderly person with other risk factors like overweight, smoking, and excessive alcohol use.

After adjusting for possible confounders, the differences in mean SBP between the exercise intensity groups were in general no longer statistically significant, except the difference between some of the Duration groups. *More than 60 minutes* remained statistically significantly higher in mean SBP than the group *30-60 minutes*, but it was also higher than the group *15-29 minutes*, which was a opposite result compared to the unadjusted analysis. The difference of 1.56 mmHg and 1.34 mmHg respectfully is small, and might be explained by the same argument that those exercising longer each time might be doing it in an attempt to lower an already high blood pressure. This is merely speculation, and needs to be addressed in other studies.

It has been shown that aerobic exercise especially, and also resistance training, over a longer period of time can have a beneficial effect on blood pressure. Hernelahti et Al (7) conclude in their cohort-study from 1975 to 1990 that persistent vigorous activity in healthy, young adults predicts a low risk of hypertension. They specify that the activity needs to be continued over a longer period of time to be a significant preventive factor. They also state that the other important factors for predicting hypertension are consistent or increased use of alcohol, overweight, and gaining a lot of weigh. Heavy drinking and gaining weight can be interpreted both as a result of a change in lifestyle, and in association with less physical activity.

5.4 Total physical activity, duration, intensity, frequency, and DBP

Unadjusted analysis with DBP as the dependent variable showed no statistically significant associations with total physical activity. There was a statistically significant lower mean DBP for the duration *30-60 Minutes* compared to other duration-groups, for the intensity *Hard* compared to other intensity-groups, and for *Almost Every Day* compared to other frequency-groups. This supports the recommendations that regular exercise at high intensity at the duration 30-60 minutes is associated with a lower DBP, but its significance is questionable since total physical activity wasn’t associated with lower mean DBP.

The differences in blood pressure are small, and when adjusting for covariates the statistically significant findings for duration and total physical activity was either reversed or not significant. Hard intensity and a higher exercise frequency remained borderline significant for lower DBP.

These findings suggest that total physical activity, and the sub-categories duration, intensity and frequency are not associated with mean DBP in a statistically significant pattern, and is not affected as much by exercise as SBP.

5.5 Results in relation to previous studies

Some cross-sectional studies examining blood pressure and physical activity are inconsistent with the results of our study. Clays et al (11) examined the association between self-reported physical activity and 24 hours ambulatory blood pressure, and found a statistically significant lower mean SBP for vigorous activity, both unadjusted, and after adjusting for gender, BMI, smoking, job strain age, and the normal level of occupational physical activity. These findings support our results, but Clays et al differs in methods used to measure blood pressure, and inclusion of confounders. They only examined SBP. Papathanasiou et al (9) examined blood pressure in relation to life-style risk factors like physical activity, smoking and BMI in a cross-sectional study with self-reported physical activity data and standardized BP measurements, and found no association between different groups of physical activity and blood pressure, or hypertension. Gaya et al (12) found similar results when adjusting for confounders like BMI and cardiorespiratory fitness. It may from these studies seem that the inverse association seen between physical activity and blood pressure might be due to lower BMI. Bacon et al (41)showed that a decrease in bodyweight and a change of diet are strong predictors of lower blood pressure.

Differences in population, different methods for measuring blood pressure, different questionnaires, different confounders and missing confounders might be reasons why similar studies get different results.

5.6 Other risk factor for hypertension

We observed that other risk factors were associated with larger differences in mean SBP than exercise. Blood pressure treatment accounted for 14.14 mmHg of the difference between those never using BP treatment and those who used to use it, and 7.99 mmHg between those never using, and those who currently use BP treatment medication; Never using having the lowest mean. The difference being largest among those who did not use medication anymore might be because of non-compliance or side-effects, or it might be co-morbidities for patients being old and having other diseases and not having the benefit of a prophylactic BP treatment.

Those reporting to smoke or those who used to smoke actually had a lower mean systolic BP than those who never smoked. This result was a bit surprising compared to other studies, which conclude that smoking is a definite risk for developing hypertension. Even though the result was significant, it was very small with a 1.21 mmHg and 2.82 mmHg difference for the groups Used to smoke daily, and Smoking daily.

Age is a known risk factor for hypertension, and we observed that SBP increased by 0,80 mmHg for each year. This does not mean that as a person ages, he will have an increase of 0.80 mmHg each time he becomes one year older, but that as a mean, the SBP will be 0.80 mmHg/year higher when looking at participants divided into groups by age. A man 20 years older than another will on average have a 0.80 mmHg x 20 = 16 mmHg higher SBP.

Sex is also a known risk factor as shown by other studies (9). This was also true in this cohort, where males had a statistically significant higher mean SBP of 4.54 mmHg compared with women.

Diabetes was surprisingly not associated with SBP, even though other studies (43) have proven its significance. However, BMI was statistically significant with a 0.70 mmHg higher mean SBP for each 1 unit increase in BMI. This means that this study supports overweight, as accounted for by BMI score, is a risk factor for hypertension (15, 16, 44)

For those who had experienced a cardiovascular event (CVD), either heart attack, angina or stroke, SBP was 3.61 mmHg lower than for those who did not have an CVD event. This may be explained by the fact that after a cardiovascular event it is recommended to establish a secondary prophylactic treatment as a mean to lower the risk factors for another event. This often consist of medical treatment, and a part of this is blood pressure lowering drugs. Life-style changes are also important, but it might not have the same effect on blood pressure due to the fact that these patients are already given substantial pharmacological treatment.

Lifestyle changes also improve lipid profile, even though the changes are small (45, 46). It has been shown that exercise can reduce the risk of atherosclerosis through lowering inflammatory factors (47), and lowering the risk of CVD.

SBP was statistically significant associated total serum cholesterol and serum triglycerides. However, the validity of these measurements was questionable since the participants did not have a standardized fast before blood samples were taken.

5.7 Mechanisms why physical exercise might reduce blood pressure.

The underlying reasons for the anti-hypertensive effect of physical activity is not fully understood, but Hansen et al (48) concluded after a 16-week training program on hypertensive subjects that exercise inflicts a change in vasodilating and vasoconstricting substances. Thromboxane increases, there is a reduction in the exercise induced ATP-increase, and a greater increase in prostacyclin from exercise. They also saw that endothelial nitric oxide synthetase in skeletal muscle was 40 % lower ($p<0.05$) in hypertensive subjects compared to normotensive controls. Goto et al (49) found results that suggest that medium intensity exercise increases endothelium-dependent vasodilation by increasing the levels of nitric oxide. Nelson et al (50) also found that plasma noradrenaline levels, which is a known vasoconstrictor, falls below baseline levels for those with essential hypertension who were followed with an exercise program. It seems that exercise will alter the vasoactive components in the body, and thus have an effect on blood pressure. Duncan et al (51) found that a 16-week aerobic exercise program in patients with diastolic hypertension both reduced blood pressure, and for those who were hyperadrenergic, the reduction was associated with the changes found in chatecolamine levels. They concluded that the effect of an aerobic exercise program which reduces blood pressure, is at least partially mediated by the changes in chatecolamine levels.

Lifestyle changes also improve lipid profile, even though the changes are small (45, 46). It has been shown that exercise can reduce the risk of atherosclerosis through lowering inflammatory factors (47), and lowering the risk of CVD.

5.8 Strengths and limitations of the methodology

Our study had a large number of participants (n=12981) with a large number of completed cases with no missing data (n=9913). The participants represented a large variety of ages, and were almost equally divided in men and women. The measurements were done in a standardized procedure with a professional nurse, and the data collection was done with a self-reporting questionnaire developed from the previous 5 studies Tromsø 1-5. One of the strengths is the inclusion of many of the likely confounders normally associated with cross-sectional studies done on blood pressure. Blood-samples were analyzed at the same laboratory at the university hospital.

Limitations are the missing confounder alcohol, and alcohol consumption, and residual confounding such as diet. The covariates triglycerides and cholesterol yielded limited knowledge because of the unstandardized procedure and non-fasting blood-samples.

It is also a large limitation that all data for physical activity was self-reported, and not measured objectively. This means that the level of activity is based on the participants' self-evaluation, and might not be accurate. Emaus et al (52) examined the validity of the total physical activity question against accelerometer measurements and found that people tend to overestimate their activity level when self-reporting. However, the rank of physical activity levels assessed by the total physical activity question showed good correlation with VO2 max, accelerometer counts and steps, supporting the use of the question when ranking physical activity levels.

As a study looking at the preventive effects of physical activity for hypertension, this study does not have substantial statistically significant results supporting this, and the main findings of BMI being a possible confounding factor were not part of the primary hypothesis. Our study is cross-sectional, which means that causal associations cannot be addressed. This study can merely suggest associations and it would not be appropriate to draw conclusions about physical activity as evidence-based conservative treatment of hypertension.

6.0 Conclusion

6.1 Total physical activity and SBP and DBP

In conclusion, SBP and DBP was not associated with total physical activity level. Although unadjusted analyses showed an inverse relationship between SBP and total physical activity, the significant association disappeared when adding BMI to the model, suggesting that some of the differences in mean SBP seems to be explained by BMI or other risk factors, rather than physical activity level.

6.2 Intensity, frequency, and duration of physical activity, and SBP and DBP

Duration, intensity and frequency of activity were generally not associated with SBP or DBP, which is expected as total physical activity was not associated with blood pressure.

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8.0 Tables

Table 1: Descriptive statistics for SBP and DBP in relation to total physical activity, frequency, intensity, duration

Variable	N (%)	Mean SBP (SD) In mmHg	Mean DBP (SD) In mmHg
Total physical activity			
• No activity	1622 (16.4%)	135.05 (23.16)	78.27 (10.67)
• Recreational Activity	6137 (61.9%)	134.60 (22.74)	77.71 (10.61)
• Exercising	1974 (19.9%)	131.83 (21.57)	77.61 (10.52)
• Hard exercise	180 (1.8%)	128.44 (19.90)	76.81 (10.77)
Exercise Frequency			
• Never	56 (0.6%)	144.05 (23.44)	79.16 (11.15)
• Less than once a week	1522 (15.4%)	133.44 (21.19)	78.92 (10.88)
• Once a week	2122 (21.4%)	134.01 (22.45)	78.29 (10.47)
• 2-3 times a week	4177 (42.1%)	133.96 (22.56)	77.34 (10.56)
• Almost every day	2036 (20.5%)	134.24 (22.57)	77.18 (10.53
Exercise Intensity			
• Easy	4428 (44.7%)	137.54 (23.85)	77.92 (10.73)
• Medium	5143 (51.9%)	131.38 (21.11)	77.70 (10.48)
• Hard	342 (3.5%)	127.70 (19.89)	76.68 (10.84)
Exercise duration			
• Less than 15 minutes	350 (3.5%)	138.31 (23.58)	78.79 (10.49)
• 15-29 minutes	1347 (13.6%)	135.03 (23.74)	77.74 (10.72)
• 30-60 minutes	5884 (59.4%)	133.23 (22.31)	77.45 (10.63)
• More than 60 minutes	2332 (23.5%)	134.75 (22.27)	78.41 (10.47
Total	**9913 (100%)**	**134.01 (22.57)**	**77.75 (10.61)**

Table 2: Adjusted association between total physical activity, frequency, intensity, duration and SBP

Variable	Difference from baseline group in mmHg	95 % CI	Significance (p<)
Total physical activity			
• No activity	6.61	3.14 - 10.08	0.001
• Recreational Activity	6.15	2.81 - 9.49	0.001
• Exercising	3.38	-0.06 – 6.82	0.054
• Hard exercise	Reference group		
Exercise Frequency			
• Never	9.81	3.82 - 15.80	0.005
• Less than once a week	-0.80	-2.30 – 0-70	0.294
• Once a week	-0.24	-1.61 – 1.14	0.737
• 2-3 times a week	-0.28	-1.48 – 0.92	0.647
• Almost every day	Reference group		
Exercise Intensity			
• Easy	9.85	7.39 – 12.30	0.001
• Medium	3.68	1.24 – 6.13	0.005
• Hard	Reference group		
Exercise duration			
• Less than 15 minutes	3.56	1.03 – 6.09	0.01
• 15-29 minutes	0.28	-1.23 – 1.79	0.716
• 30-60 minutes	-1.52	-2.60 - -0.44	0.01
• More than 60 minutes	Reference group		

Table 3: Adjusted association between total physical activity, frequency, intensity, duration and DBP

Variable	Difference from reference group in mmHg	95 % CI	Significance (p<)
Total physical activity			
• No activity	1.46	-0.17 – 3.09	0.080
• Recreational Activity	0.90	-0.68 – 2.47	0.264
• Exercising	0.80	-0.82 – 2.42	0.332
• Hard exercise	Reference group		
Exercise Frequency			
• Never	1.98	-0.83 – 4.79	0.167
• Less than once a week	1.74	1.03 – 2.44	0.001
• Once a week	1.11	0.47 – 1.76	0.001
• 2-3 times a week	0.16	-0.40 – 0.72	0.572
• Almost every day	Reference group		
Exercise Intensity			
• Easy	1.23	0.07 – 2.40	0.05
• Medium	1.02	-0.14 – 2.18	0.085
• Hard	Reference group		
Exercise duration			
• Less than 15 minutes	0.39	-0.80 – 1.58	0.525
• 15-29 minutes	-0.67	-1.38 – 0.04	0.064
• 30-60 minutes	-0.95	-0.45 - -1.46	0.001
• More than 60 minutes	Reference group		

Figure 1

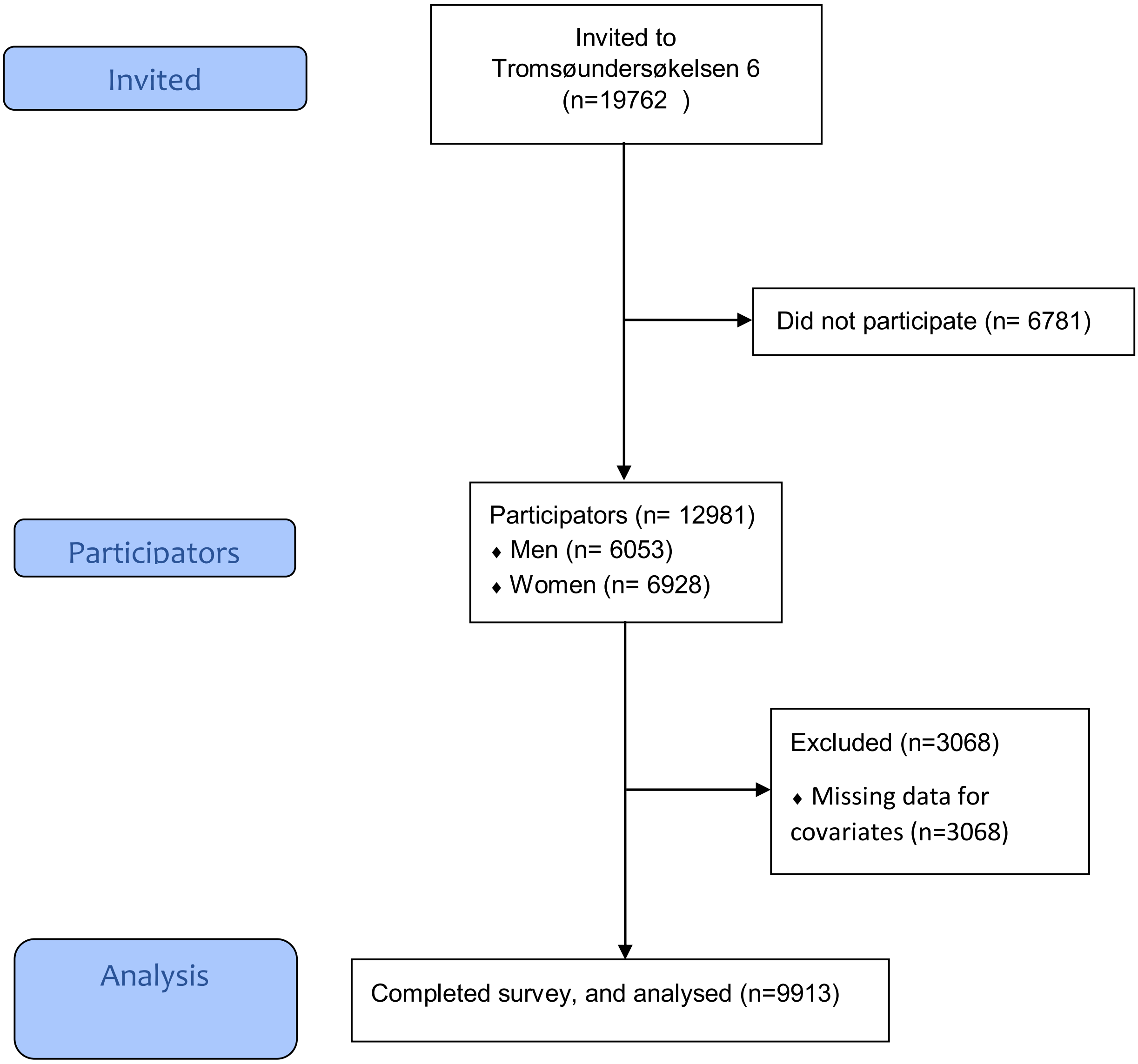

Invited
Invited to Tromsøundersøkelsen 6 (n=19762)
Did not participate (n= 6781)
Participators
Participators (n= 12981)
Men (n= 6053)
Women (n= 6928)
Excluded (n=3068)
Missing data for covariates (n=3068)
Analysis
Completed survey, and analysed (n=9913)

Figure 2

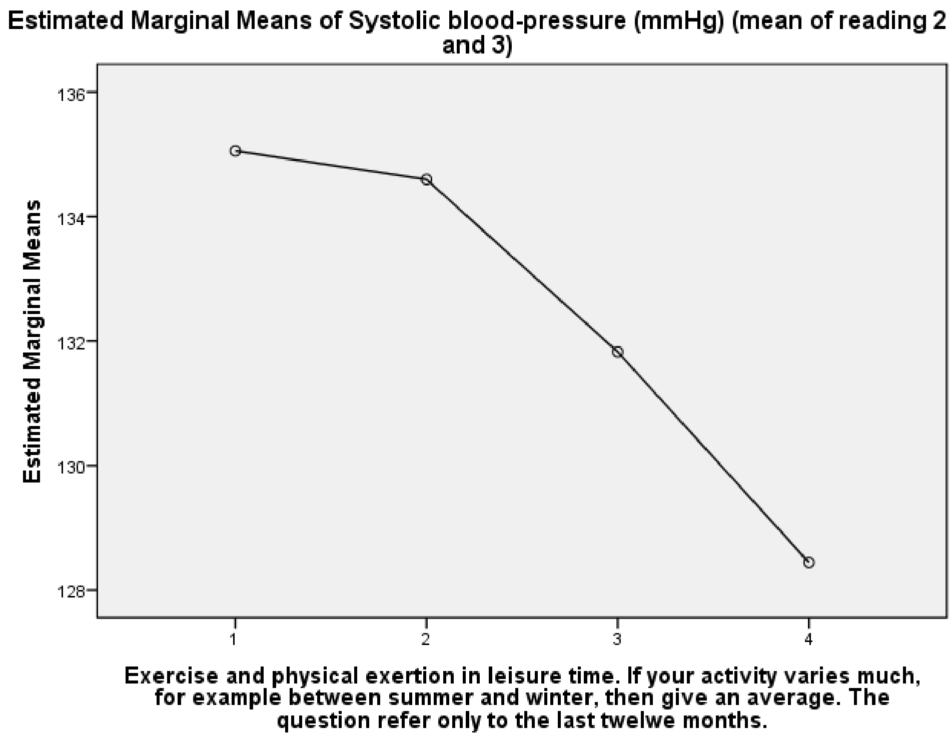


Figure 3

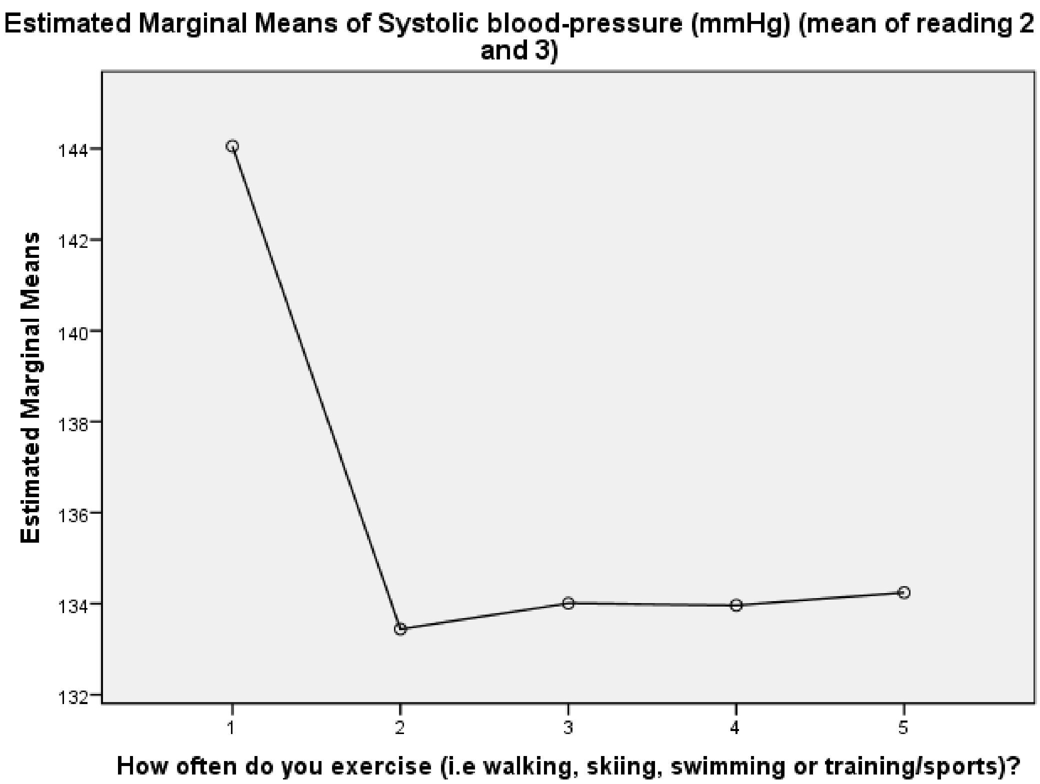


Figure 4

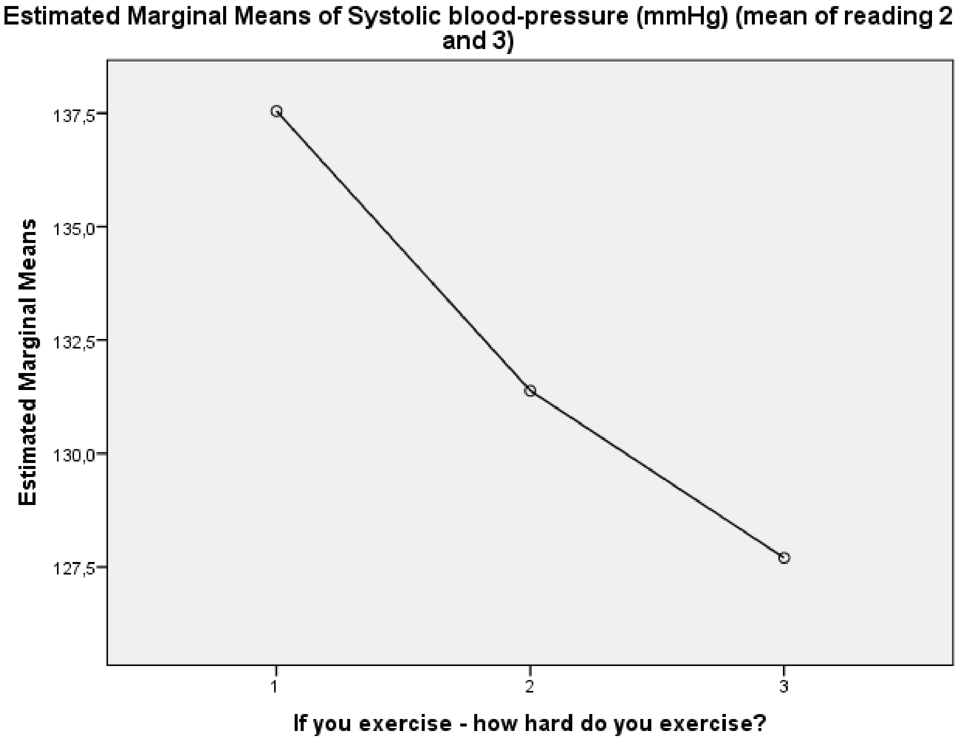
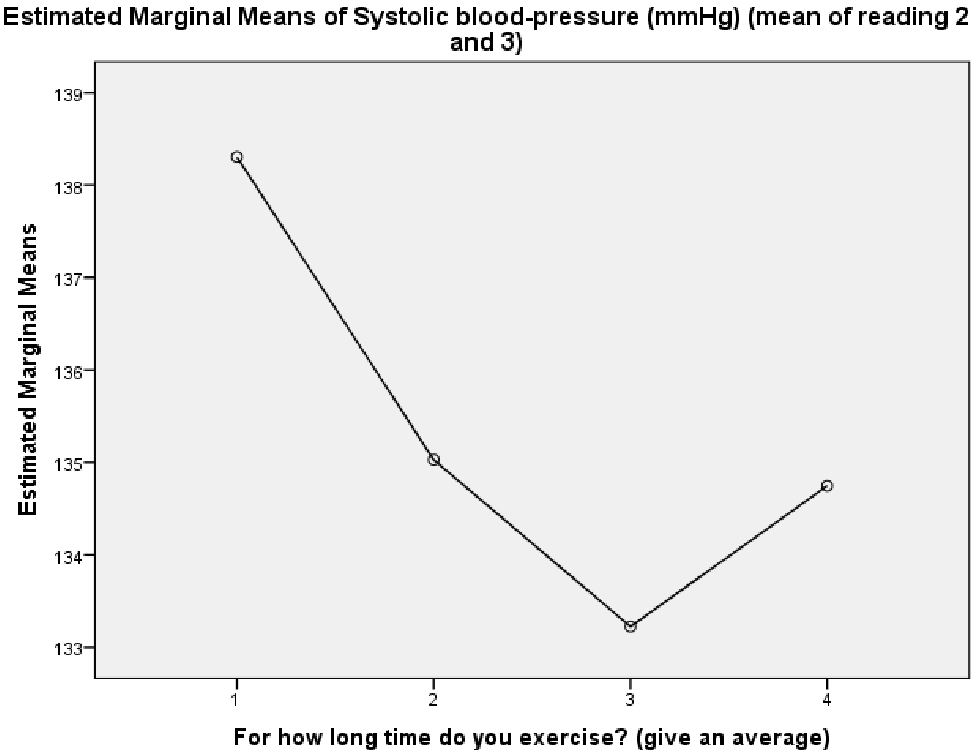


Figure 5



Referanse: Clays E, De Bacquer D, Van Herck K, De Backer G, Kittel F, Holtermann A. Occupational and leisure time physical activity in contrasting relation to ambulatory blood pressure. BMC public health. 2012;12:1002.

GRADE	
Dokumentasjonsnivå	III
Anbefaling	C

Formål

The purpose of the study was to examine the relationship between self-reported occupational and leisure time activity with ambulatory blood pressure.

Konklusjon

Workers involved in static occupational activity, not including dynamic movements of large muscle groups, have higher daily systolic blood pressure.

Objectively reported levels of moderate and high leisure time activity is related to a lower daily time systolic blood pressure

Land

Belgium

År data innsamling

2002-2003

Materiale og metode

Design: Cross-sectional. Data collected from the second part of the epidemiologic cohort study BELSTRESS II (n=2821).
Inclusion: A random collection from four of the nine organizations included in BELSTRESS II (n=182, males=109, females=73). Organizations was picked due to practical reasons and feasibility of work. 2 public administrations, one company form the secondary sector, and one from the service sector.
Exclusion: Pasients with medication for hypertension, and a history of cardio vascular disease.
Outcome: The association between occupational activity and leisure time activity and ambulatory blood pressure.
Confounding factors: Gender, age, Body mass index (BMI), smoking, job strain, and usual level of occupational and leisure time activity, respectfully.
Secondary outcome: Relation between heavy lifting and having your arms in awkward positions, and daily systolic blood pressure.
Statistical methods: Descriptive statistics, independent sample t-tests, and ANCOVA in SPSS version 19. Linear regression analysis was not used since the data for physical activity was highly skewed.

Resultater

Those with a high level of occupational activity and those who often lifted heavy loads had a 5 to 7 mmHg higher systolic ambulatory blood pressure. For those working with their arms or heads in awkward positions the study showed a 4 to 5 mmHg higher mean BP at work and in sleep. When adjusting for confounders, the relationship between ambulatory BP and occupational physical activity became borderline significant, but the relation between heavy lifting and BP remained significant.

Workers with a moderate to high leisure time activity showed a 5 to 6 mmHg significantly lower mean systolic BP during daytime (at work and at home). These results were still significant after adjusting for confounders.

Table 2 Associations between self-reported occupational/leisure time physical activity and systolic ambulatory blood pressure (mmHg) (N=182)

Occupational physical activity groups	crude mean SBP at work (SD)	*P* (*T*-test)	*P** (Ancova)	crude mean SBP at home (SD)	*P* (*T*-test)	*P** (Ancova)	crude mean SBP during sleep (SD)	*P* (*T*-test)	*P** (Ancova)
Summary measure of occupational physical activity		**<0.01**	0.06		**<0.05**	0.11		**<0.01**	0.07
High	136.4 (13.8)			133.7 (12.3)			118.8 (13.7)		
Low	130.0 (11.0)			128.6 (10.1)			111.8 (10.7)		
High physical effort at work		**<0.05**	0.12		0.06	0.17		**<0.05**	0.10
High	134.4 (14.0)			132.2 (12.6)			116.8 (12.2)		
Low	130.2 (10.7)			128.7 (9.8)			112.0 (11.1)		
Lifting heavy loads at work		**<0.05**	**<0.05**		**<0.05**	**<0.05**		**<0.01**	**<0.05**
High	135.6 (14.6)			133.5 (12.6)			118.1 (13.1)		
Low	130.3 (10.8)			128.7 (10.0)			112.1 (11.0)		
Rapid physical activity at work		0.37	0.94		0.68	0.71		0.22	0.90
High	132.7 (13.3)			130.2 (11.2)			115.1 (12.5)		
Low	130.8 (11.4)			129.4 (10.5)			112.6 (11.3)		
Awkward body positions at work		0.07	0.67		0.24	0.79		**<0.05**	0.40
High	134.5 (12.3)			131.5 (12.6)			117.7 (13.7)		
Low	130.5 (11.5)			129.1 (10.1)			112.2 (10.8)		
Awkward positions of head or arms at work		**<0.01**	0.22		0.06	0.72		**<0.05**	0.48
High	135.7 (13.1)			132.4 (13.0)			117.4 (14.6)		
Low	130.0 (11.1)			128.8 (9.8)			112.1 (10.4)		
Leisure time physical activity groups	**crude mean SBP at work (SD)**	***P* (*T*-test)**	***P*** (Ancova)**	**crude mean SBP at home (SD)**	***P* (*T*-test)**	***P*** (Ancova)**	**crude mean SBP during sleep (SD)**	***P* (*T*-test)**	***P*** (Ancova)**
Leisure time physical activity		0.72	0.29		0.55	0.22		0.64	0.47
High	130.4 (11.5)			128.4 (11.1)			112.2 (8.1)		
Low	131.4 (11.8)			129.8 (10.6)			113.4 (12.0)		

Diskusjon/kommentarer

Population: The population was clearly defined, but the selection of companies the study chose to include participants from was due to practical reasons. There were no companies including work from the primary section (with highly physical labor), and 2 of the companies were from an administrative sector. That means that the selection might include more or less stressful, but not hard work representing the entire population.

Also, they excluded participants with CVD and antihypertensive treatment, meaning that many already in a risk group weren't controlled.

Participants not responding: It has not been accounted for if someone invited didn't respond, or if they were excluded.

Data collection and measurements: The data collection was standardized and the methods used for measuring ambulatory blood pressure were equal in all cases.

Analyses and assessing outcomes: The study used self-reported measurements on physical activity both occupational and leisure time. The questionnaires were standardized, but the results depend on the participants' subjective evaluation of their own level of activity. This is due to the questions having alternative answers to choose from, and the alternatives being open for interpretation. For example: Likert scale: From do you "totally disagree" t "totally agree." This might lead to overestimating physical activity.

Referanse: Hernelahti M, Kujala U, Kaprio J. Stability and change of volume and intensity of physical activity as predictors of hypertension. Scandinavian journal of public health. 2004;32(4):303-9.			**GRADE**	
			Dokumentasjonsnivå	IIb
			Anbefaling	B

Formål	Materiale og metode	Resultater	Diskusjon/kommentarer
Examine the association between long term changes in volume and intensity of physical activity and hypertension in men and women. **Konklusjon** Persistent vigorous physical activity will, compared to inactivity, predict a low risk of hypertension in men. **Land** **Finland** **År data innsamling** 1975 1990	**Design:** Cohort-study. University of Helsinki, Finland. N=8312 **Inclusion:** All same-gender twin pairs born in Finland before 1958 with both co-twins alive in 1967 were included and sent questionnaires in 1975 and 1981. Response rate in 1975 of those identified (93,5%) was 87,6%. Re-response in 1981 was 90,7%. All between 24 and 51 years of age by 1. January 1982 were included. **Exclusion:** All not responding satisfactory to a total of three questionnaires in 1975, -81, -90. All participants with baseline hypertension or being treated for hypertension. All participators being disabled and not able to work. The final cohort included 8312 participants (males=3931, females=4381). **Outcome:** Associations between long term changes of physical activity and hypertension, estimated as odds ratios. **Confounding factors:** Body mass index (BMI), age, smoking, use of alcohol, work-related physical activity. **Measurements:** Standardized measurement of blood pressure using a sphygomamometer (not specified type) and the mean of measurement 1 and 2. Data available for only 224 subjects. **Statistical methods:** t-test and logistic regression in STATA.	Cumulative incidence of hypertension from the second survey at 1982 to the third in 1990 was 10,2 % and 8,0% for men and women respectfully. For men, the risk for developing hypertension was greater among those who persistently did not participate in vigorous physical activity (both during 1975 and 1981) with an OR of 1,60 (95% CI 1,15, 2,24, p<0,006) compared to those who consistently participated. For those participating in vigorous physical activity only in 1975 or in 1981, there was no statistically significant increase in risk for hypertension. The volume of physical activity was not associated with hypertension. There were no associations between physical activity and hypertension in women.	**Purpose:** The purpose of the study is clearly formulated **Selection bias:** The choice of including only same-sex twins is not explained. Also, the choice of excluding all not being able to work or disabled does not differentiate between those being disabled from physical, mental or other issues. Below 50 % of the population given the opportunity to participate actually completed the entire survey and was included in the study. **Measurements:** The questionnaires are subjective, and there were only two measurements of blood. There is no information on this being done as a standardized procedure or by whom it is done. Weight and height was self-reported as the basis for BMI. Only 22 subjects had values for systolic blood pressure, measured in 1993-95, and none of the participants currently using antihypertensive drugs were excluded. **Confounders:** Other important confounders one could have included was pregnancy and cardiovascular disease. **Strengths:** Long follow-up time. Twin studies will adjust for genetic predisposition and is a strength, as most diseases may to a large degree be explained by genetics. **Limitations:** Almost no actual measurement of blood pressure (n=225). Missing confounders. Excluding all not able to work no matter the reason.

Referanse: Katsuyuki Ito, Masataka Iwane, Nobuyuki Miyai, Yukiko Uchikawa, Koichi Mugitani, Osamu Mohara, Mitsuru Shiba & Mikio Arita (2016) Exaggerated exercise blood pressure response in middle-aged men as a predictor of future blood pressure a 10-year follow-up, Clinical and Experimental Hypertension, 388, 696-700, DOI10.108010641963.2016.1200597	**GRADE**	
	Dokumentasjonsnivå	IIb
	Anbefaling	B

Formål

To assess if an exaggerated exercise systolic blood pressure is associated with the predictor of future blood pressure.

Konklusjon

Exercise systolic blood pressure (SBP) in middle-aged men is a stronger predictor of future SBP after 10 years than resting SBP.

Land

Japan

År data innsamling

1996-1998 and 2006-2008 (10 year follow up)

Materiale og metode

Design: Cohort (10 year follow up). Place: Department of Healthcare, Wakayama Medical University, Japan. N= 1534 males, N (follow-up): 733 males.
Inclusion: Normal BP and no medication
Exclusion: Receiving antihypertensive treatment during the 10-year follow up.
Outcome: The level of correspondence between exercise systolic blood pressure and resting systolic blood pressure after 10 years.
Confounding factors: BMI, BP at rest, total cholesterol, HDLcholesterol, triglyceride, alcohol consumption, max O2 consumption
Secondary outcome: The factors influencing SBP after a period of 10 years.
Equipment: Ergometer exercise equipment and blood pressure measurement equipment (automated sphygmomanometer).
Statistical methods: ANOVA analysis (with Bonferoni tests) after 10 -year follow up of 3 groups divided by BP (<180mmHg (Low), 181-200 mmHg (Medium), >201 mmHg(High)) at 60% load, and Multiple regression analysis. Significance level p=0,05-

Resultater

Systolic blood pressure increased significantly more in the group with high exercise SBP after a 10 year period, than in the group with low exercise SBP (significant at p=0,05) (Table 2). Exercise Systolic blood pressure (at 60% load) is the second most influential factor of the ones included in the multivariate analysis (Table 3).

Table 3. Facter that affected the blood pressure after '10 year (multivariate analysis).

SBP					
	SE	*B*	*β*	95%CI	*P*
Resting SBP (mmHg)	0.057	0.373	0.250	(0.261-0.485)	$p < 0.001$
Exercise 60% SBP (mmHg)	0.027	0.152	0.198	(0.100-0.204)	$p < 0.001$
Age (y.o.)	0.055	0.201	0.123	(0.093-0.310)	$p < 0.001$
Resting DBP (mmHg)	0.066	0.207	0.120	(0.079-0.336)	$p = 0.002$
Alcohol/w (ml)	0.000	0.001	0.083	(0.000-0.002)	$p = 0.013$
BMI (kg/m^2)	0.188	0.441	0.078	(0.072-0.809)	$p = 0.019$
$R^2 = 0.256$ $p < 0.001$					

DBP					
	SE	B	*β*	95%CI	*p*
Resting DBP (mmHg)	0.041	0.176	0.168	(0.095-0.257)	$p < 0.001$
Exercise 60% DBP (mmHg)	0.028	0.104	0.143	(0.049-0.158)	$p < 0.001$
Resting SBP (mmHg)	0.034	0.163	0.183	(0.095-0.230)	$p < 0.001$
Alcohol/w (ml)	0.000	0.001	0.121	(0.000-0.002)	$p < 0.001$
BMI (kg/m^2)	0.113	0.377	0.110	(0.155-0.598)	$p = 0.001$
Age (y.o.)	0.034	0.095	0.095	(0.029-0.161)	$p = 0.005$
Exercise 60% SBP (mmHg)	0.017	0.037	0.080	(0.004-0.070)	$p = 0.029$

Table 2. Changes in resting blood pressure after 10 Year.

	<180 mmHg《Low : $n = 267$》		180–199 mmHg《Middle : $n = 263$》		>200 mmHg《High : $n = 203$》	
variables	Baseline	10-Year Follow-up	Baseline	10-Year Follow-up	Baseline	10-Year Follow-up
Resting SBP (mmHg)	120 ± 11	128 ± 13*	125 ± 9	135 ± 15*	128 ± 8	141 ± 15*
Resting DBP (mmHg)	72 ± 8	82 ± 8*	74 ± 9	86 ± 9*	76 ± 8	88 ± 9*
ΔResting SBP (mmHg)	8 ± 13		10 ± 15		13 ± 15*	
ΔResting DBP (mmHg)	10 ± 13		11 ± 10		12 ± 10*	

value mean ± SD.
*$p < 0.001$(High, Middle, Low: vs. At the start: 1996–1998; paired *t*-test .
*$p < 0.05$(vs. Low): Multiple comparison by modification of ANOVA and Bonferroni
Resting SBP, Resting DBP.
ΔResting SBP: Resting systolic blood pressure after 10 Year-Resting systolic blood pressure at the start of the survey.
ΔResting DBP: Resting diastolic blood pressure after 10 Year-Resting diastolic blood pressure at the start of the survey.

Diskusjon/kommentarer

Precisely formulated purpose: The purpose of the study was clearly defined.

Selection bias: Due to the fact that the study included only middle-aged males with a normal blood pressure and no medication, it might be a healthier group of individuals with a greater potential for a high increase in SBP, and therefore a larger result.

Measurement bias: The methods of measurement was precisely performed and standardized at both baseline and follow-up, but the calculation of load was calculated from a standardized VO2-max according to age. This does not take into account individual differences of physical form.

Classification bias: There were no difference in the methods used for classification of the 3 groups.

Confounding factors: Smoking is not included as a confounding factor.

Did the study follow up enough of the included participants at the 10-year interval? The study excluded more than 50 % of the baseline participants (N=801) due to receiving antihypertensive treatment.

Were the participants followed for a long enough period: Yes, a 10 year period.

Strengths: The ANOVA and ANCOVA are robust test, and follow-up period was long. Precise measurement.

Limitations: Excluding more than 50 % of the participants at baseline. Not including smoking as a confounder. Only statistically significant difference in 10-year resting SBP between the group with High Exercise SBP and the one with Low Exercise SBP

Referanse: Papathanasiou G, Zerva E, Zacharis I, Papandreou M, Papageorgiou E, Tzima C, et al. Association of high blood pressure with body mass index, smoking and physical activity in healthy young adults. The open cardiovascular medicine journal. 2015;9:5-17.

GRADE	
Dokumentasjonsnivå	III
Anbefaling	C

Formål

Examine the associations between blood pressure at rest, smoking, body mass index (BMI), and physical activity in Greek young adults.

Konklusjon

There was no association between smoking prevalence and PA, and resting BP.

Land

Greece

År data innsamling

2009-2013

Materiale og metode

Design: Cross-sectional study.
Inclusion: The participants were students from the Medical School of Ioannina University and the Physiotherapy Department of the Technological Educational Institute (TEI) of Athens. All 1500 students studying health science were given the opportunity to participate.
Exclusion: 251 students were excluded. Health related problems (n=79), missing data (n=146), refusing to participate (n=26).
Outcome: Association between resting BP, physical activity, BMI and smoking.
Confounding factors: Gender
Measurements: BMI was calculated and standardized according to WHO criteria (measuring weight with a calibrated scale, and height with standard equipment and two decimals). BP was measured using a standard mercury sphygmomanometer and calculated as the mean of the second and third measurement.

Statistical methods: SPSS version 19. ANOVA, Mann-Whitney-U test, Chi-square, Multivariable linear regression, and logistic regression.

Resultater

1249 students (males n= 522, females n=727) aged 19-30 years (mean age= 21,8 years of age). 13 % of the total population was classified as hypertensive and around 17 % had high-normal BP. Males had a higher risk of being hypertensive than females (OR=1,87; 95% CI of 1,26-2,76).

Physical activity (PA) was found to be statistically significant only when using continuous vigorous PA and linear regression analysis on the males. The model was excluded due to multicollinearity.

Table 5. Linear regression model for the association between life style risk factors and change in systolic blood pressure.

	Risk Factors	B	Standardized Beta	t value	Significance *p value*
Males	Age	0.007	0.001	0.034	NS (0.973)
	BMI	1.985	0.465	10.879	<0.001
	Smoking	-0.631	-0.048	-1.117	NS (0.265)
	PA class	-1.739	-0.104	-1.501	NS (0.134)
	Vigorous PA	0.001	0.152	2.404	0.017
	Moderate PA	0.002	0.084	1.798	NS (0.073)
	Walking	0.000	-0.008	-0.181	NS (0.857)
Females	Age	-0.154	-0.037	-1.002	NS (0.317)
	BMI	1.353	0.350	9.451	<0.001
	Smoking	-0.670	-0.054	-1.445	NS (0.149)
	PA class	-0.435	-0.024	-0.374	NS (0.709)
	Vigorous PA	0.001	0.049	0.918	NS (0.359)
	Moderate PA	-0.001	-0.030	-0.698	NS (0.486)
	Walking	0.001	0.059	1.344	NS (0.180)

Diskusjon/kommentarer

Population: The population was clearly defined and selected from a specific group of people. One can argue that using health care students 19-30 years of age is only applicable to this exact group due to the nature of the study. Health science students is arguably more aware of lifestyle recommendations, they can afford going to the university and may be of a higher social class, and the results might therefore not represent the average population 19-30 years of age in Greece.

Inclusion/exclusion: Documentation for inclusion/exclusion is excellent, and a large number of the ones invited, participated (83,3%).

Data collection and measurements: The data collection was based on a standardized questionnaire, and the measurements of BP (mean of measure 2 and 3), and BMI (weight and height) was standardized.

Analyses: The analyses used were correctly applied.

Strengths: The study uses standardized methods for measurement, and they a large result with no other clear explanations

Limitations: Limited population of only young adults studying health science. Only smoking, age and gender as confounders. Alcohol consumption and pregnancy would have been very useful in this young population with an overweight of women.

Referanse: Pouliou T, Ki M, Law C, Li L, Power C. Physical activity and sedentary behaviour at different life stages and adult blood pressure in the 1958 British cohort. Journal of hypertension. 2012;30(2):275-83.

GRADE	
Dokumentasjonsnivå	III
Anbefaling	C

Formål

To investigate associations between physical activity and sedentary behavior with blood pressure (BP) in mid-adulthood, and if body mass index (BMI) mediates associations.

Konklusjon

The study suggests that there are benefits to BP when having an active lifestyle, and becoming active, and also with minimizing television-viewing. BMI does have a mediating role.

Land

United Kingdom

År data innsamling

1958-2005

Materiale og metode

Design: Prospective Cohort study (Follow-up from birth and at 7, 11, 16, 23, 33, 42, 45 and 50 years of age).
Place: MRC Centre of Epidemiology for Child Health, Centre for Pediatric Epidemiology and Biostatistics, UCL Institute of Child Health, UK.
Inclusion: All born in England, Wales and Scotland in 1 week in March 1958 (N= 18558). N=9377 (males= 4632, females= 4665) were examined at the age of 45.
Exclusion: Participants not in contact with the study, suffering death.
Outcome: Association between activity at different ages and BP.
Confounding factors: Birth-weight, gestational age, smoking, alcohol, diet, social class, pre-existing medical condition (influencial of level of physical activity).
Secondary outcome: Association between amount of television-viewing and BP
Measurements: Trained nurse using automated sphygmomanometer 3 times.
Statistical methods: Linear regression models and logistic regression. Adjusting for missing data with inverse probability weighting to reflect the full surviving population (n=17313), and use of antihypertensive medication was adjusted for by adding 10 mmHg to both SBP and DBP.

Resultater

Active men and women at 23, 33, 42, 45 years of age had lower mean SBP and DBP and risk for hypertension later on and concurrently at 45 years of age. When adjusting for covariates and television-viewing the active men at 23, 42 and 45 still had lower SBP, DBP and risk of hypertension. There was no association between physical activity in childhood and BP as adults.
In males, Odds ratios (ORs) for hypertension in the active group of 23 year olds was 0,82 (95% CI0,74, 0,91) before adjustment for covariates and BMI, and 0,79 (95% CI 0,70, 0,90) after, compared with the inactive. There was no association between activity and BP at 33 years of age when adjusting for covariates and BMI. For women, the ORs of hypertension in the active group comrade with the inactive was 0,77 (95% CI 0,66, 0,89) prior adjustment and 0,80 (95% CI 0,66, 0,97) after at 33 years of age. At the age of 23 and 42 there was no association in the adjusted model.
Men at the age of 23 and 42 with least activity had the highest prevalence of hypertension (39,9%), and active men at 23 who became least active at the age of 42 had a higher prevalence than those still active (38,7% vs 31,4% respectively.

	Systolic BP		
	Model 1[b]	Model 2[c]	Model 3[d]
Men			
Physical activity at ages:			
23 years	−1.9 (−2.9, −0.8)	−1.8 (−3.0, −0.6)	−1.6 (−2.8, −0.4)
33 years	−0.4 (−1.5, 0.7)	0.5 (−0.9, 1.8)	0.8 (−0.5, 2.1)
42 years	−1.9 (−2.9, −0.9)	−1.2 (−2.4, −0.04)	−0.7 (−1.9, 0.5)
45 years moderate-vigorous h/day			
Leisure	−1.8 (−2.8, −0.8)	−1.3 (−2.5, −0.1)	−1.1 (−2.3, 0.04)
Work	2.1 (1.0, 3.1)	0.9 (−0.4, 2.2)	1.2 (−0.1, 2.4)
Sedentary behaviour			
Sitting at work (h/day) at 45 years	−0.2 (−0.4, 0.003)	0.1 (−0.2, 0.3)	−0.03 (−0.3, 0.2)
TV-viewing at ages			
23 years (times/week)	0.54 (0.2, 0.9)	0.46 (0.1, 0.8)	0.3 (−0.02, 0.7)
45 years (h/day)	0.9 (0.4, 1.3)	0.5 (−0.02, 1.0)	0.1 (−0.4, 0.6)
Women			
Physical activity at ages:			
23 years	−1.7 (−2.8, −0.6)	−0.7 (−2.0, 0.6)	−0.1 (−1.3, 1.2)
33 years	−1.1 (−2.2, 0.1)	−1.4 (−2.8, −0.1)	−1.0 (−2.3, 0.3)
42 years	−1.0 (−2.0, 0.1)	−0.1 (−1.3, 1.1)	0.4 (−0.7, 1.6)
45 years moderate-vigorous h/day			
Leisure	−0.6 (−1.6, 0.4)	−0.03 (−1.2, 1.2)	0.6 (−0.6, 1.7)
Work	0.8 (−0.4, 1.9)	1.2 (0.04, 2.5)	0.9 (−0.2, 2.1)
Sedentary behaviour			
Sitting at work (h/day) at 45 years	−0.20 (−0.5, 0.1)	−0.15 (−0.6, 0.2)	−0.14 (−0.4, 0.2)

Diskusjon/kommentarer

Purpose: The purpose of the study is not very well defined, especially when it comes to the secondary results of television-viewing (which not all participators had at the beginning of the study)

Inclusion: Satisfactory inclusion criteria.

Measurements: Standardized procedures.

Classification: The same procedure for classification of activity was used in all follow-ups.

Confounders: Smoking, alcohol, pregnancy was not controlled for.

Did enough of the included participators complete the study: A lot of the original participators did not have contact with the study until the end.

Long enough follow-up: 45 years is a long follow-up.

Strengths: A long period of time. Significant results between the male groups of 23 and 42 who reduced their activity.

Limitations: Many of the participators didn't complete the study. The participants undergoing antihypertensive treatment were given an addition of 10 mmHg both to SBP and DBP.