ORIGINAL RESEARCH

Relation Between Leisure Time, Commuting, and Occupational Physical Activity With Blood Pressure in 125 402 Adults: The Lifelines Cohort

Oyuntugs Byambasukh, MD; Harold Snieder, PhD; Eva Corpeleijn, PhD

***Background*—**Whether all domains of daily-life moderate-to-vigorous physical activity (MVPA) are associated with lower blood pressure (BP) and how this association depends on age and body mass index remains unclear.

***Methods and Results*—**In the population-based Lifelines cohort (N=125 402), MVPA was assessed by the Short Questionnaire to Assess Health-Enhancing Physical Activity, a validated questionnaire in different domains such as commuting, leisure-time, and occupational PA. BP was assessed using the last 3 of 10 measurements after 10 minutes' rest in the supine position. Hypertension was defined as systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg and/or use of antihypertensives. In regression analysis, higher commuting and leisure-time but not occupational MVPA related to lower BP and lower hypertension risk. Commuting-and-leisure-time MVPA was associated with BP in a dose-dependent manner. β Coefficients (95% CI) from linear regression analyses were −1.64 (−2.03 to −1.24), −2.29 (−2.68 to −1.90), and finally −2.90 (−3.29 to −2.50) mm Hg systolic BP for the low, middle, and highest tertile of MVPA compared with "No MVPA" as the reference group after adjusting for age, sex, education, smoking and alcohol use. Further adjustment for body mass index attenuated the associations by 30% to 50%, but more MVPA remained significantly associated with lower BP and lower risk of hypertension. This association was age dependent. β Coefficients (95% CI) for the highest tertiles of commuting-and-leisure-time MVPA were −1.67 (−2.20 to −1.15), −3.39 (−3.94 to −2.82) and −4.64 (−6.15 to −3.14) mm Hg systolic BP in adults <40, 40 to 60, and >60 years, respectively.

***Conclusions*—**Higher commuting and leisure-time but not occupational MVPA were significantly associated with lower BP and lower hypertension risk at all ages, but these associations were stronger in older adults. **(*J Am Heart Assoc*. 2020;9:e014313. DOI: 10.1161/JAHA.119.014313.)**

Key Words: blood pressure • commuting activity • domain-specific physical activity • hypertension • leisure-time activity • occupational activity

Hypertension is one of the most common disorders in the general population, with 90% of lifetime risk for elderly individuals.[1] Previous meta-analyses have indicated that exercise training is a relatively cost-effective intervention in the management of hypertension, even more so than pharmacological treatment.[2,3] However, little is known about the potential benefits of different domains of daily-life physical activity on blood pressure, especially from large population-based studies.[4,5] In addition, a growing body of evidence is showing that occupational physical activity (OPA) has no benefit on health.[4,6,7] Therefore, one critical step in exploring benefits of physical activity on blood pressure is to evaluate its benefit across the major domains of daily-life activities.

Previous studies have tended to focus on the benefit of leisure-time physical activity on reducing the risk of hypertension and lowering blood pressure (BP).[2,3,8,9] However, only a few observational studies have attempted to explore the impact of other domains, mostly with small sample sizes.[4,5] A meta-analysis reported that OPA does not reduce the risk of hypertension.[4] However, a recent study showed that OPA lowers the risk of mortality in patients with high BP.[10] Furthermore, several studies have shown that active transportation (commuting) is beneficial for reducing the risk of hypertension, but others

From the Department of Epidemiology, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands (O.B., H.S., E.C.); Department of Internal Medicine, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia (O.B.).

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Correspondence to: Oyuntugs Byambasukh, MSc, Unit of Lifestyle Medicine in Obesity and Diabetes, Department of Epidemiology (FA40), University Medical Center Groningen, University of Groningen, PO Box 30 001. 9700 RB Groningen, The Netherlands, E-mail: o.byambasukh@umcg.nl; oyuntugs@mnums.edu.mn

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Clinical Perspective

What Is New?

- Benefit of daily-life moderate-to-vigorous physical activity on blood pressure depends on the domain of physical activity, be it leisure time, commuting, or occupational, and higher levels of occupational activity are not directly associated with lower blood pressure the same way that leisure-time or commuting physical activity is.
- The potentially favorable effect of commuting and leisure-time physical activity were independent of body mass index categories.
- By being more active at commuting and leisure-time domains, older individuals have a relatively larger reduction in systolic blood pressure or pulse pressure than younger adults.

What Are the Clinical Implications?

- The domain of daily-life physical activity may be an important attribute and should potentially be recommended in the clinical guidelines for hypertension, similarly to intensity and duration.

have found no association.[5,6,10] Another issue is that although OPA and commuting physical activity are the major contributors to total daily-life physical activity, these domains are not differentiated in the clinical guidelines[11,12] but may be an important attribute of relevance similar to intensity and duration. Therefore, there is a need to investigate whether domain-specific physical activity confers the same impact on BP and the risk of having hypertension. We describe the following domains in this study: leisure time, commuting, and occupational. Physical activities in the leisure-time domain refer to activities that are chosen for pleasure or relaxation such as walking, cycling, and sports. Commuting physical activity is considered as the activity to travel between the place of residence and work or study. Occupational activity refers to activities that are done on purpose, related to one's occupation.

The aim of this study was to investigate the associations of different domains of daily-life physical activity, such as commuting, leisure-time, and occupational, with BP level and the risk of having hypertension. Furthermore, it was studied whether the associations depend on body mass index (BMI) categories and on age over the life course in a large cohort representative of the general population.

Materials and Methods

Data Source and Study Population

Lifelines is a multidisciplinary, prospective, population-based cohort and bio-bank of more than 167 000 people living in the north of the Netherlands. It employs a broad range of investigative procedures in assessing the biomedical, sociodemographic, behavioral, physical, and psychological factors that contribute to the health and disease of the general population, with a special focus on multimorbidity and complex genetics. Participants were recruited via general practitioners; subsequently, family members were invited to participate; and, finally, adults could self-register to participate. The Lifelines cohort does not enable public data sharing. The cohort's data are available only to researchers who, upon approval of a submitted research proposal, have signed a Data/Material Transfer Agreement. The study was conducted according to the Helsinki Declaration and was approved by the medical ethical review committee of the University Medical Center Groningen, the Netherlands. All participants provided their written informed consent.[13,14]

In this cross-sectional study of the adult subsample (18–93 years) of the Lifelines cohort, we included subjects of Western European origin.[15] Participants who had missing data needed to evaluate BP parameters: systolic BP (SBP) and diastolic BP (DBP) and to assess physical activity were excluded. We also excluded pregnant women in this study. Furthermore, participants with a history of coronary heart disease, stroke, heart failure, and renal failure and participants who had implausible data related to physical activity measurement (time spent in activities listed in the Short Questionnaire to Assess Health-Enhancing Physical Activity [SQUASH] ≥18 h/day)[16] were excluded. A total of 125 402 participants were included in the current analysis (Figure S1).

Assessment of Physical Activity

Physical activity was assessed using the SQUASH, a questionnaire estimating habitual physical activities, referring to a normal week.[17] Questions for each reported activity consist of 3 main parts: days per week (frequency), average time per day (duration), and effort. Each activity in minutes per week was calculated by multiplying frequency (days/week) by duration (min/day). Then, the activities were assigned to a certain level of intensity, indicated by the metabolic equivalent of task (MET) value of the activity.[17,18] MET values were assigned to all activities in the questionnaire with the help of Ainsworth's Compendium of Physical Activities 2011.[19] Using these MET values in combination with the reported efforts, as explained in the study of Wendel-Vos et al,[18] each activity in minutes per week were classified into light (<4.0 MET), moderate (4.0 to <6.5 MET), and vigorous (≥6.5 MET) intensity. The SQUASH questionnaire has been validated in the general population.[17]

In this study, we used activity minutes per week only at the moderate-to-vigorous level in different domains such as commuting, leisure-time, and occupational. Total minutes for each domain-specific moderate-to-vigorous physical activity

(MVPA) were calculated by summing up the all MVPA minutes for domain-related activities. For instance, leisure-time MVPA was the sum of MVPA minutes per week in leisure time walking, cycling, gardening, doing odd jobs around the house, and sports. In addition, total daily-life MVPA was calculated by the sum of all domain-specific MVPA: commuting, leisure-time and occupational. Furthermore, leisure-time MVPA was combined with commuting MVPA, as active commuting of high intensity and longer duration is often replacing sports activities, like cycling, in the setting of the Netherlands. Finally, total and each domain-specific (total physical activity, commuting-and-leisure-time physical activity, commuting physical activity, leisure-time physical activity, and occupational physical activity) MVPA minutes per week were classified as one of the following categories separately: "No MVPA" (the people who did not perform physical activity at a moderate-to-vigorous level) and tertiles of MVPA from low (tertile 1, MVPA-T1), middle (tertile 2, MVPA-T2) to high (tertile 3, MVPA-T3). Thus, T0, T1, T2, and T3 were considered as "inactive," "not very active," "active," and "very active," respectively.

BP and Hypertension

BP parameters were obtained with an automated device (DinaMap, PRO 100V2, GE Healthcare, Freiburg, Germany) in a quiet room with room temperature after 10 minutes' rest in the supine position.[13,14] The size of the cuff was chosen according to the arm circumference. Ten measurements were taken in a period of 10 minutes. The average of the final 3 readings was used for each BP parameter (systolic and diastolic). Pulse pressure was calculated as the difference between systolic and diastolic BP.

Hypertension was defined as SBP ≥140 mm Hg and/or DBP ≥90 mm Hg and/or use of antihypertensive medication. The definition of medication use was based on Anatomical Therapeutic Chemical codes using recorded medication data: C02 (antihypertensives), C03 (diuretics), C07 (β-blocking agents), C08 (calcium channel blockers) and C09 (agents acting on the renin-angiotensin system).[12,20]

Other Measurements and Definitions

Body weight and height were measured to calculate BMI as the ratio between weight (kilograms) and the square of height (meters). Blood samples were collected in the fasting state and analyzed on the day of collection at the Department of Laboratory Medicine of the University Medical Center Groningen, the Netherlands (Data S1).[13,14]

Education level was categorized as low, medium, or high (Data S1). Current smoking was categorized as nonsmokers or smokers. From the Food Frequency Questionnaire, daily caloric intake and alcohol intake were calculated and presented as kilocalories per day and grams of alcohol per day. Definitions for cardiovascular diseases, renal failure, and type 2 diabetes mellitus are described in Data S1.

Statistical Analysis

General characteristics were expressed as means with an SD for normally distributed variables, medians with interquartile range (25th–75th percentile) for non–normally distributed variables or numbers with percentages for categorical variables in total, normotensive, and hypertensive participants. The differences between normo- and hypertensive participants were compared using regression analyses with age and sex as covariates (adjusted *P* values were reported).

Linear regression analysis was performed to evaluate the association between MVPA and BP parameters including SBP and DBP, and pulse pressure. In this analysis, we created dummy exposure variables for each physical activity domain for comparison between the reference group (No MVPA) and tertiles of MVPA at each domain (T1-3). Outcomes were presented as unstandardized β coefficients with 95% CIs. Furthermore, binary logistic regression analysis was used to calculate odds ratios for risk of having hypertension associated with MVPA categories (tertiles of each domain) versus the "No MVPA" (inactive) category. In the regression analyses, the basic model was adjusted for age, square of age (because age may be nonlinearly related to outcome), sex, and education. In Model 1, we added current smoking (yes/no) and alcohol consumption (g/day) as potential lifestyle confounders to the basic model. Model 2 was adjusted for BMI in addition to Model 1. In linear regression analyses, the effect of medication was corrected by adding 15 and 10 mm Hg to SBP and DBP, respectively, for participants who reported using antihypertensives (10.8%).[21] All the regression analyses were repeated for different age categories (<40, 40–60, and >60 years) and BMI categories (BMI <25 kg/m^2, 25–30 kg/m^2, and >30 kg/m^2). Interaction effects were also tested with age and BMI separately in the association of physical activity with outcome variables.

As mentioned above, BP was corrected for the use of antihypertensive medication in the main analysis. In a sensitivity analysis, we compared the β coefficients from linear regression analyses to adjust for medication use in different ways, first, using the uncorrected BP, and then looking into the association of physical activity with BP in 2 groups according to hypertensive status (normotensive and hypertensive). In this analysis, we adjusted for age, square of age, sex, education, smoking, and alcohol use. Thereafter, we additionally adjusted for antihypertensive medication use in the group with hypertension, using a term for medication effect in the association between physical activity and BP.

Table 1. General Characteristics of the Study Population

Variable	Total (n=125 402)	Normotensive (n=94 760)	Hypertensive (n=30 642)	*P* Value
Age, y	45 (36–51)	42 (33–49)	49 (43–60)	<0.0001
Male sex, % (n)	40.5 (50 762)	38.8 (32 930)	44.1 (17 832)	<0.0001
Education: low, % (n)	27.7 (34 758)	23.8 (20 185)	36.0 (14 573)	<0.0001*
Current smoking, % (n)	21.2 (26 553)	22.5 (19 104)	18.4 (7449)	<0.0001*
Alcohol use, (gr/day)	3.87 (0.86–10.3)	3.84 (0.97–9.86)	3.91 (0.72–11.65)	<0.0001*
Daily caloric intake (kcal/day)	1995.4±616.8	1956.5±606.4	2012.8±620.6	<0.0001*
BMI (kg/m^2)	26.0±4.3	25.2±3.9	27.7±4.6	<0.0001*
Waist in men (cm)	95.0± 10.8	92.6±9.9	99.4±10.8	<0.0001*
Waist in women (cm)	86.6±12.2	84.4±11.2	91.6±12.9	<0.0001*
SBP (mm Hg)	125.3±15.2	119.8±10.4	142.1±15.4	NA
DBP (mm Hg)	73.7±9.3	71.2±7.4	81.5±10.3	NA
Pulse pressure (mm Hg)	51.6±11.0	48.7±8.5	60.6±12.9	NA
Total cholesterol (mmol/L)	5.08±1.00	4.99±0.97	5.28±1.01	0.114*
Triglyceride (mmol/L)	1.17±0.81	1.08±0.71	1.36±0.95	<0.0001*
HDL-C in men (mmol/L)	1.31±0.32	1.33±0.31	1.28±0.32	<0.0001*
HDL-C in women (mmol/L)	1.62±0.40	1.63±0.39	1.59±0.40	<0.0001*
LDL-C (mmol/L)	3.23±0.91	3.15±0.90	3.42±0.92	0.001*
FPG (mmol/L)	4.99±0.81	4.89±0.68	5.23±1.01	<0.0001*
Diabetes mellitus, % (n)	3.0 (3766)	1.4 (1157)	6.4 (2609)	<0.0001*
Total MVPA (min/week)	310 (120–770)	325 (130–796)	300 (120–720)	<0.0001*
No MVPA, % (n)	9.9 (12 408)	9.1 (7871)	11.7 (4537)	<0.0001*

Data are presented as mean±SD or median (25th–75th percentile) and number (%). BMI indicates body mass index; BP, blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; MVPA, moderate-to-vigorous physical activity; NA, not applicable; SBP, systolic blood pressure.
*Adjusted for age and sex.

All statistical analyses were carried out using SPSS version 22.0 (IBM, Chicago, IL) and Prism version 4.03 (GraphPad Software, La Jolla, CA). A 2-sided statistical significance was set at $P<0.05$ for all tests.

Results

The number of hypertensive people accounted for 24.4% of the total population. Hypertensive people were older, more frequently men with lower education levels, more likely to have diabetes mellitus, and less frequently smokers. Furthermore, daily caloric intake and alcohol consumption were higher in the hypertensive group. Hypertensive people had a larger waist circumference and higher BMI. Finally, higher concentrations of total cholesterol, low-density lipoprotein cholesterol, and fasting plasma glucose and lower concentration of high-density lipoprotein cholesterol were observed in hypertensives compared with normotensives (all $P<0.0001$) (Table 1). The mean of SBP steadily increased with age, while DBP no longer increased in the older age group (>40 y, Figure S2). According to the level of physical activity, people in all inactive groups at leisure-time and commuting activities had higher BMI and higher concentrations of total cholesterol and triglycerides and were more likely to have diabetes mellitus compared with the highest tertiles of each domain (Table S1). Conversely, a higher BMI and a higher concentration of triglycerides were noted in the group with the highest level of occupational physical activity compared with the inactive group. Moreover, they were more frequently smokers and had a higher consumption of alcohol intake. Furthermore, we stratified level of daily-life physical activities according to age (Figure S3). This shows that older adults performed more moderate activities such as nonsport leisure-time activities, while more vigorous activities are noted in younger adults.

In regression analysis, higher commuting and leisure-time, but not occupational MVPA were associated with lower BP (basic model, Figure 1). The associations remained materially unchanged after adjustments for other potential

confounders (Model 1, Table S2). Only leisure-time MVPA was associated with BP in a dose-dependent manner. β Coefficients (95% CI) were −1.25 (−1.60 to −0.89), −1.85 (−2.22 to −1.49) and −2.25 (−2.61 to −1.89) mm Hg for SBP and −0.62 (−0.84 to −0.39), −0.87 (−1.10 to −0.64) and −1.23 (−1.46 to −1.01) mm Hg for DBP for the low, middle, and highest tertile of MVPA, respectively, compared with "No MVPA" in the leisure-time domain as the reference group. The combined effect of commuting and leisure-time MVPA together was stronger than for individual domains or total daily-life MVPA (Figure 1 and Table 2). This combined time of 2 domains will be presented and named as "commuting-and-leisure-time" in later sections. Furthermore, commuting-and-leisure-time MVPA was dose-dependently associated with lower pulse pressure. In logistic regression analysis, likewise, leisure-time MVPA was dose-dependently associated with lower hypertension risk (Table S3). In contrast, commuting MVPA tertiles did not show dose-dependent associations. Compared with "No MVPA" of each domain, the odds ratios (95% CI) for the highest tertiles of commuting and leisure-time MVPA were 0.78 (0.73–0.83) and 0.74 (0.70–0.79), respectively. Furthermore, dose-dependent risk reduction was observed when combining commuting and leisure-time activities but not when occupational MVPA was included in total MVPA. The odds ratios (95% CI) for commuting-and-leisure-time MVPA tertiles were 0.82 (0.77–0.87), 0.73 (0.69–0.78), and 0.69 (0.65–0.74) compared with No MVPA.

Further adjustment for BMI attenuated the associations by 30% to 50%. Both commuting and leisure-time MVPA domains remained significantly associated with BP and hypertension risk, independent of BMI (Model 2, Table S2). There was no significant interaction between commuting-and-leisure-time MVPA and BMI. Moreover, there were no differences between BMI groups with regard to β-coefficients and risk of having hypertension (Table 3).

The associations of commuting-and-leisure-time MVPA with SBP and pulse pressure, but not DBP were age dependent and stronger in older adults (test for interaction, $P<0.01$; Figure 2A through 2C and Table S4). Moreover, associations remained dose dependent over the age groups. For example, the association between commuting-and-leisure-time MVPA and pulse pressure was dose dependent and age dependent as well (Figure 2C). β Coefficients (95% CI) for lowest versus highest tertiles of commuting-and-leisure-time MVPA were −0.29 (−0.68 to −0.09) versus −0.56 (−0.95 to −0.16), −0.91 (−1.29 to −0.53) versus −1.69 (−2.08 to −1.31) and −1.53 (−2.68 to −0.38) versus −3.15 (−4.22 to −2.10) mm Hg for SBP in adults <40, 40 to 60, and >60 years, respectively. Furthermore, dose dependency was observed in the association between MVPA and hypertension risk in older age groups (>40 years; Figure 2D).

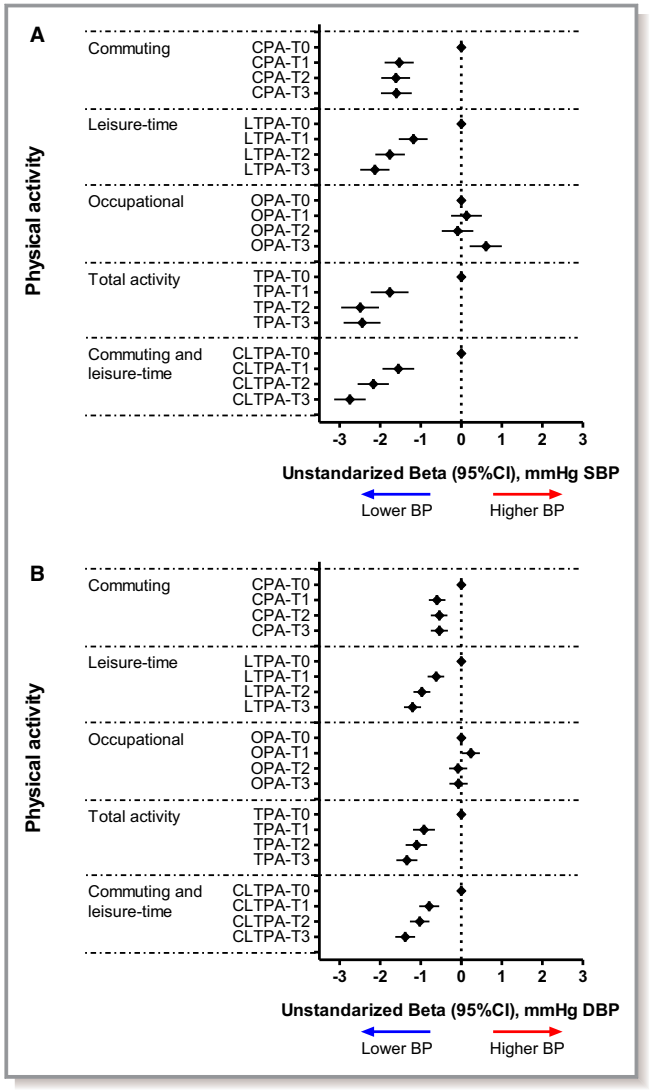

Figure 1. Association between domain-specific MVPA and BP. **A**, SBP. **B**, DBP. Regression analysis between MVPA and BP separately shown for SBP (**A**) and DBP (**B**). Determinants are dummy variables of each domain. The dummy variables were created for comparison between the reference group (T0) and tertiles of MVPA (T1-3). Outcomes were presented as unstandardized β coefficients with 95% CIs. Analysis adjusted for age, square of age, sex, and education (basic model). BP indicates blood pressure; CLTPA, commuting-and-leisure-time physical activity; CPA, commuting physical activity; DBP, diastolic blood pressure; LTPA, leisure-time physical activity; MVPA, moderate-to-vigorous physical activity; OPA, occupational physical activity; SBP, systolic blood pressure; TPA, total physical activity; T, tertile. T0, T1, T2 and T3 indicate "inactive,: "not very active," "active," and "very active" separately.

In the sensitivity analysis, similar dose-dependent associations as in the main analysis were observed in both normotensive and hypertensive people (Table 4). The benefit of commuting-and-leisure-time MVPA was virtually unchanged after adjusting for antihypertensive medication use in hypertensive people (10.8% users).

Table 2. Associations of Commuting-and-Leisure-Time MVPA With BP and Hypertension Risk

Physical Activity	Unstandardized β (95% CI), mm Hg blood pressure		
	Basic Model	Model 1	Model 2
A. SBP			
CLTPA-T0	. . .	. . .	. . .
CLTPA -T1	−1.55 (−1.94 to −1.16)*	−1.64 (−2.03 to −1.24)*	−0.99 (−1.37 to −0.61)*
CLTPA -T2	−2.17 (−2.56 to −1.78)*	−2.29 (−2.68 to −1.90)*	−1.27 (−1.64 to −0.89)*
CLTPA -T3	−2.75 (−3.13 to −2.36)*	−2.90 (−3.29 to −2.50)*	−1.68 (−2.06 to −1.30)*
B. DBP			
CLTPA-T0	. . .	. . .	. . .
CLTPA -T1	−0.79 (−1.04 to −0.55)*	−0.85 (−1.09 to −0.60)*	−0.55 (−0.79 to −0.31)*
CLTPA -T2	−1.02 (−1.27 to −0.78)*	−1.11 (−1.35 to −0.87)*	−0.63 (−0.87 to −0.39)*
CLTPA -T3	−1.38 (−1.63 to −1.14)*	−1.49 (−1.73 to −1.24)*	−0.92 (−1.16 to −0.68)*
C. Pulse pressure			
CLTPA-T0	. . .	. . .	. . .
CLTPA -T1	−0.76 (−1.04; −0.48)*	−0.79 (−1.06; −0.51)*	−0.42 (−0.71; −0.17)†
CLTPA -T2	−1.15 (−1.42; −0.87)*	−1.19 (−1.46; −0.91)*	−0.64 (−0.91; −0.37)*
CLTPA -T3	−1.36 (−1.64; −1.09)*	−1.41 (−1.68; −1.13)*	−0.76 (−1.03; −0.49)*
	Odds Ratio (95% CI)		
D. Hypertension	Basic Model	Model 1	Model 2
CLTPA-T0	1.0	1.0	1.0
CLTPA -T1	0.83 (0.78 to 0.88)*	0.82 (0.77 to 0.87)*	0.88 (0.83 to 0.94)†
CLTPA -T2	0.74 (0.70 to 0.79)*	0.73 (0.69 to 0.78)*	0.83 (0.78 to 0.88)*
CLTPA -T3	0.71 (0.66 to 0.75)*	0.69 (0.65 to 0.74)*	0.81 (0.76 to 0.86)*

Regression analyses between MVPA and BP or hypertension risk. Determinants are dummy exposure variables for commuting-and-leisure-time MVPA for comparison between the reference group (No MVPA, T0) and tertiles of MVPA at each domain (T1-3). Data are expressed as unstandardized βcoefficient or odds ratio with 95% CI. Regression analyses for individual domains are shown in Table S2. Basic model: age, square of age, sex, and education. Model 1: age, square of age, sex, education, smoking, and alcohol consumption. Model 2: age, square of age, sex, education, smoking, alcohol consumption, and BMI. BMI indicates body mass index; BP, blood pressure; CLTPA, commuting-and-leisure-time physical activity; DBP, diastolic blood pressure; MVPA, moderate-to-vigorous physical activity; SBP, systolic blood pressure; T, tertile.
*$P<0.0001$, †$P<0.001$.

Discussion

In line with previous studies, we found that an increased level of physical activities in the leisure-time domain is associated with lower BP or hypertension risk.[2,3,8,9] Furthermore, among domain-specific physical activities, the potential benefit of daily-life physical activity on BP is most prominent for leisure-time MVPA in our study. We also found a dose-response relationship of leisure-time MVPA with BP and hypertension risk, demonstrating that more physical activity is more beneficial. Moreover, with regard to the dose dependency, even a leisure-time MVPA level lower than the recommendation (>150 min/week),[11,12] that is, the lowest level of MVPA (MVPA-T1), was better than being entirely inactive (No MVPA) in our study. Therefore, our large population-based study supports the notion that increased daily-life physical activity, especially in the leisure-time domain, is of fundamental importance for the management of hypertension.[11]

Our study shows that not only physical activity during leisure time, but also increased commuting MVPA may be a way to improve the management of hypertension. It could be an option for meeting the recommended level of daily-life MVPA, and a combination of commuting and leisure-time MVPA benefit BP more. Several but not all studies agree with our findings.[5,22,23] Treff et al[5] (n=13 857) identified a positive association between commuting physical activity and BP in women. Lu et al[22] (n=84 000) found no association between commuting physical activity and BP. Kwaśniewska et al[23] (n=6401) concluded that increasing commuting physical activity level may have an influence on reducing the prevalence of metabolic syndrome but is not associated with physical activity parameters. Those inconsistent findings

Table 3. Associations of MVPA With BP or Risk of Having Hypertension, According to BMI

BMI	MVPA	Unstandardized β (95% CI), mm Hg		Odds Ratio (95% CI)
		SBP	DBP	Hypertension
<25	CLTPA-T0	. . .	. . .	1.0
	CLTPA-T1	−1.00 (−1.58 to −0.42)*	−0.76 (−1.13 to −0.39)†	0.85 (0.75 to 0.96)*
	CLTPA-T2	−1.11 (−1.68 to −0.54)†	−0.61 (−0.98 to −0.25)*	0.84 (0.75 to 0.95)*
	CLTPA-T3	−1.74 (−2.31 to −1.16)†	−1.06 (−1.43 to −0.70)†	0.80 (0.71 to 0.90)†
25−30	CLTPA-T0	. . .	. . .	1.0
	CLTPA-T1	−0.97 (−1.58 to −0.37)*	−0.38 (−0.76 to 0.01)	0.88 (0.80 to 0.96)*
	CLTPA-T2	−1.65 (−2.25 to −1.04)†	−0.75 (−1.14 to −0.37)†	0.80 (0.73 to 0.88)†
	CLTPA-T3	−1.97 (−2.57 to −1.36)†	−0.88 (−1.27 to −0.50)†	0.77 (0.70 to 0.84)†
>30	CLTPA-T0			1.0
	CLTPA-T1	−1.45 (−2.37 to −0.52)*	−0.50 (−1.07 to 0.07)	0.90 (0.79 to 1.02)
	CLTPA-T2	−1.69 (−2.63 to −0.75)†	−0.70 (−1.28 to −0.12)‡	0.77 (0.68 to 0.88)†
	CLTPA-T3	−1.33 (−2.29 to −0.36)*	−0.63 (−1.22 to −0.03)‡	0.85 (0.75 to 0.97)‡

Regression analysis between MVPA and BP or hypertension risk across different BMI level (<25, 25–30, and >30). Determinants are dummy exposure variables for each physical activity domain for comparison between the reference group (No MVPA, T0) and tertiles of MVPA at each domain (T1-3). Data are expressed as βcoefficient or odds ratio with 95% CI. All analyses adjusted for age, square of age, sex, education, smoking, and alcohol consumption. BMI, body mass index; BP, blood pressure; CLTPA, commuting-and-leisure-time physical activity; DBP, diastolic blood pressure; MVPA, moderate-to-vigorous physical activity; SBP, systolic blood pressure; T, tertile.
*P<0.001, †P<0.0001, ‡P<0.05.

might be partly explained by the definition of commuting physical activity. The above studies did not distinguish intensity of commuting physical activity and included more light-intensity physical activity like walking. For instance, Treff et al[5] included many noncycling participants in the assessment of the commuting activity domain (91.8% of participants). We focused on only moderate-to-vigorous physical activity during commuting, such as cycling or intense walking (only brisk walking). Cycling was the major contributor to the commuting domain (95.6% of all active commuters) in our study. Laverty et al[24] (n=20 458) also showed that more vigorous forms of commuting physical activity are more beneficial. Milett et al[25] (n=3902) compared risk ratios for mode of travel to work including walking, cycling, and private and public transport, and showed that only cycling was significantly associated with lower odds of hypertension after adjustment for various confounders. Therefore, we conclude that commuting physical activity at a more vigorous level is associated with lower BP.

We did not find a beneficial effect of occupational moderate-to-vigorous physical activity on BP and hypertension risk. In line with our results, a growing body of evidence is showing that OPA has no benefit on health.[4,6,7,26–29] For instance, a meta-analysis of 13 prospective cohort studies indicated that OPA is not beneficial in terms of protection against hypertension.[4] There was no significant association of both moderate and high levels of occupational PA with risk of hypertension compared with lower level of occupational physical activity, while there was a dose-response risk reduction of nonoccupational physical activity with hypertension in their pooled analysis. Moreover, Andersen and Jensen[29] reported that work-time activity had no effect on population BP. In contrast to our findings, the EPIC-Florence cohort found a significant inverse association between OPA and DBP but not SBP.[30] Fan et al[10] identified a beneficial effect of OPA in people with hypertension in relation to cardiovascular mortality showing that higher OPA is associated with lower mortality risk. A renowned study of Morris and Heady[31] showed a significant difference in cardiovascular disease risk for "double-decker bus drivers" versus "conductors who repeatedly walk up and down the bus stairs frequently," suggesting that a physically active occupation is healthier than a sedentary type of occupation. Thus, if physical activity at work requires more dynamic activities with enough impact on cardiac output, it might have a beneficial effect on health. However, most of the occupation-related MVPA consists of heavy lifting or pushing and extreme bending or twisting of the neck or back without longer periods of rest for recovery.[27] The types of occupations related to high occupational MVPA in our study included occupations such as "metal, machinery, and related trade work," "handicraft and printing work," and "other mechanics and repairs." Of course, there may be the possibility of (residual) confounding by sex, work-related stress, unhealthy environment with dust, inflammation, and body weight. For instance, Holtermann et al[32] found that

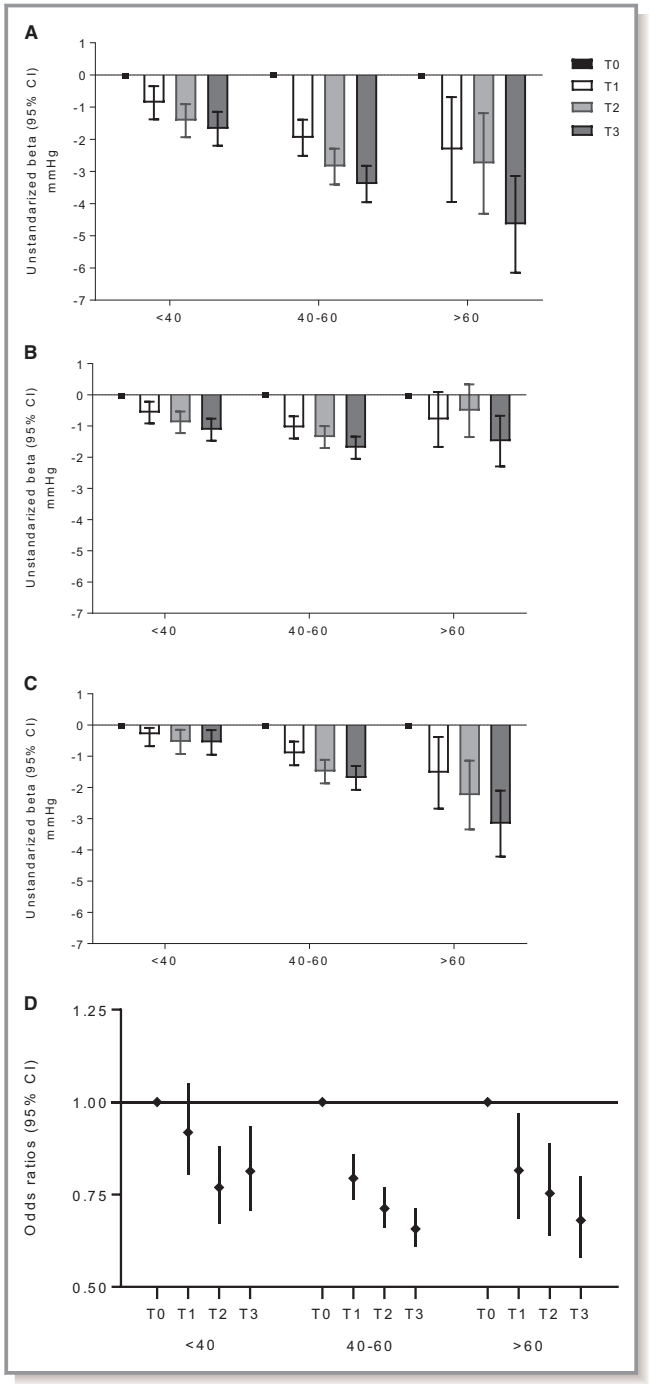

Figure 2. Association of commuting-and-leisure-time MVPA with BP and hypertension risk, according to age. **A**, SBP. **B**, DBP. **C**, Pulse pressure. **D**, Hypertension risk. Regression analysis for the association of commuting and leisure-time MVPA with blood pressure and hypertension risk at different life stages (<40, 40–60, and >60) separately shown for SBP (**A**), DBP (**B**), and pulse pressure (**C**). Determinants are dummy variables of MVPA. The dummy variables were created for comparison between the reference group (T0) and tertiles of MVPA (T1-3). Outcomes were presented as unstandardized β coefficients and odds ratio with 95% CIs. Analysis adjusted for age, square of age, sex, education, smoking, and alcohol consumption (Model 1). BP indicates blood pressure; DBP, diastolic blood pressure; MVPA, moderate-to-vigorous physical activity; SBP, systolic blood pressure; T, tertile. T0 (black), T1 (white), T2 (light gray), and T3 (dark gray) indicate "inactive," "not very active," "active," and "very active" separately.

occupational physical activity predicted all-cause mortality and myocardial infarction in men but not in women (test for interaction, P=0.02). We partly adjusted for confounders such as sex, education, and BMI in our study. Taken together, we suggest that it is important to be aware that occupational MVPA should not be considered as a substitute

Table 4. Sensitivity Analysis for the Antihypertensive Medication Effect in the Association Between Commuting-and-Leisure-Time MVPA and Pulse Pressure, According to Hypertensive Status

	Unstandardized β (95% CI), mm Hg Pulse Pressure		
	Normotensive Subjects	Hypertensive Subjects	
MVPA*	Model 1	Model 1	Model 1 + Adjustment for Antihypertensive Medication
CLTPA-T0	0 (Reference)	0 (Reference)	0 (Reference)
CLTPA-T1	−0.35 (−0.63 to −0.06)†	−0.53 (−1.01 to −0.42)†	−0.55 (−0.25 to −0.02)†
CLTPA-T2	−0.59 (−0.88 to −0.31)†	−0.68 (−1.16 to −0.20)†	−0.70 (−0.24 to −0.02)†
CLTPA-T3	−0.62 (−0.94 to −0.37)†	−1.05 (−1.53 to −0.57)†	−1.13 (−0.24 to −0.04)†

Stratified linear regression analysis between MVPA and pulse pressure. Data are expressed as standardized βcoefficients with 95% CI. Model 1 was adjusted for age, square of age, sex, education, smoking, and alcohol consumption. CLTPA indicates commuting-and-leisure-time physical activity; MVPA, moderate-to-vigorous physical activity; T, tertile.
*Commuting-and-leisure-time.
†$P<0.05$.

for leisure-time MVPA or should not be considered a measure of healthy daily-life physical activity.

In our study, the associations of daily-life MVPA with BP and hypertension risk remained significant after adjusting for BMI, showing that a beneficial effect of physical activity on BP is independent of BMI. However, the associations attenuated by 30% to 50% after adjustment. This might be explained by the fact that obesity is a major risk factor for hypertension and one way in which physical activity lowers BP through body weight control.[11,12] Furthermore, we show that the association between MVPA and blood pressure is present, regardless of BMI category. This is in line with previous studies.[33,34] A review of both observational and intervention studies showed that higher baseline physical activity was associated with a lower incidence of hypertension regardless of BMI, and that increased physical activity reduced BP independently from weight loss.[33] A very recent meta-analysis of 24 prospective cohort studies reported that there was no significant difference between overweight and normal-weight participants in the association between physical activity and risk of hypertension.[34] In conclusion, our data support that the associations of MVPA with BP are partly mediated by BMI, but also that higher MVPA can be related to lower BP independent of BMI.

We found that the association of commuting-and-leisure-time MVPA with systolic BP but not diastolic BP is age dependent. This may partly be explained by age-related changes in BP such as a steady increase in SBP and marked decrease in DBP at older ages.[35] Moreover, a stronger association between MVPA and hypertension in older adults might be related to an age-related increased risk for hypertension in older adults.[1,35] However, despite the strong age-related effects, the dose dependency between MVPA and BP or hypertension risk remained present over all age groups, suggesting that more MVPA is more beneficial. For example, a higher MVPA was also associated with pulse pressure in an age- and dose-dependent manner in our study. Thus, we suggest that active people at any age are more likely to have healthier BP and lower hypertension risk.

The main strength of our study is its large sample size from the general population, which allows us to estimate the effect of major domains of daily-life physical activity on BP and risk of having hypertension overall and in various subgroups by age and by BMI categories with sufficient statistical power. The Lifelines study population previously has been shown to be representative of the population of the north of the Netherlands, indicating that the risk of selection bias is low and risk estimates can be generalized to the general population.[15] Furthermore, another strength is that measurement of BP parameters was accurately performed with a standard protocol. Using the last 3 of 10 readings of BP after 10 minutes' rest in the supine position will have largely avoided a white coat effect on readings of BP parameters. However, there are some limitations to our study. A limitation is our assessment of physical activity, which is based on self-report and is subject to recall bias. However, the SQUASH is validated in the general population with the Spearman correlation coefficient for reproducibility of 0.58.[17] Moreover, other validation studies tested reproducibility of the questionnaire for men and women, for patients, and for multiethnic Dutch people including various age groups. Results showed high test-retest reliability scores between 0.6 and 0.8 within intervals of 6 to 8 weeks.[17,36,37] Another limitation is that we could not control for the effect of salt intake, which can be a confounder in the association of MVPA and BP. Furthermore, our study design was cross sectional. It is, therefore, not possible to rule out reverse causality. People with hypertension may have changed their physical activity behavior after being told that they need to take antihypertensive medication. The use of antihypertensives also influences BP recordings.

Therefore, we corrected the BP of people taking medication in the main analysis and performed a sensitivity analysis using uncorrected BP. In the sensitivity analysis, findings were similar as in the main analysis.

Conclusions

To conclude, commuting and leisure-time MVPA, but not occupational MVPA, were significantly associated with lower BP and lower risk for hypertension over all ages and BMI categories, with a stronger association in older adults. Taking into account the differential association for occupational and nonoccupational activities, we believe current guidelines for the prevention of hypertension should indicate whether an individual can reach the recommended level of MVPA in different domains of daily-life activities, such as commuting and occupational MVPA, or if this should be achieved by leisure-time activities only. The present study suggests focusing on leisure-time physical activity, but commuting physical activity could also be included in the recommendation for daily-life physical activity if the commuting physical activity is to be of the more vigorous kind. Also, when using accelerometers, this aspect should be taken into consideration when making interpretations. Furthermore, we suggest that occupational MVPA should be evaluated more closely to see when it can be considered as beneficial.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Data S1.

Supplemental Methods

Anthropometry and laboratory measurements

Body height, weight, waist circumference, and blood pressure were measured by a fixed staff of well-trained research assistants using standardized protocols. Body weight was measured to the nearest 0.1 kg in light clothing and in the fasting state after urination. Height and waist circumference were measured to the nearest 0.5 cm. Height was measured with a wall-mounted stadiometer placing their heels against the rod and the head in Frankfort Plane position. Waist circumference was measured in standing position with a tape measure all around the body, at the level midway between the lower rib margin and the iliac crest.[1][2]

The blood samples were collected in the fasting state, between 8.00 and 10.00 a.m. and analyzed on the day of collection at the Department of Laboratory Medicine of the University Medical Center Groningen, the Netherlands. Participants were requested to fast for at least 12 hours prior to the blood draw. Fasting blood glucose was measured by the hexokinase method. Serum levels of total and HDL cholesterol were measured using an enzymatic colorimetric method, triglycerides using a colorimetric UV method, and LDL-C using an enzymatic method, all on a Roche Modular P chemistry analyzer (Roche, Basel, Switzerland). [1][2]

Definition of lifestyle confounders and diseases

Education level: Education was categorized as low (no education, primary education, lower or preparatory vocational education and lower general secondary education), medium (intermediate vocational education or apprenticeship, higher general senior secondary education or pre-university secondary education) and high (higher vocational education and university).

Current smoking: Smoking status was categorized as non-smokers and smokers. Non-smokers were those who had not smoked during the last month and had also never smoked for longer than a year.

Daily caloric intake and alcohol intake: Data on daily caloric and alcohol intake were collected from a food frequency questionnaire and presented as kilocalories a day (kcal/day) and grams of alcohol a day (gr/day). The calculation was based on intake frequency and the average number of units consumed on a day (divided the number of alcoholic drinks/week by 7). In the Netherlands a standard unit contains 9.9 grams of alcohol. For each type of alcoholic beverage, respondents indicated whether they consumed it never (0%), sometimes (30%), often (70%) or always (100%).[1][2]

Disease: Cardiovascular disease was assigned if participants self-reported one of the following disease symptoms to occur: heart failure, atrial fibrillation, vascular diseases (myocardial infarction, stroke, aneurysm) and used medications related to these symptoms (beta-blockers, angiotensin converting enzyme inhibitors, diuretics, vitamin K antagonist, statins, aspirin and clopidogrel). Information on diagnosis of renal failure was derived from a self-reported questionnaire. Type 2 diabetes mellitus (T2DM) was defined if participants who had self-reported T2DM or fasting blood glucose ≥ 7.0 mmol/L or HbA1c ≥ 6.5% or use of anti-T2D medication(s) or use of glucose-lowering agents (Anatomical therapeutic chemical codes A10A and A10B).[3][4][5]

Table S1. General characteristics of the study population, according to domain-specific physical activity level.

Variables		Category of physical activity			
		T0	T1	T2	T3
TPA	N	9.9 (12,408)	30.0 (37,665)	29.4 (36,904)	30.6 (38,425)
	MVPA (min/week)	0	1-183	184-479	480-6840
	Age (years)	45.89 ± 11.9	44.16 ± 12.1***	44.06 ± 12.9***	43.98 ± 12.7***
	Male sex, % (n)	45.1 (5,595)	35.8 (13,740)***	38.1 (14,103)***	45.9 (17,324)
	Education: Low, % (n)	35.2 (4,363)	25.1 (9,626)***	23.5 (8,653)***	32.1 (12,116)**
	Smoking, % (n)	32.6 (4,042)	20.7 (7,968)***	17.3 (6,357)***	21.7 (8,186)***
	Alcohol use, (gr/day)	2.92 (9.64)	3.38 (8.67)**	4.16 (8.94)***	4.7 (10.31)***
	BMI (kg/m^2)	27.1 ± 4.9	26.0 ± 4.3***	25.6 ± 4.1***	25.9 ± 4.2***
	Total cholesterol (mmol/L)	5.19 ± 1.02	5.07 ± 0.99***	5.05 ± 0.99***	5.07 ± 1.00***
	Triglyceride (mmol/L)	1.35 ± 0.98	1.18 ± 0.84***	1.12 ± 0.73***	1.15 ± 0.77***
	Diabetes, % (n)	5.1 (628)	3.1 (1,175)***	2.6 (959)***	2.7 (1,004)***
LTPA	N	17.1 (21,387)	29.1 (36,456)	25.2 (31,607)	28.7 (35,952)
	MVPA (min/week)	0	3-120	121-295	300-4200
	Age (years)	44.23 ± 11.6	44.27 ± 12.3	44.33 ± 12.9	44.15 ± 13.1
	Male sex, % (n)	46.6 (9,975)	37.8 (14,329)***	36.9 (11,762)***	43.0 (14,696)***
	Education: Low, % (n)	35.4 (7,573)	26.7 (10,129)***	24.8 (7,895)***	26.8 (9,161)***
	Smoking, % (n)	32.3 (6,912)	21.4 (8,100)***	17.5 (5,595)***	17.4 (5,946)***
	Alcohol use, (gr/day)	3.87 (9.90)	3.54 (8.66)***	3.91 (8.61)***	4.59 (8.93)
	BMI (kg/m^2)	26.8 ± 4.8	26.0 ± 4.3***	25.8 ± 4.1***	25.6 ± 4.0***
	Total cholesterol (mmol/L)	5.13 ± 1.00	5.08 ± 1.00***	5.06 ± 0.99***	5.06 ± 1.00***
	Triglyceride (mmol/L)	1.31 ± 0.94	1.18 ± 0.84***	1.12 ± 0.74***	1.11 ± 0.72***
	Diabetes, % (n)	4.0 (850)	3.1 (1,180)***	2.6 (839)***	2.6 (897)***
CPA	N	65.1 (81,587)	12.3 (15,399)	12.1(15,215)	10.5 (13,201)
	MVPA (min/week)	0	1-50,0	51-120	122-1140
	Age (years)	45.3 ± 12.6	42.67 ± 12.2***	42.59 ± 11.8***	41.89 ± 12.8***
	Male sex, % (n)	44.0 (35,862)	27.5 (4,049)***	32.1 (4,771)***	42.7 (6,080)**
	Education: Low, % (n)	29.4 (24,027)	26.6 (3,922)***	22.9 (3,405)***	23.9 (3,404)***
	Smoking, % (n)	22.8 (18,367)	19.5 (2,875)***	17.8 (2,645)***	16.8 (2,396)***
	Alcohol use, (gr/day)	3.45 (10.29)	3.52 (9.03)***	3.87 (8.87)***	5.16 (9.96)*
	BMI (kg/m^2)	26.3 ± 4.3	25.5 ± 4.2***	25.3 ± 4.2***	25.3 ± 4.0***
	Total cholesterol (mmol/L)	5.12 ± 1.00	5.02 ± 0.98***	5.01 ± 0.98***	5.00 ± 1.00***
	Triglyceride (mmol/L)	1.22 ± 0.86	1.08 ± 0.67***	1.08 ± 0.66***	1.11 ± 0.73***
	Diabetes, % (n)	3.5 (2,868)***	2.1 (303)***	2.1 (305)***	2.0 (290)***
OPA	N	78.7 (98,752)	7.3 (9,103)	6.9 (8,661)	7.1 (8,886)
	MVPA (min/week)	0	1-480	484-1348	1350-6720
	Age (years)	45.13 ± 12.8	40.8 ± 11.8***	41.01 ± 10.8***	41.13 ± 10.7***
	Male sex, % (n)	39.0 (38,477)	39.4 (3,483)	35.3 (3,142)***	63.5 (5,660)***
	Education: Low, % (n)	26.3 (25,983)	28.4 (2,504)***	32.1 (2,859)***	38.3 (3,412)***
	Smoking, % (n)	19.8 (19,520)	22.8 (2,012)***	25.8 (2,292)***	30.6 (2,729)***
	Alcohol use, (gr/day)	3.71 (9.1)	3.88 (9.27)*	3.41 (9.02)	5.86 (11.01)***

BMI (kg/m^2)	25.9 ± 4.3	25.8 ± 4.3	26.1 ± 4.5***	26.3 ± 4.2***
Total cholesterol (mmol/L)	5.10 ± 1.00	4.96 ± 0.98***	4.97 ± 0.97***	5.01 ± 0.98***
Triglyceride (mmol/L)	1.17 ± 0.81	1.16 ± 0.78	1.13 ± 0.70***	1.25 ± 0.90***
Diabetes, % (n)	3.2 (3,175)	2.3 (202)***	2.2 (8,867)	2.2 (194)

Data are presented as mean ± SD and number (percentages, %). MVPA are presented as minimum-maximum. MVPA=moderate-to-vigorous physical activity, TPA=total physical activity, LTPA=leisure-time PA, CPA=commuting PA, OPA=occupational PA, BMI=body mass index. The differences between groups were compared using ANOVA or the Mann-Whitney U test for continuous variables. The frequency distributions of categorical variables were analysed using the Pearson Chi-Square test. ***Indicates a significant difference within each physical activity group relative to the reference group of inactive (T0); P value ≤ 0.000. **Indicates a significant difference within each physical activity group relative to the reference group of inactive (T0); P value ≤ 0.001. *Indicates a significant difference within each physical activity group relative to the reference group of inactive (T0); P value ≤ 0.05.

Table S2. Associations of domain-specific MVPA with blood pressure.

Domains	MVPA	Unstandardized beta (95% CI), mmHg	
		Model 1	Model 2
Systolic blood pressure			
Commuting	CPA-T0	-	-
	CPA-T1	-1.57 (-1.93;-1.22)***	-0.96 (-1.30;-0.61)***
	CPA-T2	-1.65 (-2.00;-1.29)***	-0.91 (-1.25;-0.57)***
	CPA-T3	-1.65 (-2.03;-1.27)***	-0.94 (-1.30;-0.57)***
Leisure-time	LTPA-T0	-	-
	LTPA-T1	-1.25 (-1.60;-0.89)***	-0.66 (-1.01;-0.32)***
	LTPA-T2	-1.85 (-2.22;-1.49)***	-1.04 (-1.39;-0.69)***
	LTPA-T3	-2.25 (-2.61;-1.89)***	-1.27 (-1.61;-0.92)***
Occupational	OPA-T0	-	-
	OPA-T1	0.10 (-0.28;0.48)	0.04 (-0.32; 0.41)
	OPA-T2	-0.10 (-0.49;0.29)	-0.32 (-0.69; 0.06)
	OPA-T3	0.57 (0.18;0.97)**	0.40 (0.02; 0.78)*
Diastolic blood pressure			
Commuting	CPA-T0	-	-
	CPA-T1	-0.77 (-0.99;-0.54)***	-0.48 (-0.70;-0.26)***
	CPA-T2	-0.74 (-0.96;-0.52)***	-0.39 (-0.61;-0.18)***
	CPA-T3	-0.52 (-0.76;-0.28)***	-0.19 (-0.42; 0.05)
Leisure-time	LTPA-T0	-	-
	LTPA-T1	-0.62 (-0.84;-0.39)***	-0.35 (-0.56;-0.13)**
	LTPA-T2	-0.87 (-1.10;-0.64)***	-0.49 (-0.72;-0.27)***
	LTPA-T3	-1.23 (-1.46;-1.01)***	-0.77 (-0.99;-0.55)***
Occupational	OPA-T0	-	-
	OPA-T1	0.21 (-0.03; 0.45)	0.19 (-0.05; 0.42)
	OPA-T2	-0.21 (-0.46; 0.03)	-0.32 (-0.55;-0.08)*
	OPA-T3	-0.32 (-0.57;-0.07)*	-0.40 (-0.64;-0.16)**
Pulse pressure			
Commuting	CPA-T0	-	-
	CPA-T1	-0.81 (-1.06;-0.56)***	-0.48 (-0.72;-0.23)***
	CPA-T2	-0.91 (-1.16;-0.66)***	-0.52 (-0.76;-0.27)***
	CPA-T3	-1.13 (-1.40;-0.86)***	-0.75 (-1.01;-0.49)***
Leisure-time	LTPA-T0	-	-
	LTPA-T1	-0.63 (-0.88;-0.38)***	-0.32 (-0.56;-0.07)*
	LTPA-T2	-0.98 (-1.24;-0.72)***	-0.55(-0.80;-0.29)***
	LTPA-T3	-1.02 (-1.27;-0.77)***	-0.49 (-0.74;-0.25)***
Occupational	OPA-T0	-	-
	OPA-T1	-0.11 (-0.38;0.16)	-0.14 (-0.40; 0.12)
	OPA-T2	0.12 (-0.16;0.39)	0.01(-0.27; 0.27)
	OPA-T3	0.89 (0.61;1.17)**	0.80 (0.53; 1.07)*

Regression analysis between domain-specific MVPA and blood pressure. Determinants are dummy exposure variables for each physical activity domain for comparison between the reference group (No MVPA, T0) and tertiles of MVPA at each domain (T1-3). Data are expressed as unstandardized beta coefficient with 95% confidence interval (95% CI). MVPA=moderate-to-vigorous physical activity, CPA=commuting PA, LTPA=leisure-time PA, OPA=occupational PA, T=tertile.

Model 1: age, age^2, sex, education, smoking and alcohol consumption

Model 2: age, age^2, sex, education, smoking and alcohol consumption and BMI

***p<0.0001, **p<0.001, *p<0.05.

Table S3. Associations of domain-specific MVPA with risk of having hypertension.

Domains	MVPA	Odds Ratio (95%CI)		
		Basic Model	Model 1	Model 2
Commuting	CPA-T0	1.0	1.0	1.0
	CPA-T1	0.81 (0.76; 0.87)***	0.81 (0.76; 0.86)***	0.86 (0.81; 0.92)***
	CPA-T2	0.81 (0.76; 0.86)***	0.80 (0.76; 0.86)***	0.87 (0.81; 0.92)***
	CPA-T3	0.78 (0.73; 0.84)***	0.78 (0.73; 0.83)***	0.84 (0.78; 0.90)***
Leisure-time	LTPA-T0	1.0	1.0	1.0
	LTPA-T1	0.86 (0.82; 0.92)***	0.86 (0.81; 0.91)***	0.92 (0.87; 0.98)**
	LTPA-T2	0.76 (0.73; 0.82)***	0.76 (0.72; 0.81)***	0.85 (0.80; 0.90)***
	LTPA-T3	0.76 (0.71; 0.80)***	0.74 (0.70; 0.79)***	0.85 (0.80; 0.90)***
Occupational	OPA-T0	1.0	1.0	1.0
	OPA-T1	1.00 (0.94; 1.07)	1.00 (0.94; 1.07)	0.99 (0.92; 1.06)
	OPA-T2	0.99 (0.93; 1.06)	0.99 (0.93; 1.06)	0.96 (0.90; 1.03)
	OPA-T3	1.06 (0.99; 1.13)	1.05 (0.98; 1.12)	1.00 (0.97; 1.11)

Logistic regression analysis between domain-specific MVPA and hypertension risk. Determinants are reference group (No MVPA, T0) and tertiles of MVPA at each domain (T1-3). Data are expressed as odds ratio with 95% confidence interval (95% CI). MVPA=moderate-to-vigorous physical activity, CPA=commuting PA, LTPA=leisure-time PA, OPA=occupational PA, T=tertile.

Basic model: age, age^2, sex and education

Model 1: age, age^2, sex, education, smoking and alcohol consumption

Model 2: age, age^2, sex, education, smoking, alcohol consumption and BMI

***p<0.0001, **p<0.001, *p<0.05.

Table S4. Associations of domain-specific MVPA with blood pressures (by age).

Age	MVPA	Unstandardized beta (95% CI), mmHg		
		Systolic BP	Diastolic BP	Pulse pressure
<40	Commuting			
	CPA-T1	-0.94 (-1.41;-0.48)***	-0.54 (-0.86;-0.53)**	-0.40 (-0.75;-0.05)*
	CPA-T2	-1.50 (-1.97;-1.03)***	-0.85 (-1.16;-0.23)***	-0.66 (-1.00;-0.31)***
	CPA-T3	-1.57 (-2.04;-1.11)***	-0.55 (-0.86;-0.07)*	-1.02 (-1.37;-0.68)***
	Leisure-time			
	LTPA-T1	-0.69 (-1.16;-0.23)***	-0.38 (-0.69;-0.07)*	-0.31 (-0.66; 0.03)
	LTPA-T2	-1.16(-1.64;-0.68)***	-0.68 (-1.01;-0.36)***	-0.47 (-0.83;-0.11)*
	LTPA-T3	-1.25 (-1.73;-0.78)***	-0.87 (-1.19;-0.55)***	-0.38 (-0.74;-0.02)*
	Occupational			
	OPA-T1	-0.04 (-0.51; 0.43)	0.10 (-0.21; 0.42)	-0.15 (-0.50; 0.20)
	OPA-T2	0.45 (-0.04; 0.93)	-0.12 (-0.44; 0.21)	0.57 (0.21; 0.93)**
	OPA-T3	0.91 (0.45; 1.37)**	-0.18 (-0.49; 0.14)	1.08 (0.74; 1.43)**
40-60	Commuting			
	CPA-T1	-1.57 (-2.10;-1.04)***	-0.87 (-1.20;-0.53)***	-0.70 (-1.06;-0.34)***
	CPA-T2	-1.68 (-2.19;-1.16)***	-0.76 (-1.09;-0.43)***	-0.91 (-1.26;-0.57)***
	CPA-T3	-1.53 (-2.07;-0.98)***	-0.73 (-1.07;-0.38)***	-0.80 (-1.17;-0.43)***
	Leisure-time			
	LTPA-T1	-1.52 (-2.02;-1.01)***	-0.77 (-1.09;-0.45)***	-0.74 (-1.09;-0.40)***
	LTPA-T2	-2.29 (-2.81;-2.20)***	-1.05 (-1.38;-0.71)***	-1.24 (-1.60;-0.88)***
	LTPA-T3	-2.72 (-3.25;-1.10)***	-1.37 (-1.70;-1.04)***	-1.36 (-1.71;-1.01)***
	Occupational			
	OPA-T1	0.42 (-0.16; 0.99)	0.22 (-0.14; 0.58)	0.20 (-0.09; 0.58)
	OPA-T2	0.25 (-0.81; 0.31)	-0.36 (-0.71;-0.01)	0.11 (-0.27; 0.49)
	OPA-T3	0.02 (0.57; 0.60)*	-0.52 (-0.88;-0.15)*	0.53 (0.14; 0.93)*
>60	Commuting			
	CPA-T1	-3.77 (-5.29;-2.25)**	-1.23 (-2.05;-0.41)**	-2.54 (-3.61;-1.47)***
	CPA-T2	-1.85 (-3.56;-0.15)*	-0.61 (-1.53; 0.31)	-1.24 (-2.44;-0.04)*
	CPA-T3	-2.31 (-3.99;-0.64)*	-0.89 (-1.79; 0.01)	-1.42 (-2.60;-0.25)*
	Leisure-time			
	LTPA-T1	-1.59 (-3.08;-0.10)*	-0.43 (-1.24; 0.37)	-1.15 (-2.20;-0.11)*
	LTPA-T2	-3.40 (-4.89;-1.90)***	-0.75 (-1.56; 0.06)	-2.65(-3.70;-1.59)***
	LTPA-T3	-3.76 (-5.24;-2.28)***	-1.17 (-1.97;-0.37)**	-2.59 (-3.63;-1.55)***
	Occupational			
	OPA-T1	0.52 (-0.15; 2.18)	0.62 (-0.64; 1.16)	0.26 (-0.91; 1.43)
	OPA-T2	-1.42 (-4.09; 1.24)	-0.78 (-2.22; 0.65)	-0.64 (-2.51; 1.24)
	OPA-T3	1.42 (-1.74; 4.55)*	1.11 (-0.59; 2.80)*	0.30 (-1.91; 2.51)*

Regression analysis between domain-specific MVPA and blood pressure at different life stages (<40, 40-60 and >60). Determinants are dummy variables of MVPA. The dummy variables were created for comparison between the reference group (T0) and tertiles of MVPA (T1-3). Outcomes were presented as unstandardized beta-coefficients with 95% confidence intervals (95%CI). Analysis adjusted for age, age^2, sex, education, smoking and alcohol consumption (Model 1). MVPA=moderate-to-vigorous physical activity, T=tertile, BP=blood pressure, CPA=commuting PA, LTPA=leisure-time PA, OPA=occupational PA. ***p<0.0001, **p<0.001, *p<0.05. NS=non-significant.

Figure S1. Flowchart of the study population.

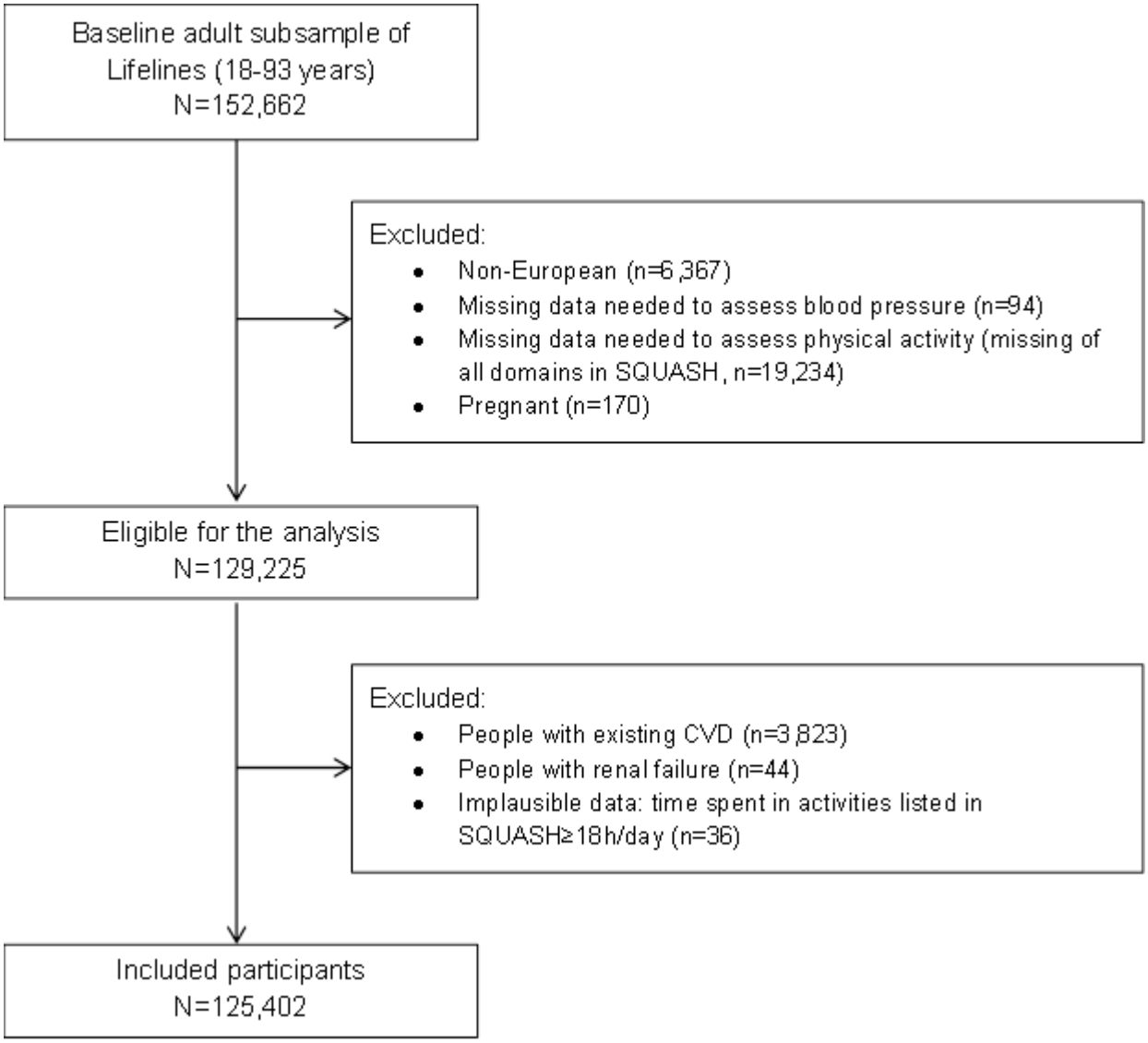
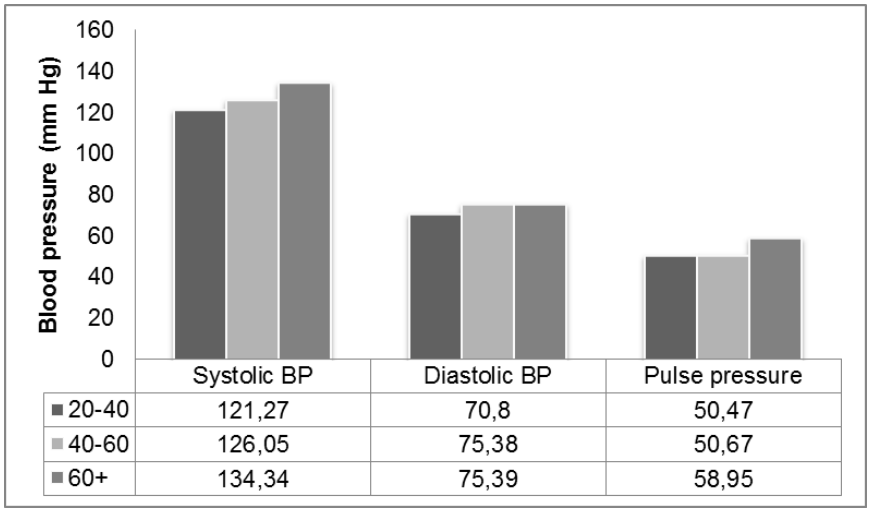


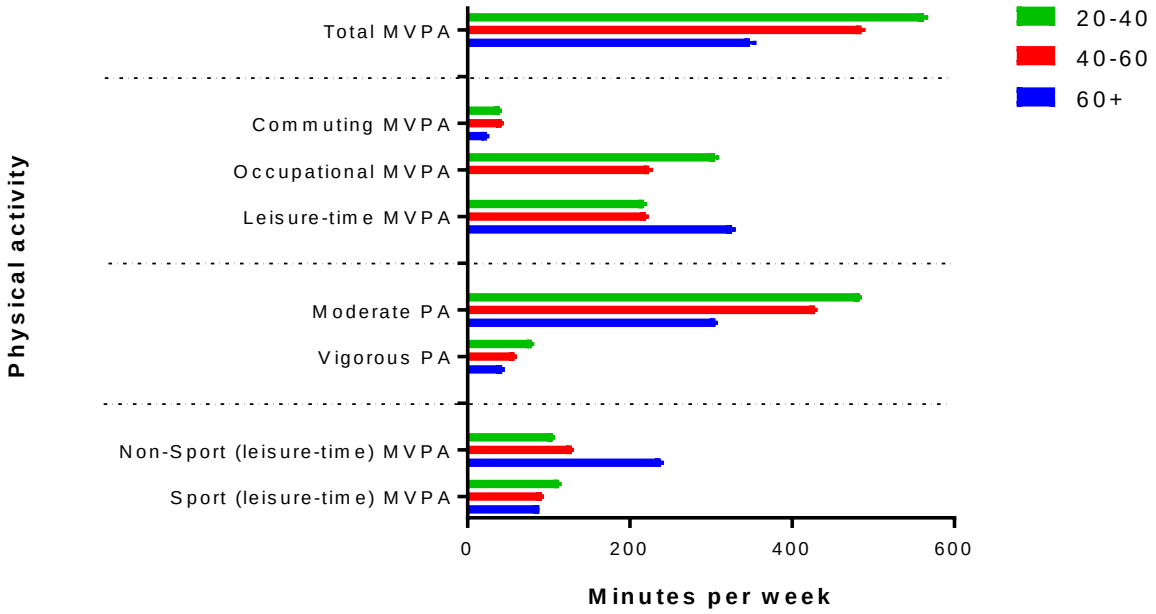
Figure S2. Adjusted mean of blood pressure, according to age.



	Systolic BP	Diastolic BP	Pulse pressure
20-40	121,27	70,8	50,47
40-60	126,05	75,38	50,67
60+	134,34	75,39	58,95

Blood pressure parameters are expressed as mmHg and adjustments for sex and education

Figure S3. Level of daily-life physical activity according to age.



MVPA (min/week) are expressed as adjusted means (adjusted for age, sex, education) for total and domain- and intensity- specific physical activities. MVPA=moderate-to-vigorous physical activity.

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