Masterarbeit

# PERCEIVED STRESS OF DIFFERENT MODES OF COMMUTING


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Matteo Christian Sattler, BSc MSc


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Univ.-Prof. Mireille van Poppel, PhD




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# Abstract

**Background:** In Austria, promotion of physical activity (PA) is a major Public Health target in order to improve and maintain the health of the population. An easy but effective way to do so is by promoting activities which can be incorporated into daily life such as cycling and walking for commuting. Although several studies showed that active commuting is linked to several physical health benefits, less is known for mental health, specifically regarding perceived stress. Therefore, this study aimed to assess the association between commuting mode (active, passive) and commuting stress in Austrian adults. **Methods:** Overall, 227 residents of Graz were invited to participate in the 'Healthy On The way' (HOTway) pilot study. Information about commuting mode and potential confounders (e.g., age, body mass index, commuting time) was obtained by an electronic questionnaire. Active commuting was defined as cycling and/or walking. Participants were asked to fill in a short, perceived stress questionnaire on three working days, respectively before commuting (baseline) and after arrival (commuting stress). Associations between commuting stress and commuting mode were evaluated using multiple linear regression models. **Results:** Data of 185 adults (mean age: 28 ± 10 years, 88 women), including 116 active and 69 passive commuters were analyzed. After controlling for perceived stress before commuting and other confounders, active commuting was associated with less commuting stress compared to passive commuting ($b$ = –0.44 [–0.72, –0.16], $p$ < 0.05). **Conclusions:** Active commuting can be used to increase PA levels at low cost and may also be beneficial for mental health, for example by helping an individual to cope with daily stressors or reducing the allostatic load. Future studies of robust design should measure stress responses and PA objectively. Promoting active commuting to improve and maintain health in the Austrian population is highly recommended.

# Zusammenfassung

**Hintergrund:** In Österreich stellt die Förderung von körperlicher Aktivität ein großes Ziel von Public Health Ziel dar, um die Gesundheit der Bevölkerung zu erhalten und zu verbessern. Eine einfache aber zugleich effektive Möglichkeit ist es, Aktivitäten zu fördern, welche in die tägliche Routine integriert werden können, wie etwa Radfahren oder Gehen für den Arbeitsweg. Obgleich viele Studien einen Zusammenhang zwischen einem aktiven Arbeitsweg und physische Gesundheit nachgewiesen haben, gibt es weniger Belege für die psychische Gesundheit, besonders bezüglich des Stressempfindens. Daher war das Ziel dieser Studie, den Zusammenhang zwischen der Art des Arbeitswegs (aktiv, passiv) und dem Stressempfinden bei österreichischen Erwachsenen zu überprüfen. **Methode:** Insgesamt wurden 227 Einwohner aus Graz zur „Health On the Way“ Pilot-Studie eingeladen. Die Art des Arbeitswegs sowie Informationen über andere Störvariablen (z.B. Alter, Body-Mass-Index, Dauer des Arbeitswegs) wurden mit einem elektronischen Fragebogen erhoben. Ein aktiver Arbeitsweg wurde definiert als Radfahren und/oder Gehen. Alle Personen wurden gebeten, an drei Tagen einen kurzen Stressfragebogen auszufüllen, jeweils vor dem Arbeitsweg (Ruhemessung) und nach Ankunft am Arbeitsort (Stressempfinden während des Arbeitswegs). Zusammenhänge zwischen der Art des Arbeitswegs und dem Stressempfinden wurde mittels multiplen linearen Regressionsmodellen überprüft. **Ergebnisse:** Daten von 185 Erwachsenen (mittleres Alter: 28 ± 10 Jahre, 88 Frauen), bestehend aus 116 aktiven und 69 passiven Arbeitswegen, wurden analysiert. Nach Kontrolle von Stressempfinden vor dem Arbeitsweg und anderen Störvariablen wiesen Personen mit einem aktivem Arbeitsweg ein geringeres Stressempfinden am Arbeitsweg auf als Personen mit einem passiven Arbeitsweg ($b = –0.44$ [–0.72, –0.16], $p < 0.05$). **Schlussfolgerung:** Ein aktiver Arbeitsweg kann das Ausmaß der körperlichen Aktivität mit geringem Aufwand steigern und könnte sich auch positiv auf die psychische Gesundheit auswirken, beispielsweise durch Unterstützung von Personen im Umgang mit täglichen Stressoren oder durch Reduzierung der allostatischen Last. Zukünftige Studien von robustem Design sollen objektive Verfahren für die Erhebung von körperlicher Aktivität und Stress-Reaktivität

verwenden. Die Förderung eines aktiven Arbeitswegs, um die Gesundheit der österreichischen Bevölkerung zu erhöhen und zu erhalten, wird stark empfohlen.

# Eidesstattliche Erklärung

Ich erkläre ehrenwörtlich, dass ich die vorliegende Masterarbeit selbständig angefertigt und abgefasst, und jene Personen sowie Institutionen, die am Zustandekommen der Forschungsdaten beteiligt waren, namentlich genannt habe. Ich versichere, dass ich andere als die angegeben Quellen und Hilfsmitteln nicht verwendet und die wörtlich oder inhaltlich übernommen Stellen als solche kenntlich gemacht habe. Weiterhin versichere ich, dass die Masterarbeit sowie die ihr zu Grunde liegenden Studien den Regeln der guten wissenschaftlichen Praxis entsprechen. Diese Masterarbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen inländischen oder ausländischen Prüfungsbehörde vorgelegt.

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**Affidavit**

I hereby declare that unless otherwise indicated in the text or references, or acknowledged below, this thesis is entirely the product of my own work. I assure that I did not use others than the cited references and tools that are indicated in the text. Throughout this thesis I followed the guidelines of “Good Scientific Practice”. This thesis has not been submitted either in whole or part for a degree at this or any other university or institution.

Graz, 25.09.2019

Matteo Christian Sattler, BSc MSc

# Vorwort

In der heutigen Zeit spielt die Inaktivität der Bevölkerung, wie etwa sitzenden Tätigkeiten, für die Gesundheit eine bedeutende Rolle. Eine Vielzahl an österreichischen Arbeitnehmerinnen und Arbeitnehmer üben vermehrt sitzende Tätigkeiten in im Rahmen ihrer Berufstätigkeit aus. Hinzu kommen nicht selten mentale Anforderungen wie etwa Zeitdruck oder Unsicherheiten mit dem Arbeitsplatz. Die Investition in die psychische Gesundheit der Bevölkerung ist von dringender Public Health Relevanz.

Umso wichtiger sind entsprechende erholende Aktivitäten wie Sport oder allgemeine körperliche Aktivität. Körperliche Aktivität stellt einen der wichtigsten Faktoren für die Förderung und den Erhalt von biopsychosozialer Gesundheit dar. Dies wurde durch zahlreiche wissenschaftliche Studien nachgewiesen. Um gesundheitsfördernde Effekte zu erreichen, muss nicht notwendigerweise einem Trainingsplan nachgegangen oder Sport (z.B. Fußball) betrieben werden. Auch Aktivitäten in anderen Bereichen wie etwa zu Hause (z.B. Staubsaugen), in der Freizeit (z.B. Spazieren gehen oder Wandern) oder für den Transport (z.B. mit dem Fahrrad von A nach B) sind gesundheitsfördernd.

Die Förderung eines körperlich aktiven Lebensstils muss unser primäres Ziel sein, um die Gesundheit des Einzelnen zu stärken. Dadurch kann den negativen Auswirkungen von langen Sitzzeiten sowie psychischen Belastungen entgegengewirkt werden. Eine einfache und zugleich effektive Möglichkeit der Gesundheitsförderung stellen Aktivitäten des täglichen Lebens dar, wie etwa Gehen oder Radfahren. So unternimmt, meist täglich, jede/r österreichische Arbeitnehmerin/Arbeitnehmer einen bestimmten Arbeitsweg. Im Gegensatz zu einem passiven Arbeitsweg wie etwa mit dem Auto, kann der Wechsel zu einem aktiven Arbeitsweg (zu Fuß oder mit dem Fahrrad) bedeutende gesundheitliche Effekte mit sich bringen (z.B. Senkung des Mortalitätsrisikos).

Die Rolle des aktiven Arbeitsweges für die mentale Gesundheit, im Speziellen für das Stressempfinden, wurde noch kaum überprüft. In Österreich liegen hierzu, nach

bestem Wissen des Autors, noch keine Daten vor. Diese wissenschaftlichen Erkenntnisse sind allerdings dringend notwendig, um einen aktiven Arbeitsweg auf Bevölkerungsebene fördern beziehungsweise Anreize dafür stellen zu können. Die vorliegende Masterarbeit soll diesbezüglich wesentliche Erkenntnisse liefern.

# Danksagung

An dieser Stelle möchte ich mich bei all denjenigen bedanken, ohne deren Unterstützung die Anfertigung dieser Masterarbeit niemals möglich gewesen wäre.

Zuerst möchte ich mich bei meiner Betreuerin Mireille van Poppel bedanken. Ich bin dankbar für all die konstruktiven Gespräche. Auch möchte ich ihre hohe Geduld betonen, die sie in den letzten Wochen vor Abgabe dieser Arbeit hatte. Nicht weniger Dank gilt dem Team des Universitätslehrgangs, nämlich Maria Sendlhofer und Martin Sprenger. Die erhaltene Ausbildung war für mich sehr wertvoll! Ich werde nicht nur den wissenschaftlichen Austausch, sondern auch die informellen Gespräche und gemeinsam unternommenen Ausflüge vermissen. Abschließend möchte ich mich bei den wichtigsten Menschen in meinem Leben, meinen Freunden und bei meiner Familie bedanken, ohne die die die Fertigstellung dieser Arbeit niemals möglich gewesen wäre. Besonderem Dank gilt hier meiner Freundin Birgit, die mich während der gesamten Dauer unterstützte, und die nicht zuletzt am Tag der Abgabe ein wunderbares Essen zubereitete, um mir die notwendige Zeit für die Finalisierung der Arbeit zu verschaffen.

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# Abbreviations

ACTH = adrenocorticotropic hormone

BMI = body mass index

CI = confidence interval

DALYs = disability-adjusted life years

DLW = doubly labeled water

EE = energy expenditure

HOTway = Healthy On The way

HR = heart rate

$HR_{max}$ = maximal heart rate

IPAQ-SF = International Physical Activity Questionnaire – short form

IQR = interquartile range

kcal = kilocalories

METs = metabolic equivalents

min = minutes

MVPA = moderate-to-vigorous physical activity

OR = odds ratio

PA = physical activity

PAEE = physical activity energy expenditure

PSS-10 = 10-item Perceived Stress Scale

RR = relative risk

STROBE = Strenghtening the Reporting of Observational Studies in Epidemiology

$VO_2$ = oxygen uptake

$VO_{2max}$ = maximal oxygen uptake

WHO-5 = 5-item World Health Organization Well-Being Index

# 1 Introduction

## 1.1 The need to target mental health

Poor mental health poses a growing challenge both for health care systems and the individual. Since 1990, the burden of poor mental health increased continuously (1–3). Overall, mental and substance use disorders such as anxiety and depressive disorders, are the leading cause of the non-fatal burden of non-communicable diseases and account for more than 160 million disability-adjusted life years (DALYs) worldwide (2, 4). The persistence and recurrence of mental disorders depicts a challenge for intervention and prevention efforts. Additionally to significant impairments in daily life, such as in social and occupational functioning (5, 6), these disorders often co-occur with other non-communicable diseases (7). For example, there is a strong association between major depressive disorder, post-traumatic stress disorder and cardiovascular disease (7, 8). The burden of mental and substance use disorders is shown in Figure 1. The burden usually increases during adolescence and remains high until early adulthood (e.g., until 30 to 35 years).

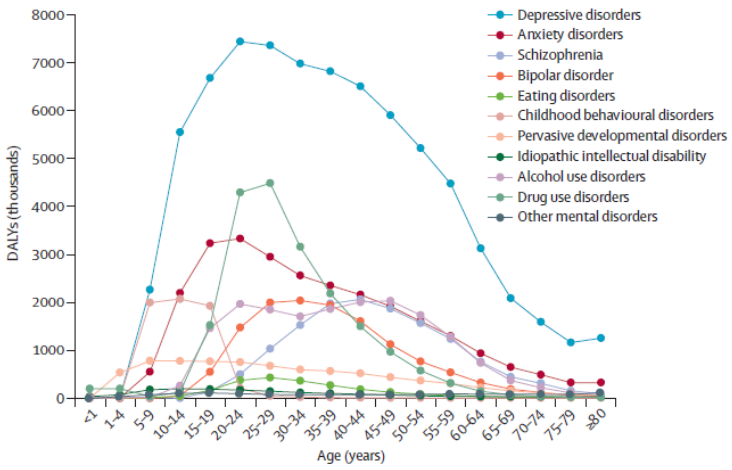


**Figure 1** Burden of various mental and substance use disorders in terms of DALYs in the year 2010 (Whiteford et al. (2); p. 1580). DALYs = disability-adjusted life years.

In Austria, mental health problems are common. Around 10% of women and 6% of men reported that they had experienced a serious depression in the past 12 months. Moreover, around 69 to 78% of these received a psychiatric diagnosis by the physician (9). This shows the strong need to target mental health problems in the Austrian population.

## 1.2 Psychological stress

Chronic stress, for example caused by major life events or prolonged workload, is linked to serious poor mental health outcomes such as anxiety and depression (10–13). Therefore, one way to reduce the development of mental health problems is by targeting stress, for example by reducing demands on the individual or increasing the ability of the individual to cope with the demands (14).

Several definitions for the concept “stress” have been proposed. In 1965, Selye (15) defined stress as a non-specific, defense response of the body characterized by chemical and structural changes (p. 97). The response can either protect against future demands or can produce a disease whenever the stress response is prolonged or flawed. Selye (15) describes these principles by using the general adaptation syndrome (p. 98). In the beginning, the available defensive resources are mobilized (“alarm reaction”). In the next stage (“resistance”), individuals adapt to the stressor. When the stressor is too long or severe, a state of exhaustion may follow. He also emphasized the importance of hormones for the stress response such as the adrenocorticotropic hormone (ACTH).

Others (16) used the term stress to describe physiologically and emotionally challenging experiences and emphasized the distinction between “good stress” (positive stress – Eustress) and “bad stress” (negative stress – Distress) (16, 17). Eustress refers to experiences that are of limited duration and can be controlled by the person whereas distress refers to experiences which are prolonged or recurrent, emotionally draining and physically exhaustive and, thus, cannot be controlled by the person (p. 874). Please note that the following thesis focuses on the concept of

distress. However, to increase readability the term stress will be used throughout the thesis.

With ongoing research two important concepts emerged, namely allostasis and allostatic load (16). Allostasis can be defined as the active process of maintaining stability (e.g., homeostasis) whereas allostatic load refers to the cumulative wear of the body due to dysregulation of the active adaptation (p. 874). Hence, stress can be seen as a state of threatened homeostasis resulting in efforts to restore the initial state (adapting) using several physiological, biochemical behavioral, cognitive and emotional changes (18, 19).

Lazarus and Folkman (20) emphasized the importance of the cognitive appraisal for stress responses. According to their model, negative stress will only be experienced when the person appraises the situation both as threatening and unable to cope due to a lack of (perceived) resources (20). Because of differences in the appraisal, the same stressor possibly influence stress responses and health outcomes differently between individuals (21–23). For example, a person who perceive sufficient resources may experience the stressor as more challenging which increases the probability of successful coping (24). The concept of appraisal is nowadays well established (21, 25).

Although some people are resilient to many negative life events, adapt and recover, others do not and develop serious life-threatening conditions (26). The impact of stress on health depends not only on appraisal processes but also on (the interaction of) several other factors such as individual capacity, social support, biochemical brain responses as well as genetic and epigenetic mechanism (16, 20, 26, 27). Stressful events seem to accumulate throughout life and can influence a broad range of health outcomes in late life (26, 28–30). For example, it is well documented that daily chronic stressors, psychological traumata and, consequently, posttraumatic stress disorder can strongly heighten the risks for cardiovascular disease and hamper a positive prognosis in patients suffering from this disease (31). Likewise, psychosocial work stress, such as job strain or long working hours, was often shown to be a robust and independent risk factor for cardiovascular disease, type 2 diabetes and stroke events. This was demonstrated by 27 cohort studies

including more than 600,000 participants (32). In line with this, long working hours and a culture of 24/7 reduces the chance of sufficient work life balance and social support (33).

Stress also elevates the development of depression (e.g., anxious depression) and other related conditions such as burnout (12, 13). Anxiety and chronic stress even induce several brain changes such as reduced functioning of the prefrontal cortex and hippocampus (11). This may also be one reason for the influence of chronic stress and posttraumatic stress disorder on cognitive dysfunction in later life, including higher risks for dementia and Alzheimer's disease (34–36).

Finally, detrimental effects of stress can be transmitted across generations (37). For example, stressful experiences during pregnancy can increase the risks for diverse mental health outcomes of the offspring such as anxiety and depressive disorders or attention deficit hyperactivity disorder (38). These intergenerational influences on health can be explained by epigenetic alterations (38, 39). An illustration of the principle is shown in Figure 2. However, the determination of the true effect of stressful environments during pregnancy on the development of the fetus and offspring is not straight forward and several methodological considerations, such as establishing causality and the role of mediators, have to be considered, as suggested by DiPietro (40).

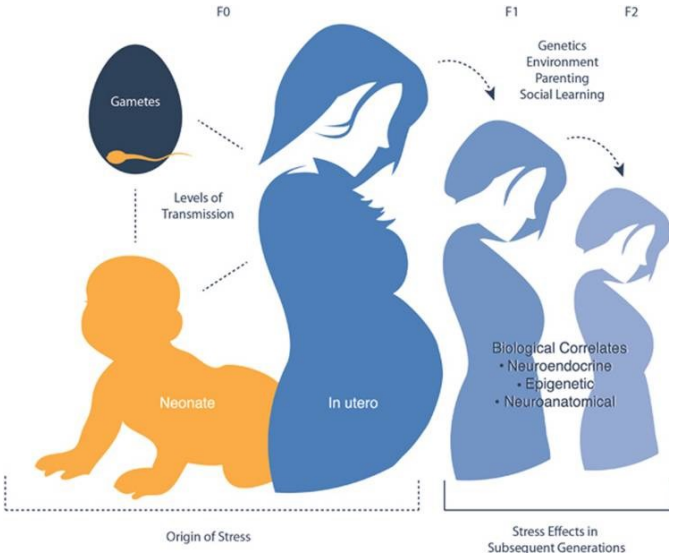

**Figure 2** Three-level intergenerational transmission of stress and potential effects on health (p. 234) as proposed by Bowers et al. (41). Parental stress affects health before conception, during pregnancy, and after giving birth (e.g., early neonatal care). Furthermore, the next generations will be affected by "new" stressors such as parenting, environmental changes and social learning and the effects of these will also be transmitted to the new offspring.

Altogether, because of the harmful influences of stress on health, it is important to promote the resources of a person which will increase the chance that she or he is able to cope with the stressor. Resistance (i.e., resilience) and, therefore, a better handling of stressors will likely protect against the development of untoward outcomes (42). One factor to strengthen the resources and resilience of a person is physical activity (PA) (42–44).

## 1.3 The concept of physical activity

PA is defined (45) as any bodily movement produced by skeletal muscles that results in energy expenditure (EE; p. 126). PA is a complex, multi-dimensional behavior and can be described by parameters of duration (e.g., total active hours per day), frequency (e.g., frequency of soccer events each week, exercise sessions), intensity (rate of EE), and type of activity (e.g., muscle-strengthening activities, cycling, walking) (46, 47). Moreover, people can be active in different settings or domains such as at home (e.g., gardening, vacuuming), at work (e.g., carrying loads), for transport (e.g., cycling and walking to get to work or to the supermarket) and during leisure time for sports, exercise and recreation (e.g., gymnastics, participation in sporting events, walking for pleasure, playing a musical instrument) (48).

Any activity requires EE to be performed (45). All activities summarized over a defined time period (e.g., one week) can be defined as the total volume of PA or the total energy expenditure due to PA (physical activity energy expenditure [PAEE]) (49). Resting EE and the thermic effect of food combined with PAEE results in total EE (50). The intensity level of activities and, thus, the energy required to perform

the activity, is relative to one's individual physical fitness (47). Common metrics to describe the relative intensity are percentage of the maximal oxygen uptake (% of $VO_{2max}$) or heart rate (% of $HR_{max}$) (47). Common metrics for absolute intensity are kilocalories (kcal) or oxygen uptake ($VO_2$) per minute (ml/min) (51). Many epidemiological studies use metabolic equivalents (METs) of activities for a standardization of the absolute intensity of activities. These values are multiples of the resting metabolic rate of a standard adult (52). Information about MET values for hundreds of different activities can be found in the Compendium of Physical Activities (53). For example, the MET value for cycling for leisure at a speed of 5.5 mph is 3.5 which means that it requires 3.5 times more energy than at rest for an average adult person (53). Furthermore, the intensity of activities is often described in broad, absolute intensity categories such as light (1.6 – 2.9 METs), moderate (3 – 5.9 METs) and vigorous (≥ 6 METs) PA (45, 53, 54). Thus, considering a 24-hour day, an individual can spent varying proportions in inactivity (e.g., rest, sedentary time), sleep or in different intensity categories such as light, moderate and vigorous PA (48).

## 1.4 The measurement of physical activity

PA and its aspects can be measured with several methods, including self-reports (e.g., diaries, questionnaires), physiological and physical measurement techniques (e.g., doubly labeled water [DLW], direct and indirect calorimetry, HR monitor, accelerometer, pedometer) and direct observation. A detailed description of these techniques was provided elsewhere (46, 47, 50, 55, 56). In this section, a short overview of the most commonly used methods to assess PA behaviors in free-living environments (i.e., questionnaires and diaries, accelerometers, pedometers, HR monitors) will be provided in order to facilitate the readers understanding of the concept of PA and the interpretation of the results of empirical studies.

PA self-reports are one of the most commonly used methods to assess PA (57). Questionnaires are easy to administer and can provide valuable information about the setting (e.g., leisure time, occupation, household), duration, intensity and

frequency of PA as well as about different types of activities (46, 58). Questionnaires ask about activities performed in the past. For example, participants may be instructed to recall the sum (e.g. in minutes) of all moderate and vigorous activities performed in the past 7 days or in a usual week (59). Despite several advantages of PA questionnaires, reporting errors (e.g., regarding the duration of activities, or the classification of the intensity of the activity) have to be considered (60). In contrast, diaries reduce the reporting errors by asking the participants to record their activities continuously throughout the day (e.g., each hour, every 15 minutes). Thus, detailed PA information can be collected although with higher burden on the participants (47).

Pedometers are often used to collect the number of steps per day performed by the participant. These devices can be worn on the waist and measure the vertical acceleration (in gravity units) of the body's movement (47). Whenever an acceleration of the hip exceeds a defined threshold, a step is counted (46, 61). Even though pedometers represent a cost-effective way to measure walking, they do not provide information about the frequency, duration and intensity of PA (47, 61).

Within the last decade, the popularity of accelerometers tremendously increased. Accelerometers are similar to pedometers but measure acceleration continuously in up to three axes (46). The device can be worn on the hip, waist or ankle for several weeks and information about the frequency, duration and intensity of PA is stored (46, 47). Usually, gravity units ($m/s^2$) or transformed metrics such as counts are used for further analyses (47). The measured acceleration is often used to estimate time spent in different PA intensity categories (e.g., sedentary, light, moderate, vigorous) by using cut points (62). Despite the low burden on participants and the detailed assessment of the actual movement (47), the most apparent disadvantages are the lack of standards in data collection and processing (63, 64), and the fact that not all activities can be equally captured. For example, depending on the wearing position, activities such as swimming, cycling will not be reliably measured (47, 65, 66).

HR monitors can be used to measure physiological responses to PA for several days in free-living settings (46). The HR signal is measured by electrodes attached

to the chest, sent to the receiver and stored (47). In contrast to other methods such as accelerometers or questionnaires, these devices provide more reliable information concerning the intensity of PA because of the robust relationship between changes in PA intensity and HR (61, 67). This represents the major advantage of HR monitoring. However, activities at lower intensity such as light household tasks may not be accurately captured due to interferences with other influences such as caffeine or emotions (47, 61).

## 1.5 The importance of physical activity for health

More than 60 years ago, Morris et al. (68) demonstrated in their fundamental research how PA can affect health. The authors aimed to detect causal factors of lower mortality and disease incidence in order to be able to prevent the adverse outcomes. It was hypothesized that physically inactive men have higher incidence rates of coronary heart disease compared to physically active men (68). More than 30,000 participants were prospectively observed. The results of the study were in line with the expectations and showed that the incidence rates of coronary heart disease were higher for bus drivers than conductors of the London Transport Executive. Bus conductors were assumed to be more active throughout the day (e.g., walking the length of the buses, stair climbing) (68).

Today, the health benefits of PA rely on a large body of research. In 2011, a meta-analysis (69) pooled dose-response estimates from nine epidemiological studies on the prevention of coronary heart disease. The results are congruent with the observations of Morris et al. (68) and showed that higher levels of PA during leisure time were associated with reduced risks of the disease. Specifically, participants who engaged in about 150 minutes of moderate-to-vigorous physical activity (MVPA) per week had a 14% (relative risk [RR] = 0.86; 95% confidence interval [CI]: 0.77 – 0.96) lower risk of coronary heart disease (69). Moreover, the risks continued to decrease with increasing levels of MVPA, although the effect of risk reduction declined at very high levels. These findings support the continuous relationship between PA and health. Figure 3 displays the main results of the study.

A meta-analysis by Kyu et al. in 2016 (70) revealed a similar pattern when using data of the Global Burden of Disease Study 2013. The aim of this investigation was to assess the relationship between total physical activity (including all settings) and the risk for several detrimental health outcomes such as colon cancer, diabetes, breast cancer and ischemic stroke. The authors pooled 174 prospective cohort studies and reported also a continuous relationship between PA and health (70). Most importantly, the largest gains were observed for initially low PA levels. Thus, the most benefits occur when an inactive person starts being active. This knowledge can be used as an important message for PA promotion. The shape of the dose-response relationship found in this study is shown in Figure 4.

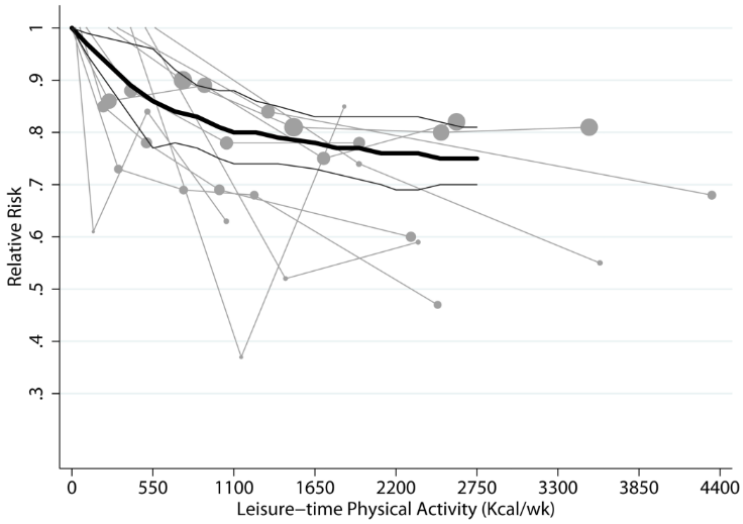


**Figure 3** Dose response relationship between Leisure-time PA and risk of coronary heart disease (Sattelmair et al. (69); p. 792). Plot shows splines with 95% CI intervals. CI = confidence interval, kcal = kilocalories, PA = physical activity, wk = week.

The fact that only little PA is necessary to gain substantial health benefits was also shown by another study (71) which pooled prospective cohort studies in older adults. Participating in fewer minutes than the usually recommended 150 minutes of MVPA was already associated with a 22% risk reduction in all-cause mortality (RR = 0.78, 95% CI: 0.71 – 0.87). In contrast, older adults who met the 150 minutes of MVPA had either a 28% (RR = 0.72, 95% CI: 0.65 – 0.80) or 35% (RR = 0.65, 95% CI: 0.61 – 0.70) risk reduction. The latter effect is observed when engaging in even higher

levels of MVPA (i.e., > 1000 MET minutes per week) (71). Furthermore, PA done in even small frequencies can provide relevant health benefits. For example, people may perform their leisure-time exercises in one or two sessions per week. Based on data of 11 prospective cohort studies, a PA pattern like this (i.e., summing up to at least 150 minutes of MVPA per week) was able to significantly reduce mortality due to cancer and cardiovascular disease in adults aged greater than 40 years (72).

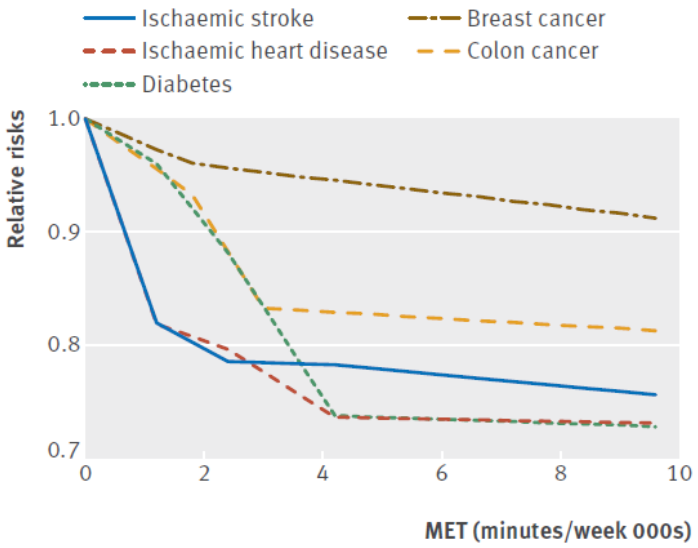


**Figure 4** Dose response relationship between total PA and several adverse health outcomes. Results from 174 prospective cohort studies (Kyu et al. (70); p. 7). MET = metabolic equivalent, PA = physical activity.

Importantly, PA affects health of individuals among all age groups and genders in an universal manner (57, 73). In children and adolescents, sport-related PA can reduce social isolation and anxiety. For example, one study (74) observed the life course of 900 young adults. Participating in sport-related high school activities during adolescence predicted lower levels of social isolation as well as positive educational outcomes after high school (74). Similarly, higher sport participation (i.e., team sport) in children was associated with lower scores of social anxiety (75). Although reverse causation may be possible, higher levels of total PA and MVPA during adolescence (at age 11 years) were associated with lower levels of fatigue at age 13 years (76).

Regarding cardiovascular disease, one study (77) used objective PA data of more than 20,000 children and adolescents (aged 4 – 18 years) from the International Children's Accelerometry Database and showed that higher levels of MVPA were significantly associated with better cardiometabolic risk factors such as systolic blood pressure, waist circumference, high density lipoprotein cholesterol and fasting insulin. The association remains significant after controlling for gender, age, monitor wear time and sedentary time. In addition, there is a strong effect of MVPA on body mass index (BMI) and fat mass in children and adolescents (78, 79). For example, increasing MVPA by about 15 minutes per day at age 12 reduces fat mass at age 14 by around 10% in girls (95% CI: 6.7 – 12.8) and around 12% in boys (95% CI: 9.5 – 14.3) (79).

Not only physical health, but also mental health and cognitive functioning are directly affected by participating in PA. For instance, within the Avon Longitudinal Study of Parents and Children, higher levels of MVPA in children and adolescents predicted better performance in executive attention tasks (80). Furthermore, several studies showed that higher levels of total PA as well as MVPA are associated with better mental health (e.g., anxiety and depressive symptoms), self-perceptions and self-esteem in children and adolescents (81–85). Results from large prospective cohort studies and randomized controlled trials substantiate the importance of PA for mental health in children and adolescents (84). For example, higher levels of PA during adolescence were linked to less future depressive symptoms in late adolescence (84). Finally, a large body of research reported effects of MVPA on cardiorespiratory fitness and bone health in children and adolescents (57).

In adults (of all ages), there is strong evidence that PA decreases not only severe diseases such as coronary heart disease, metabolic syndrome or type 2 diabetes but also substantially improves cardiorespiratory fitness, muscular fitness, bone health and functional health (86). Moreover, PA reduces the risks for excessive weight gain (87) and immediately affects the body. For instance, in a clinical trial (88), healthy, young adults reduced their ambulatory activity from about 11,000 to 1,300 steps per day over 2 weeks. Already within this short period, a significant reduction of 17% in peripheral insulin sensitivity was observed.

In a great number of studies in several adult populations, higher levels of MVPA have been consistently associated with better mood and well-being (89). In addition to the observational evidence, several randomized controlled trials demonstrated that exercise can be used to treat major depressive disorders, and shows comparable effects to antidepressants (90). Similar effects were observed for anxiety. For example, based on 16 randomized controlled trials, a resistance training resulted in small-to-moderate reductions in anxiety symptoms among general as well as clinical populations (91). However, it seems that the evidence for the effects of PA on anxiety is still limited and sometimes inconsistent (90). Overall, the European Psychiatric Organization (90) recommends to use PA (of at least moderate intensity) to reduce psychiatric symptoms in individuals with mild-to-moderate depression or schizophrenia-spectrum disorders.

In addition to the above mentioned health benefits for the general adult population, regular PA (i.e., the total volume of PA) at older age reduces the risks for neurological conditions such as Alzheimer's disease and severe cognitive decline (92, 93). The protective effect of PA against neurodegeneration is well established although the mechanisms are not fully understood yet (94). Likewise, there is moderate-to-strong evidence that PA improves general cognitive functioning in older adults (57). For instance, the conclusion drawn from the results of 11 randomized controlled trials was that aerobic exercise interventions not only result in significant improvements in cardiovascular fitness but also in cognitive performance such as auditory attention, visual attention and cognitive processing speed (95). Compared to younger adults, older adults have an increased risk for falls (96), which can lead to serious reductions in quality of life and functional independence (97). Older adults engaging in various forms of PA, compared to inactive older adults, can strongly reduce these risks (e.g., odds ratio [OR] = 0.75, 95% CI: 0.64 – 0.88) (98). Several studies investigated the link between PA and mental health in older adults (57). Lower levels of total PA have been linked to increased social isolation and loneliness (99). Similarly, PA performed by older adults increases well-being, quality of life, quality of sleep and can be protective against future symptoms of depression (57, 100, 101). Overall, experts in the field highlight that PA is medicine for older adults (102).

PA impacts the health of several other populations such as pregnant women and even infants. Excessive weight gain and gestational diabetes mellites in pregnancy can be reduced by increasing leisure-time PA. This was shown by a meta-analysis, published in 2017, which covered 30 randomized controlled trials (103). Moreover, PA at moderate intensity can improve cardiovascular functioning, mood stability and depressive symptoms of the mother (104, 105). Because pregnancy is the key interface between health of at least two generations (39, 106), it is nowadays well-known that PA of the mother also affects the health of the fetus and the offspring. For instance, recent studies showed that higher levels of PA (e.g., at moderate intensity during leisure time) were associated with lower fat mass and better stress tolerance of the fetus as well as improved neurocognitive development of the offspring (104, 107, 108).

Finally, the health benefits of PA are neither limited to specific types of activities, such as sports, nor to a specific intensity (e.g., MVPA). Even though strong effects can be attributed to specific types of sports such as swimming or cycling (109), also walking can achieve clinically relevant health benefits at low cost, for example through reducing cardiovascular risk factors (e.g., body fat, fasting glucose). This was highlighted by a recent meta-analysis including 37 randomized controlled trials (110). Another longitudinal study (111) used isotemporal substitution models to estimate the effect of PA on health by reducing any amount of sedentary time. In these models, replacing 30 minutes per day of sedentary time with PA at even lower intensity (i.e., light PA) was associated with lower mortality risk due to cardiovascular disease (hazard ratio = 0.76, 95% CI: 0.63 – 0.92).

In 2018 (57, 112) several experts in the field summarized the quality of evidence for the health benefits of PA. Thus, for further information about other populations (e.g., people with disabilities) and additional health benefits of PA, the reader will be referred to this work.

## 1.6 The interaction between sedentary behavior and physical activity

Nowadays, a large amount of each day (usually more than 8 hours) is spent in sedentary behaviors (113, 114). Sedentary behavior is defined as a distinct concept and not just inactivity (115). High levels of sedentary time (i.e., the time spent in sedentary behaviors) were shown to have severe effects on health. For example, one meta-analysis pooled the evidence from prospective cohort studies investigating the effects of TV viewing on health (116). The results revealed that increasing TV viewing by about 2 hours per day was linked to higher risks for type 2 diabetes (RR = 1.20, 95% CI: 1.14 – 1.27), cardiovascular disease (RR = 1.15, 95% CI: 1.06 – 1.23) and all-cause mortality (RR = 1.13, 95% CI: 1.07 – 1.18). Moreover, the association with all-cause mortality was curvilinear, suggesting an increasing impact on mortality with very large durations of daily TV viewing (i.e., beyond 3 hours) (116). Another meta-analysis (117) showed that prolonged sedentary time (not only TV viewing) was linked to higher cancer incidence (hazard ratio = 1.13, 95% CI: 1.05 – 1.21) and cancer mortality (hazard ratio= 1.17, 95% CI: 1.11 – 1.24). Interestingly, the detrimental effects of TV viewing on these health outcomes were stronger in people also showing lover levels of PA.

In line with this, it seems that PA and sedentary time interact, and PA may even be able to reduce (parts of) the negative effects of sedentary time. This was shown by a recent harmonized meta-analysis (118) using data of more than 1 million participants. In this analysis, higher levels of MVPA attenuated and even eliminated the increased risk of death due to high sedentary time. Specifically, daily sedentary time (even if higher than 8 hours) was not linked to higher risks of death in people who also do lots of MVPA (i.e., ≥ 35.5 MET hours per week or approximately 60 to 75 minutes per day) (118). A similar, but weaker relationship was observed for TV viewing. However, in this case, PA only attenuated but not eliminated the adverse effects. The results of this study (118) are visualized in Figure 5. The results of this analysis can be used to frame highly convincing Public Health messages in order to promote PA in people who sit or must sit (e.g. at the workplace) for prolonged periods each day.

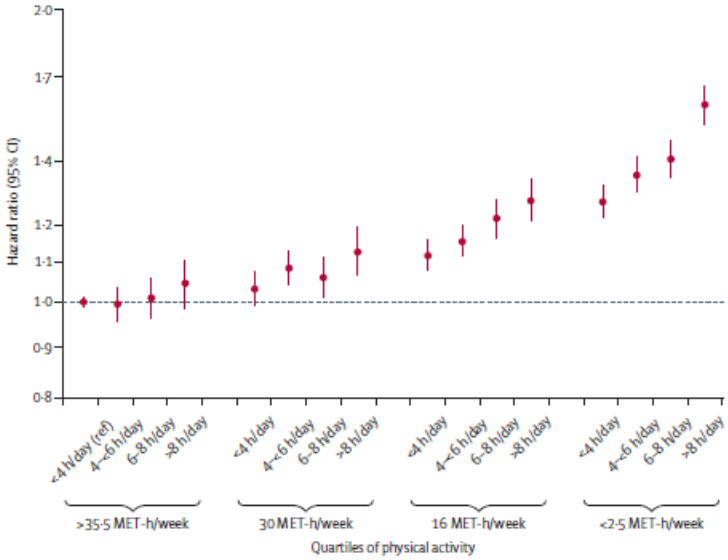


**Figure 5** The interaction between PA and daily sedentary time: effects on all-cause mortality. Results from a harmonized meta-analysis (p. 1307) by Ekelund et al. (118). A similar but less pronounced pattern was observed for TV viewing (p. 1307, Figure B; data not shown). CI = confidence interval, h = hours, MET = metabolic equivalent, PA = physical activity.

## 1.7 Physical activity recommendations

The large body of research for the health benefits of PA is also the fundament of current national and global PA recommendations (i.e., "how PA can be used to improve and maintain health throughout life") (57). According to the Physical Activity Guidelines for Americans, 2nd edition (112), adults should participate in at least 150 to 300 minutes of moderate-intensity, or 75 to 150 minutes of vigorous-intensity aerobic activities, or a combination of both. The activities should be spread throughout the week. Moreover, adults should participate in muscle-strengthening activities of moderate or greater intensity on at least 2 or more days per week (112). For children and adolescents, a minimum level of 60 minutes of MVPA on at least three days per week was recommended (112). Similarly to adults, children should incorporate muscle-strengthening and bone-strengthening activities into daily routine (112). For older adults, the same guidelines as for the general adult population can be applied. In addition, it is recommended that older adults engage

in multicomponent PA, including aerobic and muscle-strengthening activities as well as balance training (112).

## 1.8 Population levels of physical activity and global strategies

Despite the strong evidence for the health benefits of PA, many people are inactive which means they do not meet the PA guidelines ("physical inactivity"). Worldwide, almost a third of the general adult population (31.1%, 95% CI: 30.9 – 31.2) does not fulfill the recommended 150 minutes of MVPA per week (119). This physical inactivity varies strongly between countries, genders and age groups. For example, the percentage of physical inactivity is usually higher for women than men and for younger compared to older adults (119). Moreover, PA levels are typically lower for people with little social support, lower levels of self-efficacy, and lower health status (120). A comprehensive overview of potential correlates and determinants of (population levels of) PA was provided previously (120) and the adapted model is shown in Figure 6.

A recent study (121) analyzed PA data of 168 countries (1.9 million participants) and demonstrated that physical inactivity was considerably higher in high-income (37%) compared to low income countries (16%). Moreover, it seems that physical inactivity is even raising in high-income countries (i.e. from 2001 to 2016) (121). The authors concluded that this can partly be due to the higher prevalence of motorized transportation and sedentary occupations. Altogether, surveillance of PA increased in terms of quantity and quality, but substantial gaps remain. For many low and middle income countries (e.g., countries in Africa or central Asia), information about population levels of PA are missing (119).

In Austria, only 50% of all adults (aged ≥ 18 years) participate in at least 150 minutes of MVPA per week whereas only 25% meet both recommendations (i.e., 150 minutes of MVPA and muscle-strengthening activities) (9). Therefore, there is a strong need to promote PA in Austria.

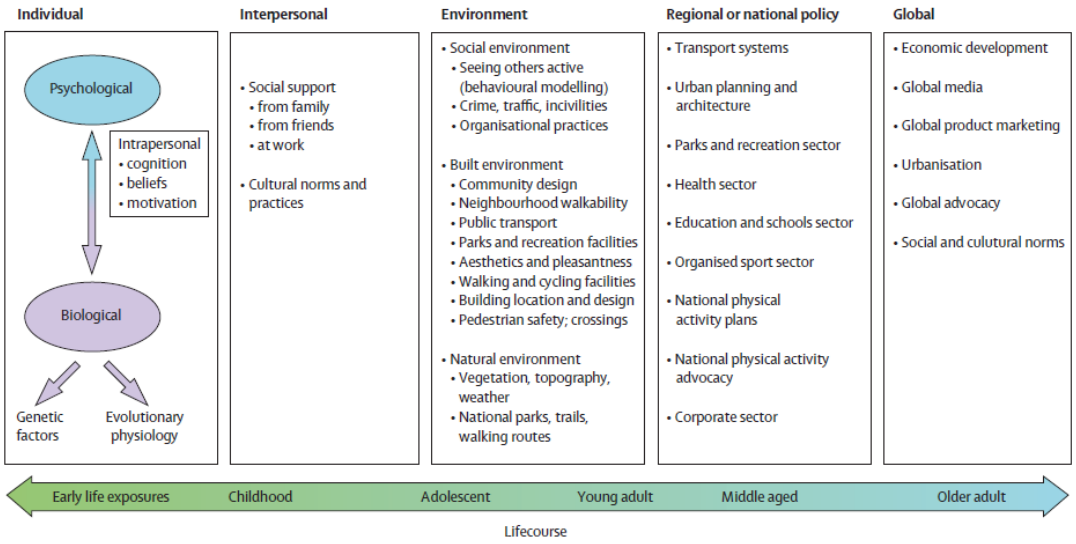


**Figure 6** Modified ecological model (p. 259) showing determinants of PA, by Bauman et al. (120). PA = physical activity.

Globally, the World Health Organization aims to reduce physical inactivity in adults by 10% until 2025 (122, 123). This sounds pellucid, since it is estimated that physical inactivity is responsible for more than 5 million of the 57 million deaths per years which equals 9% (95% CI: 5.1. – 12.5) of premature mortality (86). The authors of this study also concluded that, if physical inactivity was reduced by 10%, more than 533,000 deaths per year could be prevented (86). Additionally, it is estimated that physical inactivity cost health care systems around 54 billion dollars a year (124). Thus, physical inactivity is not only relevant for the health of each individual but also for national economies.

Increasing the percentage of people meeting the guidelines clearly makes sense. However, PA is continuously associated with positive health outcomes and some activity is better than none (112). Therefore, researchers recommended that, even if people may not fulfill current guidelines, inactive people should increase PA at any amount to experience health benefits (123).

Altogether, experts in the field called physical inactivity as the biggest public health problem of the 21$^{st}$ century (125). It is necessary to promote PA, especially in high-income countries such as Austria. An easy and effective way of PA promotion is by

promoting activities which can be easily incorporated into daily routine such as cycling and walking. However, it can be questioned whether such simple activities provide mental health benefits (e.g., well-being, perceived stress).

## 1.9 Walking and cycling for mental health

Most studies focused on the effects of total PA, exercise or MVPA on mental health. For example, data of more than 1 million adults from the Centers for Disease Control and Prevention Behavioral Risk Factors Surveillance System survey indicated that higher self-reported mental health in the past month (i.e., fewer experiences of stress, depression, and emotional problems) was related to higher levels of PA participation and exercise (126). However, some studies investigated the role of specific behaviors such as walking and cycling for mental health.

Walking interventions can be effective in reducing anxiety and depressive symptoms, as suggested by an extensive review of the literature (127). However, the authors of this review also concluded that only little is known about relevant dose-response patterns such as the optimum frequency, duration and intensity of walking. Another meta-analysis (128) only included randomized controlled trials and revealed a large effect of walking for the treatment of depressive symptoms (standardized mean difference = –0.86, 95% CI: –1.21 to –0.61). In addition to reductions in anxiety and depressive symptoms, walking interventions may also be used to improve general levels of self-esteem (129). Furthermore, engaging in walking-related activities results in higher self-rated quality of life in both older women (130) and women with depressive symptoms (131). Clinically relevant effects of walking on quality of life were also observed in various patient populations such as in patients with lung (132) or breast (133) cancer. Finally, Marselle et al. (134) demonstrated that participating in group walks in natural environments (e.g., parks) was associated with higher well-being and less perceived stress compared to walks in urban environments.

Similar benefits were observed for cycling. For example, one study (135) reported higher well-being and cognitive functioning, such as improved processing speed, when comparing older adults receiving a cycling intervention with non-cycling controls. Another study (136) showed that cycling interventions may be able to improve self-efficacy in people suffering from serious mental health conditions. Likewise, improvements in mental health following a group cycling program were observed in a study conducted in Australia (137). Using data of more than 8000 participants from seven European cities, the results of the Physical Activity through Sustainable Transport Approaches longitudinal study showed that the use of cycling was associated with less perceived stress and fewer feelings of loneliness (138). Finally, cycling can even have immediate effects on mental health. For example, in one study (139), state anxiety in young, healthy adults was reduced following a 20 minute bicycle ergometer exercise.

Overall, both cycling and walking have been consistently related to several positive mental health outcomes (57). Promoting cycling and walking in daily life is feasible, for instance by using these modes for transport (i.e., in order to get to work, school, or university). Such an “active commuting” seems to have best returns of investment from a public health perspective. For example, a meta-analysis, published in 2019, showed that active commuting can effectively reduce all-cause mortality (Figure 7). However, it can be questioned whether active commuting is linked to stress outcomes.

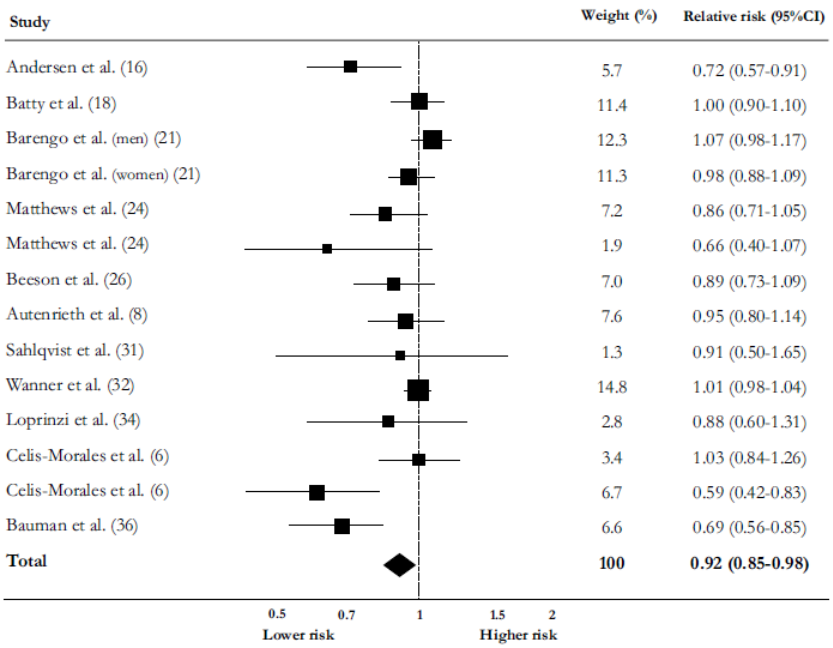


**Figure 7** Active commuting and all-cause mortality. Forest plot summary (49:437 [p. 12]) by a meta-analysis of Dinu et al. (140). The pooled effect indicated a significant reduction in all-cause mortality due to active commuting. CI = confidence interval.

## 1.10 Active commuting and stress

A great amount of daily PA can be accumulated by active commuting (141) and many physical health benefits of active commuting such as lower body fat, lower BMI, as well as lower risks for cardiovascular disease have been reported (140, 142, 143). Despite this knowledge, only a minority of adults reported that they used active commuting (e.g., to work) on a regular basis (Table 1).

**Table 1** Percentage of adults reporting active commuting to work (p. 252) according to Hallal et al. (119)

| | Walk to work | Cycle to work | Walk or cycle to work |
|---|---|---|---|
| Australia[53,54] | 3·8% | 0·9–1·7%* | 4·7% |
| Austria[55] | 5·0–6·6%* | .. | .. |
| Brazil[56] | .. | .. | 11·9% |
| Canada[50,51,57] | 6·6% | 1·0–1·2%* | .. |
| China[58] | 22·6% | 23·5% | 46·1% |
| Denmark[32] | .. | 25·0% | .. |
| Finland[59] | .. | .. | 19·5% |
| France[60] | .. | .. | 34·9% |
| Germany[52,61] | 23·0% | 9·0% | 32·0% |
| Ireland[62] | 10·9% | 1·9% | 12·8% |
| New Zealand[63] | 7·0% | 2·5% | .. |
| Switzerland[64] | 2·2% | 0·3% | 2·5% |
| Sweden[65] | 23·5% | 9·5% | 22·2–33·0%* |
| Netherlands[66,67] | 12·1% | 21·0–25·8%* | 37·9% |
| UK[68] | 12·5% | 2·0% | 14·5% |
| USA[39,50,51,69] | 3·1–4·0%* | 0·5–3·4%* | 4·0–16·7%* |

*Interval reported in several studies or data obtained from several regions or states.

In contrast to considerable evidence for the physical health benefits of active commuting, less is known for mental health benefits, in general, nor with respect to stress. For example, passive commuting such as driving at rush hour is associated with less positive mood, possibly due to congestion (144). Another cross-sectional study (145) obtained information about commuting satisfaction such as ratings on travel time, safety from traffic, safety from crime and comfort. In this study, commuting satisfaction was higher in cyclists, pedestrians and train commuters compared to passive commuters such as car, metro and bus users. One study (146) also demonstrated a relationship between life satisfaction and active commuting.

Only few longitudinal studies investigated the relationship between active commuting and mental health. One study (147) used data from the British Household Panel Survey which resulted in 17,985 included participants. The authors observed that active commuters had higher levels of well-being compared to passive commuters (i.e., car users). Another longitudinal study (148) used data from the Commuting and Health in Cambridge study and showed that maintaining

active commuting over a longer period of time (i.e., one year), was linked to lower sickness absence and higher well-being.

Finally, few studies assessed the relationship between commuting and stress. One cross-sectional study (149) asked participants to fill in a perceived stress questionnaire (example item: ‘‘Overall, commuting is stressful for me”; p. 113) after arrival at work and observed that car commuters reported significantly higher commuting stress and more negative mood compared to train commuters. The authors also obtained information about perceived effort and predictability and suggested that these factors potentially mediate the relationship between commuting mode and stress (149). A similar result was shown by a cross-sectional study in employees living in Montreal (150). The participants of this study answered questions regarding the perceived commuting stress (e.g., “commuting is stressful for me”) after arrival at work. Active (i.e., cyclists) compared to passive commuters had lower stress levels at arrival. However, the data was collected on a single sunny day without any baseline information (e.g., stress levels before commuting). Another cross-sectional study (151) among 788 adults working and living in Barcelona revealed that cycling – compared to non-cycling – for commuting was linked to less experienced stress during the past month. Moreover, the impact on perceived stress increased with more cycling days per week (151). Finally, perceived stress may also mediate the relationship between commuting demands (e.g., commuting time) and health outcomes such as quality of life. This was suggested by Rüger et al. in 2017 (152).

## 1.11 Public health relevance and lack of knowledge

In the 21st century, the pattern of work changes. A 24/7 culture, changes in technology and complexity increases the demands on the individual (33). This threatens a healthy work life balance (33). However, in order to maintain health, a person must be able to cope with these and other demands. PA can play an important role in the process of coping and several studies demonstrated the strong link between PA and mental health. Therefore, PA promotion is a major public health

goal and of upper relevance in Austria not only due to the high prevalence of physical inactivity (e.g., “Rahmengesundheitsziele” (153)).

From a Public Health perspective, integrating PA into daily life, such as through active commuting, seems to be an excellent choice to not only increase PA at low cost but also assure substantial health benefits on the population level. The unemployment rate of Graz was about 6% in 2018 (154) which means that almost every person commutes to work, school or university, mostly on a daily basis. Thus, promoting active commuting modes, such as cycling and walking, shows wide impact.

As shown by the body of evidence, the physical health benefits of active commuting are sound. In contrast, little is known about the role of the commuting mode for mental health, specifically for stress. Studies investigating the relationship between commuting mode and commuting stress typically used existing datasets from other studies and surveys (e.g., household surveys) which limits the external validity of the findings. In contrast, those studies which measured commuting stress after arrival at work did not adjust for baseline levels of perceived stress (i.e., before commuting). Finally, I am unaware of any studies performed in the Austrian population addressing the association between active commuting and commuting stress.

Altogether, there is a strong need to increase our understanding regarding of the link between commuting mode and commuting stress in Austria. Moreover, there is a need for studies with better external validity which perform adjustments for baseline perceived stress (i.e., before commuting) in order to correctly quantify the commuting stress. The acquired knowledge regarding the proposed link can help in framing Public Health messages and promoting PA at low cost in the Austrian population.

## 1.12 Research question

The overall aim of this thesis was to assess the association between commuting mode and perceived commuting stress. Specifically, the following hypothesis was tested by an empirical investigation:

i) Active commuting, compared to passive commuting, is associated with reduced levels of commuting stress in Austrian adults.

# 2 Methods

The reporting of the present study follows the Strenghtening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations (155).

## 2.1 Study design and setting

This cross-sectional observational study was part of the 'Healthy On The way' (HOTway) project. The HOTway pilot study was designed to assess the association between the commuting mode and several environmental and psychological factors in residents of the city of Graz, Austria. The study centre was the Institute of Sport Science of the University of Graz. Recruitment of participants and data collection was performed from October 2016 until July 2017. The study received ethical approval by the local research ethics committee (GZ. 39/1/63 ex 2016/179).

Students of Sports Sciences and Kinesiology visited eligible participants at home. All participants received information about the study procedures (Appendix A) and provided informed consent (Appendix B). They were then asked to fill in a short, perceived stress questionnaire ("stress monitoring") on three working days, respectively in the morning (i.e. before commuting) and immediately after arrival at work (Appendix C). Furthermore, they were asked to record their residential and working address on a city map together with their usual commuting route. Finally, participants received a link to an electronic questionnaire in order to collect information about commuting behavior, sociodemographic characteristics, general levels of PA as well as psychological (e.g., mental health) and environmental factors (e.g., perceived environment of the neighborhood). The electronic questionnaire was administered using the tool LimeSurvey which was provided by the University of Graz. Questions (and questionnaires) used in the present study are shown in the Appendix D. After completing the three step-procedure, the stress monitoring and city maps were brought back to the study centre. In the proposed study, differences

in perceived commuting stress between active and passive commuters will be evaluated.

## 2.2 Participants

A convenience sample of female and male adults living in Graz, Austria, were recruited by the students. The following eligibility criteria were applied: i) aged ≥ 18 years; ii) working and/or studying (e.g., at school, university); iii) German-speaking; iv) able to walk; v) having a constant address of work and residence for at least two months in Graz; and vi) using the same commuting mode on at least four out of five days per week. No other exclusion criteria, for instance concerning sex, gender, ethnicity or education were applied.

## 2.3 Measurements

### 2.3.1 Socio-demographics

Participants reported the following socio-demographic information: age, sex, income, education, work status, shift work, marital status, household composition (e.g., presence of children in the same household), as well as height and weight (used to calculate BMI [kg/m²]).

### 2.3.2 Commuting behavior

Information regarding commuting behavior was collected using self-designed questions (see Appendix D for the full list of questions). Commuting mode was obtained with a single question asking about typical modes (walking, cycling, car, motorbike, public transport or a combination of those) used for commuting as well as the average duration spent in these modes. Participants also reported the commuting distance (i.e., “What is the length of your commute, in km for one direction”) and the commuting time (i.e., “How long does it take you to get to work?).

### 2.3.3 Perceived commuting stress

To assess commuting stress, participants were instructed to answer a short self-designed questionnaire (stress monitoring form) on three working days (preferable on Monday, Wednesday, and Friday) before commuting and after arrival at work. This monitoring form was based on current stress literature (i.e., control – demand models) (156, 157) and adopted from the Perceived Stress Questionnaire (158, 159). The form consists of seven global statements regarding perceptions of control and psychological strain. This were considered as most important for commuting.

The following seven statements were included:

1. *You feel rested*
2. *You feel tense*
3. *You feel mentally exhausted*
4. *You feel you do not have full control*
5. *You are angered because of important things that were outside of your control*
6. *You feel under pressure from deadlines*
7. *You feel that too many demands are made on you*

The same statements were used to collect levels of perceived stress before commuting and after arrival. However, they slightly differed. Before commuting, participants were instructed to record their current levels of perceived stress. This was considered as a baseline measurement of stress (e.g., in the morning). After arrival, participants answered the same statements, but each statement now referred to the commute (e.g., You felt rested during the commute) in order to reduce the influence of any job-related events on current stress levels after arrival.

Each statement can be answered on a 10-point Likert scale ranging from 0 (very little) to 10 (very strong). The average of the seven statements across all three days after arrival was used as the main outcome for all analyses (= commuting stress). The average of the seven statements across all three days before commuting was considered as baseline perceived stress.

### 2.3.4 General mental health

The 5-item World Health Organization Well-Being Index (WHO-5) was used to collect information about general mental health. The WHO-5 (160) is a short, self-administered questionnaire which can be used to measure subjective well-being. The WHO-5 is a standardized, unidimensional instrument and is available in 20 different languages. For the present study, the German version of the WHO-5 was used (161). The questionnaire was shown to be a valid screening instrument for clinical depression with high sensitivity and specificity (162). The internal consistency (Cronbach's alpha = 0.92) and the split-half reliability ($r_{tt}$ = 0.87) of the German version is high (161). In the present study, Cronbach's' alpha for the scale was high (Cronbach's alpha = 0.80).

The WHO-5 consists of positively phrased questions and ask the participant to recall her or his levels of well-being during the last 14 days on a 6-point rating scale, ranging from „all time" to „at no time" (162). The answers can be summarized to provide an overall well-being score, ranging from 0 (absence of well-being) to 25 (maximal well-being). This summary score was used for all analyses.

### 2.3.5 Long-term perceived stress

General (long-term) perceived stress was collected using the standardized 10-item Perceived Stress Scale (PSS-10) (163). The PSS-10 is commonly-used in epidemiological and clinical research and is a validated self-reported measure based on the psychological conceptualization of stress (164). We used the German version of the PSS-10 which demonstrated good psychometric properties (165). In the present study, the PSS-10 showed sufficient internal consistency (Cronbach's alpha =.80).

The PSS-10 assesses the degree to which situations in the past month were appraised as stressful (e.g., unpredictable, uncontrollable, overload) and is therefore and indicator of long-term perceived stress. Responses to each of the 10 items are made on a 5-point scale (0: never; 1: rarely; 2: sometimes; 3: often; 4: very often). Following reversing of negatively phrased questions (question numbers:

4, 5, 7, and 8), the answers were summarized to provide an overall score with higher levels indicating higher long-term stress.

### 2.3.6 Physical activity

Participants general levels of PA were assessed using the German version of the International Physical Activity Questionnaire – short form (IPAQ-SF) (166). This standardized, cost-effective questionnaire was developed in 1998 by PA experts for the purpose of PA surveillance (166). As a consequence, the IPAQ-SF was widely used to assess PA levels worldwide, and across several European countries (167). It was previously shown that the questionnaire has acceptable construct validity and reliability (168).

The IPAQ-SF assesses moderate PA, vigorous PA and walking performed in the past seven days. The last question records the average daily sedentary time. The IPAQ-SF is a global measure and refers to all domains of PA (i.e., household/gardening, occupation, leisure time [including recreation and sports], and transport) without providing domain-specific PA levels. Data processing was performed in accordance with the analysis guide (169). The summary score (expressed in average minutes/day [min/day]) of all listed PA questions (i.e., moderate PA, vigorous PA, walking) was used as an indicator of general (total) PA.

### 2.3.7 Bias

Short-term positive and negative affect (and perceived stress), can vary from day to day (170–172). Therefore, we considered a repeated measurement design for the assessment of commuting stress. Participants were asked to fill in the stress monitoring form on three days, ideally spread throughout the week (i.e., Monday, Wednesday, Friday). Using averages of these measurements should reduce both random measurement error and natural variation of stress and, therefore should allow a better estimation of the perceived stress associated with the commuting mode. Furthermore, to reduce any laboratory introduced biases, this study used field-based assessments of commuting stress, namely before and after arrival.

### 2.3.8 Study size

No particular criterion for a minimum sample size was applied in this pilot study. However, a sample size of approximately 150 participants was targeted which would allow to detect a small difference ($d$ = 0.3) in the (change of) perceived stress (α = 0.05, β = 0.2), as calculated using G*Power version 3 (173). Small associations between psychological outcomes, such as anxiety and depressive symptoms, well-being and perceived stress with PA (e.g., total, cycling/walking) have been observed in the literature (147, 174–176).

### 2.3.9 Statistical analysis

Statistical analyses were performed using SPSS Data Analysis version 24.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics for all variables were calculated, including mean and standard deviation for continuous variables with normal distribution, median and interquartile range (IQR) for continuous variables without normal distribution, and frequencies and percentages for categorical variables. Normal distribution was assessed by Shapiro-Wilk, Q-Q-Plots and Histogram.

Commuting stress was the average of the seven statements of the stress monitoring form answered on three days after arrival. Regarding commuting mode, active commuting was considered as either walking and/or cycling (passive commuting: car, motorbike, public transport, or a combination of those). Bivariate Pearson correlation coefficients ($r$) were calculated to assess the association between commuting stress, commuting mode and all other variables (used in main analyses).

To assess the association between commuting mode and commuting stress (main analyses), several bivariate and multiple linear regression models were performed. All models were adjusted for baseline perceived stress (i.e., before commuting). The following confounders were considered: age, sex, education, work status, BMI, commuting time, well-being, total PA. Commuting time was considered as most important (177) and was included in the model before adding other potential confounders. Commuting distance was strongly related to commuting time ($r$ > 0.5), which causes problems of multi-collinearity. Moreover, it was assumed that it was

less reliable reported than commuting time. Therefore, only commuting time but not distance was considered for the adjustments. Likewise, long-term perceived stress was not considered for the adjustment because of strong collinearity with perceived stress before commuting ($r > 0.50$). Finally, total PA and well-being may also show strong collinearity with perceived stress before commuting and commuting mode. However, in this study, the correlation was $r < 0.50$ and, thus, these two variables were added to the last model (fully adjusted) allowing the reader to compare the different results. Significance was considered as $p < 0.05$ for all models.

# 3 Results

## 3.1 Participants

Of the 227 adults invited, 213 consented to participate in the study. Of these, 201 answered the stress monitoring form both before commuting and after arrival and provided valid data on all three days. Further 16 were excluded because of reporting using different commuting modes on the three days. Therefore, 185 participants were included in the analysis.

Furthermore, two participants reported implausible high values on the IPAQ-SF (according to the analysis guide) and one participant only reported days per week without providing information about minutes of PA. These three participants were also excluded from all analyses including the IPAQ-SF. Overall, included and non-included participants were similar regarding age, sex, education and BMI.

## 3.2 Descriptive statistics

Baseline characteristics of all included participants is shown in Table 2. Participants were between 18 and 64 years old. Passive commuters (*M* = 33 years) were slightly older than active commuters (*M* = 25 years). There was no significant difference between active and passive commuters regarding sex, education, shift work, marital status, long-term stress, well-being and PA. However, a significant difference concerning age, BMI, work status, income, household composition (i.e., children in the same household), commuting distance and commuting time was observed.

**Table 2** Descriptive characteristics of participants

| Characteristic | *Total* (*N* = 185) | *Active commuters*[a] (*n* = 116) | *Passive commuters* (*n* = 69) |
|---|---|---|---|
| Age*, M (SD) | 28.0 (10.1) | 25.2 (6.2) | 32.6 (12.8) |
| Sex, n (%) | | | |
| female | 88 (47.6) | 55 (47.4) | 33 (47.8) |
| male | 97 (52.4) | 61 (52.6) | 36 (52.2) |
| BMI*, M (SD) [range] | 22.7 (2.5) [16.5-30.5] | 22.2 (2.3) [17.9-30.5] | 23.4 (2.6) [16.5-29.4] |
| Education, n (%) | | | |
| High school diploma | 97 (52.4%) | 69 (59.5%) | 40 (57.8%) |
| University degree | 61 (33.0%) | 47 (40.5%) | 29 (42.0%) |
| Work status**, n (%) | | | |
| working (non-student) | 107 (57.8) | 51 (44.0) | 56 (81.2) |
| student | 78 (42.2) | 65 (56.0) | 13 (18.8) |
| Shift work, n (%) | | | |
| No | 174 (94.1) | 111 (95.7) | 63 (91.3) |
| yes | 11 (5.9) | 5 (4.3) | 6 (8.7) |
| Monthly income**, n (%) | | | |
| < 1000 € | 78 (42.2) | 59 (50.9) | 19 (27.5) |
| 1000–1800 € | 46 (24.9) | 25 (21.6) | 21 (30.4) |
| > 1800 € | 26 (14.1) | 7 (6.0) | 19 (27.5) |
| No answer | 35 (18.9) | 25 (21.6) | 10 (14.5) |
| Marital status (in relationship), n (%) | 95 (51.4) | 65 (56) | 30 (43.5) |
| Children in the same household**, n (%) | | | |
| No | 171 (92.4) | 112 (96.6) | 59 (85.5) |
| yes | 14 (7.6) | 4 (3.4) | 10 (14.5) |
| Commuting distance*** (km), Median (IQR) | 3.0 (1.5-5.0) | 2.0 (1.0–3.0) | 5.0 (3.5–8.0) |
| Commuting time*** (min) | 15.0 (10.0–20.0) | 12.0 (8.3–17.8) | 20.0 (15.0–25.5) |
| Long-term stress (PSS-10 sum score), M (SD) | 14.2 (5.4) | 13.9 (5.7) | 14.6 (5.7) |
| Well-being (WHO-5 sum score), M (SD) | 15.3 (4.0) | 15.2 (3.9) | 15.4 (4.2) |
| Total PA (IPAQ-SF total min/day), Median (IQR) | 111 (69–163)[b] | 111 (75–167)[b] | 111 (52–153) |

*Note.* IPAQ-SF = International Physical Activity Questionnaire – short form, IQR = interquartile range, km = kilometers, M = mean, min = minutes, PA = physical activity, PSS-10 = 10-item Perceived Stress Scale, SD = standard deviation, WHO-5 = 5-item World Health Organization Well-Being Index.

[a]Cycling and/or walking

[b]IPAQ values for three active commuters were missing.

* significant difference between active and passive commuters (*t* test)

** significant difference between active and passive commuters (chi-square test)

*** significant difference between active and passive commuters (Mann-Whitney U test)

## 3.3 Perceived stress and commuting

Figure 8 shows mean values of baseline perceived stress and commuting stress for active and passive commuters, respectively. There was a small, significant difference between active and passive commuters regarding commuting stress (i.e., reported after arrival), t(183) = 2.3, $p$ = 0.021; Hedges' $g$ = 0.36 (95% CI: 0.07 – 0.66). There was no significant difference concerning baseline perceived stress (i.e., before commuting), t(183) = -0.42, $p$ = 0.676; Hedges' $g$ = 0.08 (95% CI: -0.21 – 0.38).

Table 3 shows inter-correlations between all variables included in the main analyses. Commuting stress was associated with being an active commuter, but no association was observed for stress before commuting with commuting mode ($r$ = 0.03). Further, active commuting was associated with lower commuting time, younger age, lower BMI and being a student.

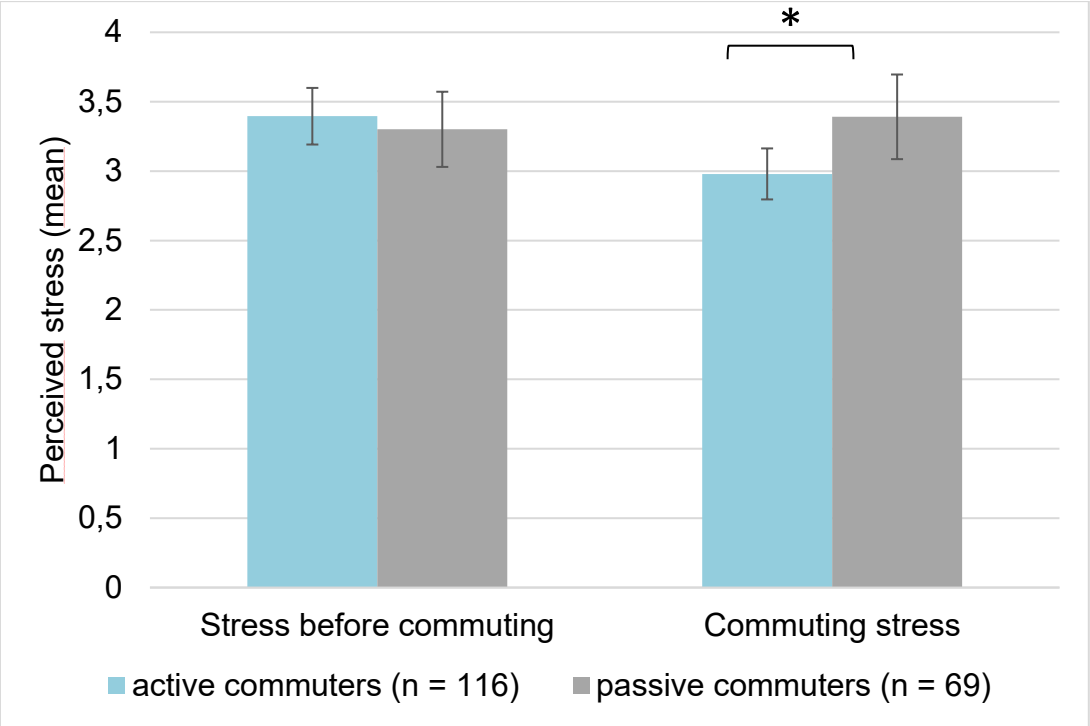


**Figure 8** Perceived stress and commuting mode. General levels of perceived stress before commuting (baseline) and commuting stress (reported after arrival) are shown. A significant difference between active and passive commuters (i.e., walking and/or cycling) in commuting stress was observed ($p$ = 0.021; Hedges' $g$ = 0.36 [95% CI: 0.07 – 0.66]). Baseline levels of perceived stress before commuting were similar ($p$ = 0.676; Hedges' $g$ = 0.08 [95% CI: -0.21 – 0.38]). CI = confidence interval.

Results from bivariate and multiple linear regression models, adjusted for potential confounders, are shown in Table 4. Only lower perceived stress before commuting and active commuting were significantly associated with lower commuting stress. Specifically, based on the results of the fully adjusted model, active commuting was associated with a decrease of 0.4 points in commuting stress (measured by the stress monitoring form with a potential range of values from 1 to 10 points).

**Table 3** Pearson correlation coefficients (r) between perceived stress, commuting mode and other individual characteristics

| | Stress before commuting | Active commuting | Commuting time | Age | Sex (male) | BMI | education (university) | Work status (student) | Well-being (WHO-5 sum score) | Total PA (IPAQ-SF total min/day)* |
|---|---|---|---|---|---|---|---|---|---|---|
| Commuting stress | **0.74** | **–0.17** | 0.12 | –0.09 | –0.11 | 0.02 | –0.01 | 0.02 | **–0.24** | 0.02 |
| Stress before commuting | | 0.03 | –0.03 | **–0.19** | **–0.17** | –0.02 | –0.05 | 0.11 | **–0.38** | –0.01 |
| Active commuting | | | **–0.43** | **–0.37** | 0.01 | **–0.24** | –0.02 | **0.36** | –0.03 | 0.08 |
| Commuting time | | | | **0.15** | –0.09 | 0.08 | –0.02 | **–0.20** | 0.13 | 0.05 |
| Age | | | | | –0.02 | **0.17** | **0.22** | **–0.39** | 0.07 | –0.03 |
| Sex (male) | | | | | | **0.56** | –0.02 | –0.09 | 0.08 | 0.05 |
| BMI | | | | | | | 0.02 | **–0.19** | 0.05 | –0.01 |
| Education (university) | | | | | | | | **–0.31** | 0.07 | 0.05 |
| Work status (student) | | | | | | | | | –0.04 | 0.03 |
| Well-being (WHO-5 sum score) | | | | | | | | | | 0.09 |

Note. BMI = body mass index, IPAQ-SF = International Physical Activity Questionnaire – short form, min = minutes, WHO-5 = 5-item World Health Organization Well-Being Index. Correlation coefficients with $p < 0.05$ were marked in bold.

*All comparisons with IPAQ-SF based on 182 participants.

**Table 4** Results of five different linear regression models: Associations with the outcome perceived commuting stress (reported after arrival)

| | Model 1<br>*N* = 185, $R^2$ = 0.55 | Model 2<br>*N* = 185, $R^2$ = 0.59 | Model 3<br>*N* = 185, $R^2$ = 0.59 | Model 4<br>*N* = 185, $R^2$ = 0.59 | Model 5 (fully adjusted)<br>*N* = 182, $R^2$ = 0.59 |
|---|---|---|---|---|---|
| Stress before commuting | **0.740** (0.642, 0.838) | **0.746** (0.652, 0.840) | **0.747** (0.653, 0.841) | **0.749** (0.650, 0.849) | **0.762** (0.654, 0.870) |
| Active commuting | | **–0.454** (–0.676, –0.233) | **–0.390** (–0.635, –0.146) | **–0.440** (–0.716, –0.165) | **–0.442** (–0.721, –0.164) |
| Commuting time | | | 0.008 (–0.005, 0.020) | 0.008 (–0.004, –0.021) | 0.006 (–0.007, 0.019) |
| Age | | | | –0.003 (–0.015, 0.010) | –0.003 (–0.016, 0.010) |
| Sex (male) | | | | 0.097 (–0.178, 0.372) | 0.110 (–0.168, 0.388) |
| BMI | | | | –0.016 (–0.072, 0.040) | –0.018 (–0.074, 0.038) |
| Education (university) | | | | 0.078 (–0.159, 0.314) | 0.071 (–0.170, 0.312) |
| Work status (student) | | | | 0.040 (–0.219, 0.300) | 0.037 (–0.227, 0.302) |
| Wellbeing (WHO-5 sum score) | | | | | 0.008 (–0.022, 0.038) |
| Total PA (IPAQ-SF total min/day) | | | | | 0.000 (–0.001. 0.001) |

*Note*. BMI = body mass index, IPAQ-SF = International Physical Activity Questionnaire – short form, min = minutes, PA = physical activity, WHO-5 = 5-item World Health Organization Well-Being Index. Unstandardized regression coefficients (B) are presented for each independent variable together with 95% confidence intervals in brackets. Coefficients with $p < 0.05$ were marked in bold.

# 4 Discussion

Active commuting is associated with substantial health benefits (140, 143) and it was recently shown that people can accumulative substantial proportions of weekly total PA and PAEE through active commuting (178). Despite sufficient evidence for physical health, the role of the commuting mode for mental health, especially for stress is less clear. Studies addressing this topic usually used existing databases which strongly decreases the external validity of the results. Moreover, I am unaware of any studies performed in Austrian adults. Therefore, the present study aimed to investigate differences in commuting stress between active (i.e., walking and/or cycling) and passive commuters in an Austrian population of adults.

## 4.1 Key findings

The results of the present study showed that active commuters had lower commuting stress compared to passive commuters. This is in line with results from previous studies (150, 151). However, only a small difference in commuting stress between active and passive commuters was observed (i.e., 0.4 points of a 10-point scale).

In general, the commute can be seen as a stressor which puts demands on the individual (152). These demands (e.g., unexpected events, commuting time) are recurring because commuting is mostly done on a daily basis. Thus, it was suggested that repetitive stressors of the commute play a key role in the relationship between commuting and perceived stress (152). I concur with Rüger et al. (152) and argue that commuting can increase the allostatic load of a person whenever associated with multiple allostatic states due to repetitive and/or severe demands (179). It might be possible that passive compared to active commuting is linked to more frequent allostatic states and thus, shows stronger negative influences on stress and other mental health outcomes. In contrast, active commuting may be associated with little allostatic load.

In addition to the lack of severe demands, active commuting may help to cope with harmful stressors. For example, Lambiase et al. (180) simulated the commuting mode in children and investigated the effects on cardiovascular stress reactivity. One group performed a self-paced 1.6km walk on a treadmill whereas the a second group sat in a chair for 10 minutes. Both groups were watching pictures of their neighborhood ("typical commute"). Following a recovery period of 20 minutes, a cognitive stress test was administered. Children in the walking group had lower systolic blood pressure, heart rate and perceived stress reactivity to the cognitive stressor (180). Hence, active commuting may help to cope with demands of the present day or even long-lasting demands from the past, for instance, by increasing mood and reducing rumination during the recovery process (181). The importance of the commute for the daily recovery was also shown by a study of Hoof (182). For a sufficient recovery status after arrival at home, relaxation and detachment during the commute are needed, especially for days with high job demands. Active commuting may increase the level of detachment (e.g. "forgetting things about work") and relaxation, probably due to fewer stressful events (e.g., congestion) (182).

The lack (or lower degree) of stressful events may be one of the main advantages of active compared to passive commuting. When traveling by car or public transport several factors such as unexpected delays, congestion, behavior of pedestrians and traffic volume have to be considered. As suggested previously (152), these commuting aspects may even increase the demands on the individual. However, some commuting aspects may also increase the demands on active commuters. For example, studies using galvanic skin responses while people are commuting in real-environments provide new insights into the dynamic response of commuting stress (183). In this study, published in 2018 (183), researchers were able to show that cyclists had increased stress responses when cycling close to traffic, at intersections and whenever the bikeway was narrow.

In fact, one commuting aspect, namely traffic congestion, was shown to have immediate impacts on health. For instance, Samra et al. (184) performed measurements of systolic and diastolic blood pressure of drivers exposed to either

high or low traffic congestion. The results demonstrated that high traffic congestion was associated with increased systolic and diastolic blood pressure. Moreover, a prolonged exposure was also associated with an corresponding increase in blood pressure (184). Congestion is usually more relevant for passive rather than active commuters and may help in explaining the results of the present study.

Partly related to congestion, many studies showed the importance of perceived control, predictability and commuting time for commuting stress (149, 185, 186). For instance, one study (187) investigated time pressure in drivers and demonstrated that greater time pressure was associated with increased negative emotions and perceived stress. Likewise, another study (188) showed that predictability significantly influences commuting stress. A study from 2015 (189) demonstrated that higher commuting time was associated with lower mood, especially for car commuters, probably due to greater fatigue and sadness. Interestingly, a lower mood was not observed in car passengers, suggesting that only the act of driving is linked to a deteriorating mental health state (189). Because of the strong impact of commuting time on mental health outcomes, the authors (189) also recommended that policies should aim to reduce travel times. Overall, higher levels of commuting stress of passive commuters, as revealed in the present study, may be partly explained by less experienced control, fewer predictability and longer commuting time.

The need to keep commuting time low is also decisive when interpreting results from time use research. Each day is constrained to 24 hours which forces people to spend their day in several (in-)voluntary activities, including PA as well as general needs such as eating and sleeping. Hence, if commuting time increases, the additional time needed for the commute must be deducted from other activities. Unfortunately, it was shown that higher commuting time resulted in less time spent in PA, sleep and eating preparations (190). Therefore, it is highly relevant to keep commuting times as low as possible in order to prevent the accumulative effect of unhealthy lifestyles on health (190).

The importance of another factor, namely the built environment was highlighted by several studies (191–193), and it is likely that aspects of the built environment

influence the relationship between commuting mode and perceived stress. For example, natural environments such as green and blue spaces (e.g., parks, trees, rivers) possibly reduce commuting stress. For example, a large cross-sectional study investigated the association between the natural environment, commuting and mental health in more than 3000 adults living in four European cities (194). The results showed that commuting through natural environments was linked to better mental health. The authors (194) therefore recommended to invest in routes with nature to promote active commuting.

On the other side, aspects of the built environment may not only impact the commuting stress but also the choice of the commuting mode in the first place. Factors such as intersections, population density and road density have often been reported to be associated with the commuting mode (192, 195). Likewise, another study (196) showed a higher likelihood for (recreational) walking when there is better access to green spaces such as parks and higher street connectivity within the neighborhood. In general, aspects of the built environment (e.g., connectivity, density) may impact the prevalence of active commuting differently depending on broad regional differences such as urban or rural areas (197). Moreover, one of the most important predictors regarding the choice of the commuting mode is commuting time (191). In the present study, commuting time was higher for passive compared to active commuters, but not related to commuting stress. It seems that aspects of the built environment affect both commuting mode and commuting stress, a knowledge which is important for governments to develop an infrastructure which promotes active commuting.

However, the number of potential influences on commuting stress and the choice of the commuting mode is large. For example, not only external factors such as travel costs, commuting time, congestion but also internal factors such as personality, preferences, and general lifestyle may be involved (145). Thus, future studies covering a broad range of potential influences are needed. Altogether, based on the present findings, active commuting may not only provide strong physical but also mental health benefits, possibly by reducing allostatic load and/or helping to cope with other stressful events.

## 4.2 Limitations and Strengths

This study has some limitations that must be acknowledged. Although we controlled for some of the potential confounders, we did not include a more comprehensive list of variables, potentially also influencing the relationship between commuting mode and commuting stress (e.g., built environment, weather conditions). Hence, residual confounding is possible. Secondly, a convenience sample of participants living in Graz was recruited by the students which likely introduces selection bias and a lower level of generalizability of the results.

Next, we were also unable to control for the time when the participants filled in the stress monitoring form. It is possible that some participants answered the statements not immediately after arrival at work but somewhat later. This makes influences of other stressful events during work more likely although participants were asked to recall the stress perceived during commuting.

Furthermore, one may argue to consider using public transport as active commuting due to active parts of the journey. Specifically, the use of public transport is associated with usually low-to-moderate levels of walking and, hence, influences health (198). However, in order to determine the merely effect of PA in terms of walking and cycling, public transport was not considered as an active mode in the present study which is in line with other studies in the field (143). Moreover, differences in PAEE illustrate the distinction between public transport and mere active commuting. Based on the results of a recent study (178), it was shown that both walking and cycling for commuting required high levels of PAEE (median of walking: 4.6 METs, median of cycling: 6.5 METs) in contrast to car (median: 1.3 METs) or bus use (median: 1.7 METs).

Perceived stress and commuting mode were assessed with self-reports. More objective methods such as cortisol and accelerometer measurements would provide more reliable and valid estimates. Specifically, the use of accelerometers (with or without HR monitoring) would allow to assess the role of the intensity of PA associated with both the commuting mode and commuting stress. Problems with

reporting accuracy may also exist for other aspects of the commute (e.g., commuting time and distance) obtained using self-reports. Another problem was the small sample size which hampers reliable testing of potential interactions (e.g., commuting mode and commuting time).

Finally, the design of the study was cross-sectional which makes conclusions about causality impossible. It is possible that not only the commuting mode influences commuting stress but also that the commuting stress affects the choice of the mode. For example, a person may walk to work just because a route with low stress exposure (e.g. through natural environments) is available.

The strengths of the HOTway pilot study were that i) it is the first study investigating the association between commuting mode on commuting stress in Austrian adults; ii) commuting stress was measured on three days in the free-living environment to reduce random measurement error and increase external validity; and iii) in contrast to other studies (150, 151), baseline measurements of perceived stress, namely before commuting, were obtained.

## 4.3 Future studies

Future studies on the relationship between commuting mode and perceived stress in Austria should consider the following:

i) Using objective devices for the measurement of PA. This would allow to further define the shape of the dose-response relationship. For example, there is insufficient evidence concerning the optimum frequency, duration and intensity of active commuting (110, 199)
ii) Using physiological parameters of the stress response (e.g., cortisol). Moreover, certain parameters such as heart rate variability or galvanic skin response, which can be measured in free-living settings, may offer great potential to study dynamic stress responses while commuting
iii) Consider an assessment of work-related stressors

iv) Evaluate the influence of active commuting on recovery processes after work, including measurements after work (which were omitted in the present study)

v) Consider the influence of the built environment. A better understanding of aspects of the built environment can be used to improve the existing infrastructure in Austria in order to promote active commuting

Finally, to increase the effectiveness of PA promotion in Austria, future studies should also address attitudes towards commuting and potential barriers for active commuting behaviors.

# 5 Conclusions

One may argue that active commuting may not be safe or put individuals at increased risk of injuries due to exposure to motorized traffic and air pollution. However, recent health impact assessments (200) showed that using active modes of transport, in general, is associated with substantial net health benefits. Moreover, promoting active commuting and, thus, reducing the prevalence of car use, would even reduce these risks such as death or injury from crashes (201).

Importantly, more than half of the PA level recommended by current guidelines can be accumulated through active commuting (141, 178). Active commuting seems to be a cost-effective investment to improve and maintain health of populations. For example, walking of 1.9 km in about 22 minutes twice per day (on 5 days per week) already reduces all-cause mortality (199). The results of the present study showed that active commuting is also linked to positive mental health outcomes, such as lower commuting stress. Active commuting may help to cope with daily stressors and reduce the allostatic load of a person. Therefore, in accordance with public health experts (201), it is highly recommended to promote active commuting in Austria.

## Additional declarations

**Conflict of interest:** None declared

**Funding:** No funding was received.

**Ethical approval:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was provided. Number of ethical approval: GZ. 39/1/63 ex 2016/179.

**Informed consent:** Informed consent was obtained from all individual participants included in the study

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# Appendices

## Appendix A: Particpant information sheet

**Informationen zur Studie**

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer,
bei der folgenden Studie handelt es sich um ein Projekt der Forschungsgruppe „**Physical Activity und Public Health**“ **des Instituts für Sportwissenschaft der Karl-Franzen-Universität Graz**. Die Studie trägt den Namen: „Der Zusammenhang von aktivem Transport, Stressempfinden, Persönlichkeit, allgemeiner körperlicher Aktivität, mentaler Gesundheit und Umgebung“.

Bitte lesen Sie sich die folgenden Informationen in Ruhe durch.
Fragen Sie bitte, wenn etwas nicht klar ist oder Sie weitere Informationen wünschen.
Die Kontaktdaten finden Sie am Ende des Informationsblatts.

Angaben zum Datenschutz:
Alle Daten werden absolut anonymisiert erhoben und ausgewertet. Ihre Daten werden streng vertraulich behandelt und zu keinem Zeitpunkt an dritte Personen oder Personen außerhalb des Projektteams weitergegeben. Der Rückschluss auf ihre Identität ist daher nicht möglich.

Freiwilligkeit:
Die Teilnahme an dieser Studie, falls Sie sich zur Teilnahme entscheiden, ist selbstverständlich freiwillig und kann jederzeit ohne Nennung von Gründen widerrufen werden. Durch das Widerrufen der Teilnahme entstehen keine Nachteile für Sie.

Risiken der Studie:
Durch die Teilnahme an der Studie entstehen für Sie weder körperliche noch seelische Risiken. Das Projekt und alle damit verbundenen ethischen

Fragestellungen wurden durch die Ethikkommission der Karl-Franzen-Universität geprüft und genehmigt.

Hintergrund und Ziel der Studie:

In der vorliegenden Studie soll die Verwendung von aktiven (zu Fuß, Fahrrad) im Vergleich zu passiven (Auto, Motorrad, öffentliche Verkehrsmittel, Taxi) Transportmitteln für den Arbeitsweg in Zusammenhang mit anderen Merkmalen wie Umgebungseigenschaften (z.B. Wohnumgebung, Eigenschaften des Arbeitswegs), Persönlichkeit, Stressempfinden, allgemeine körperliche Aktivität und mentale Gesundheit genauer untersucht werden.

Was erwartet Sie bei dieser Studie:

Die Studie besteht aus 3 unterschiedlichen Teilen. Im *ersten Teil* ist ein Online-Fragebogen auszufüllen, in dem verschiedene Angaben zu Ihrer Person sowie zum Arbeitsweg und Wohnumgebung abgefragt werden (z.B.: Alter, Geschlecht, Wahl des Transportmittels für den Arbeitsweg, Persönlichkeitseigenschaften, allgemeines Stressempfinden, körperliche Aktivität).

Für den *zweiten Teil* bitten wir Sie Ihren Arbeitsweg auf eine Karte der Stadt Graz einzuzeichnen. Damit können objektive Umgebungsinformationen für diese Strecke gewonnen werden (z.B. Grünflächen auf dem Weg, Ampeln, Radwege, Distanz).

Der *dritte Teil* beinhaltet einen Stress-Monitoring-Fragebogen zum Thema „Stressempfinden“. Es geht dabei um das von Ihnen erlebte Stressempfinden während des Arbeitsweges (also für die Strecke vom Heimatort zum Arbeitsort/Studienort). Diesen Stress-Fragebogen sollen Sie insgesamt an 3 verschiedenen Wochentagen (Montag, Mittwoch, Freitag) ausfüllen, und zwar jeweils kurz vor Abfahrt und kurz nach Ankunft am Arbeitsort/Studienort.

Kontaktdaten:

Bei Fragen und Beschwerden jeglicher Art steht Ihnen die Studienleitung um Frau van Poppel und Herrn Sattler jederzeit und sehr gerne zur Verfügung.

Kontakt:

Univ.-Prof. Dr. Mireille van Poppel
Karl-Franzens-Universität
Institut für Sportwissenschaft
Mozartgasse 14
8010 Graz
E: mireille.van-poppel@uni-graz.at
T: 0316 380 -2335

Matteo C. Sattler, MSc
Karl-Franzens-Universität
Institut für Sportwissenschaft
Mozartgasse 14
8010 Graz
E: matteo.sattler@uni-graz.at
T: 0316 380 - 2321

## Appendix B: Participant consent form

**Einwilligungserklärung zur Teilnahme an der Studie**

*Studie zum Zusammenhang von aktivem Transport, Stressempfinden, Persönlichkeit, allgemeiner körperlicher Aktivität, mentaler Gesundheit und Umgebung*

1. Ich erkläre, dass ich das **Informationsblatt** zur Studie gelesen und verstanden habe. Alle offenen Fragen wurden zu meiner vollsten Zufriedenheit beantwortet.

2. Ich verstehe, dass meine Teilnahme an der Studie freiwillig ist und ich die Teilnahme an der Studie jederzeit, ohne Nennung von Gründen und ohne Nachteile, widerrufen kann.

3. Ich erkläre mich damit einverstanden, dass alle im Rahmen der Studie erhobenen Daten ausschließlich zu Forschungszwecken und absolut anonym erhoben, ausgewertet und auf einem Computer (passwortgeschützt) gespeichert werden.

4. Ich erkläre mich damit einverstanden, dass die aufgezeichnete Strecke meines Arbeitswegs/Studienwegs für wissenschaftliche Zwecke (objektive Umgebungseigenschaften wie zum Beispiel Grünflächen, Verkehrsaufkommen, Distanzen) verwendet wird.

5. Ich verstehe, dass zu keiner Zeit meine exakte Wohnadresse und Arbeitsadresse /Studienadresse registriert wird.

6. Ich erkläre mich mit der Teilnahme an der oben genannten Studie einverstanden.

| _____ | _____ | _____ |
|---|---|---|
| Name der/des StudienteilnehmerIn | Datum | Unterschrift |

# Appendix C: Stress monitoring form

ID:«Numme

**Wochentag:** Mittwoch (anderer Wochentag: _____)

Fragen bezogen auf den **Weg zur Arbeit** (Ausfüllen jeweils Montag, Mittwoch und Freitag; falls an einem dieser Tage nicht oder nie gearbeitet wird, dann bitte abweichenden Wochentag oben eintragen: „anderer Wochentag"). Beantworten Sie die Fragen kurz vor der Abfahrt zu und unmittelbar nach der Ankunft an Ihrem Arbeitsort/Studienort. Bitte beachten Sie, dass es sich um den Weg handeln muss, den Sie auch auf der Karte eingezeichnet haben.

Sind Sie heute mit dem Auto gefahren: ja ☐ / nein ☐ Wenn ja: sind Sie selbst gefahren oder waren Sie Beifahrer? Fahrer ☐ / Beifahrer ☐

Fragengruppe **vor dem** Arbeitsweg (z.B.: nach dem Aufstehen, beim Frühstück,..)

***Bitte beurteilen Sie folgende Aussagen bezogen darauf wie Sie sich jetzt fühlen.***

Sie fühlen sich ausgeruht.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie fühlen sich angespannt.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie fühlen sich mental erschöpft .

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie haben das Gefühl keine Kontrolle zu haben.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie ärgern sich, wichtige Dinge nicht beeinflussen zu können.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie fühlen sich unter Zeitdruck.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie haben das Gefühl, dass zu viele Anforderungen an Sie gestellt werden.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Fragengruppe für die Beurteilung **des** Arbeitswegs (unmittelbar bei Ankunft am Arbeitsort)

***Bitte beurteilen Sie folgende Aussagen, wie Sie sich während des Arbeitswegs gefühlt haben.***

Sie fühlten sich auf Ihrem Arbeitsweg ausgeruht.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie haben sich auf Ihrem Arbeitsweg angespannt gefühlt.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie haben sich auf Ihrem Arbeitsweg mental erschöpft gefühlt.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie hatten auf Ihrem Arbeitsweg das Gefühl keine Kontrolle zu haben.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie haben sich auf Ihrem Arbeitsweg darüber geärgert, wichtige Dinge nicht beeinflussen zu können.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie fühlten sich auf Ihrem Arbeitsweg unter Zeitdruck.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sie hatten das Gefühl, dass Ihr Arbeitsweg zu viele Anforderungen an Sie gestellt hat.

| Sehr gering (1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Sehr stark (10) |
|---|---|---|---|---|---|---|---|---|---|
| o | o | o | o | o | o | o | o | o | o |

Sind während diesen Arbeitsweges besondere Vorkommnisse aufgetreten? (z.B. Vollbremsung, etc.): _____

# Appendix D: Electronic questionnaire

[]

**ProbandenInnen ID:**

*

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

Bitte die ID verwenden die auf der Karte und den Monitoringpapieren steht.

[]

**Ihr Alter in Jahren:**

*

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[]

**Geschlecht:**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- weiblich
- männlich

[]

**Bildungsgrad:**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Keinen Pflichtschulabschluss
- ○ Pflichtschulabschluss (ohne Lehre)
- ○ Abschluss mit Lehre (Berufsschule)
- ○ Berufsbildende mittlere Schule (ohne Berufsschule)
- ○ Abschluss mit Matura (AHS, BHS, Kolleg)
- ○ Akademie, Fachhochschule
- ○ Universität, Hochschule

[]

**Derzeitige Beschäftigung:**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Erwerbstätig (Voll- oder Teilzeit)
- ○ Andere Form der Erwerbstätigkeit, z.B. geringfügiges Beschäftigungsverhältnis
- ○ Präsenz- bzw. Zivildienst
- ○ Schülerin, Studentin
- ○ Sonstiges [ ]

[]

**Berufsbezeichnung:**

*

Bitte geben Sie Ihre Antwort hier ein:

[ ]

[]

**Schichtarbeit:**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[]

**Selbstständig:**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[]

**Körpergröße (in cm):**

*

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
cm

[]

**Gewicht (in kg):**

*

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

kg

Zumindest geschätzt.

[]

**Derzeitiger Familienstand:**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- verheiratet
- in einer Partnerschaft
- getrennt/geschieden/verwitwet/ledig

[]

**Lebt noch jemand in Ihrem Haushalt?**

*

Bitte wählen Sie alle zutreffenden Antworten aus:

- niemand-alleine
- Partner
- Eltern
- andere Erwachsene Verwandte
- andere Erwachsene ohne Verwandtschaftsverhältnis
- eigene Kinder
- fremde Kinder

[]

**Anzahl der Kinder unter 15 Jahre in Ihrem Haushalt:**

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[]

**Durchschnittliches monatliches Netto-Einkommen:**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- bis 600€
- von 600 € bis 1000€
- von 1000€ bis 1400€
- von 1400€ bis 1800€
- von 1800€ bis 2300€
- von 2300€ bis 3000€
- über 3000€
- keine Angabe

## Type of Transport

[ ]

**Besitzen Sie einen Führerschein der Klasse A (Motorrad/Moped)?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[ ]

**Steht Ihnen ein Motorrad/Moped für den täglichen Arbeitsweg zur Verfügung?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[ ]

**Besitzen Sie einen Führerschein der Klasse B (PKW)?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[ ]

**Steht Ihnen ein PKW für den täglichen Arbeitsweg zur Verfügung?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[ ]

**Können Sie Fahrradfahren?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[ ]

**Steht Ihnen ein funktionstüchtiges Fahrrad zur Verfügung, mit dem Sie fahren können?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[]

**Wie oft haben Sie in den letzten 12 Monaten im Durchschnitt folgende Verkehrsmittel bei Ihren Wegen benützt?**

*

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

| | Fast täglich | Sehr häufig, mehrmals die Woche | Etwa 1-2 mal die Woche | Etwa 1-3 mal im Monat | Nie (oder fast nie) |
|---|---|---|---|---|---|
| öffentliche Verkehrsmittel | ○ | ○ | ○ | ○ | ○ |
| das Auto als Fahrer/in oder Mitfahrer/in | ○ | ○ | ○ | ○ | ○ |
| ein Moped/Motorrad | ○ | ○ | ○ | ○ | ○ |
| das Fahrrad (in der "warmen" Jahreszeit) | ○ | ○ | ○ | ○ | ○ |
| das Fahrrad im Winter | ○ | ○ | ○ | ○ | ○ |
| mindestens 10 Minuten durchgehend zu Fuß gegangen | ○ | ○ | ○ | ○ | ○ |

[]

**Wie gerne sind Sie generell mit den verschiedenen Transportmitteln unterwegs?**

**Antworten auf einer Skala von -50 (mag ich gar nicht) bis 50 (mag ich gerne).**

*

Bitte geben Sie Ihre Antwort(en) hier ein:

| | |
|---|---|
| Wie gerne gehen Sie generell zu Fuß? | |
| Wie gerne fahren Sie generell mit dem Fahrrad? | |
| Wie gerne fahren Sie generell mit dem Auto? | |
| Wie gerne fahren Sie generell mit dem Moped/Motorrad? | |
| Wie gerne fahren Sie generell mit öffentlichen Verkehrsmitteln? | |

## Arbeitsweg

Angaben für die Strecke von Ihrem Wohnort zur Arbeit/Universität/Schule, die Sie am öftesten nutzen. Es geht bei den folgenden Fragen um Ihren typischen Arbeitsweg, den Sie also am häufigsten wählen.

[ ]

**Haben Sie eine Fahrgemeinschaft für den Arbeitsweg?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ja
- ○ Nein

[ ]

**Wie lange (in Minuten) brauchen Sie üblicherweise für Ihren gesamten Arbeitsweg?**

*

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
min

Bitte so genau wie möglich schätzen.

[ ]

**Wie viele Minuten von Ihrem Arbeitsweg verwenden Sie durchschnittlich für welches Transportmittel?**

*

Bitte wählen Sie alle zutreffenden Antworten aus:

- ☐ Zu Fuß
- ☐ Fahrrad
- ☐ Auto
- ☐ Moped/Motorrad
- ☐ Öffentliche Verkehrsmittel (inklusive Taxi)

(z.B.: 15min zu Fuß + 20min Busfahrt oder 25min Fahrrad; bitte so genau wie möglich schätzen)

[ ]

**Zeit zu Fuß**

*

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war bei Frage '25 [waytimetrans]' ( Wie viele Minuten von Ihrem Arbeitsweg verwenden Sie durchschnittlich für welches Transportmittel? )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
min

[ ]

**Zeit mit Fahrrad**

*

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war bei Frage '25 [waytimetrans]' ( Wie viele Minuten von Ihrem Arbeitsweg verwenden Sie durchschnittlich für welches Transportmittel? )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
min

[ ]

**Zeit mit Auto**

*

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war bei Frage '25 [waytimetrans]' ( Wie viele Minuten von Ihrem Arbeitsweg verwenden Sie durchschnittlich für welches Transportmittel? )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

min

[ ]

**Zeit mit Moped/Motorrad**

*

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war bei Frage '25 [waytimetrans]' ( Wie viele Minuten von Ihrem Arbeitsweg verwenden Sie durchschnittlich für welches Transportmittel? )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

min

[ ]

**Zeit mit öffentlichen Verkehrsmitteln**

*

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war bei Frage '25 [waytimetrans]' ( Wie viele Minuten von Ihrem Arbeitsweg verwenden Sie durchschnittlich für welches Transportmittel? )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

min

[ ]

**Wie lange schätzen Sie die Strecke (in km) von Ihrem Wohnort bis zur Arbeit/Universität/Schule?**

**Gemeint ist nur der Hinweg!**

*

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

km

[ ]

**Falls Sie einmal Ihren Arbeitsweg wechseln, warum tun Sie das?**

Bitte geben Sie Ihre Antwort hier ein:

z.B. wegen dem Wetter.

[]

**Zu welcher Uhrzeit fahren Sie gewöhnlich zur Arbeit/Universität/Schule?**

*

Bitte ein Datum eingeben:

[]

**Fragen zum Verkehrsaufkommen:**

*

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

| | Sehr gering | | | | | | | | | Sehr stark |
|---|---|---|---|---|---|---|---|---|---|---|
| Wie hoch ist das Verkehrsaufkommen für Ihren typischen Arbeitsweg unabhängig vom benutzten Transportmittel? | O | O | O | O | O | O | O | O | O | O |

[] *

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

| | Sehr gering | | | | | | | | | Sehr stark |
|---|---|---|---|---|---|---|---|---|---|---|
| Wie stark werden Sie durch das Verkehrsaufkommen auf Ihrem Weg beeinflusst? | O | O | O | O | O | O | O | O | O | O |

[]

**Sind aktuell Baustellen auf dem Weg zur Arbeit/Universität/Schule?**

*

Bitte wählen Sie nur eine der folgenden Antworten aus:

- O Ja
- O Nein

[]

**Wie viele Baustellen?**

*

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war 'Ja' bei Frage '36 [traffic3]' ( Sind aktuell Baustellen auf dem Weg zur Arbeit/Universität/Schule? )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[] *

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:** ((traffic3.NAOK == "Y"))

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

| | Sehr gering | | | | | | | | | Sehr stark |
|---|---|---|---|---|---|---|---|---|---|---|
| Wie stark werden Sie durch die Baustellen auf Ihrem Weg beeinflusst? | O | O | O | O | O | O | O | O | O | O |

## IPAQ

Wir sind daran interessiert herauszufinden, welche Arten von körperlichen Aktivitäten Menschen in ihrem alltäglichen Leben vollziehen. Die Befragung bezieht sich auf die Zeit die Sie während der **letzten 7 Tage** in körperlicher Aktivität verbracht haben. Bitte beantworten Sie alle Fragen (auch wenn Sie sich selbst nicht als aktive Person ansehen). Bitte berücksichtigen Sie die Aktivitäten im Rahmen Ihrer Arbeit, in Haus und Garten, um von einem Ort zum anderen zu kommen und in Ihrer Freizeit für Erholung, Leibesübungen und Sport.

Denken Sie an all Ihre **anstrengenden** und **moderaten** Aktivitäten in den **vergangenen 7 Tagen**. **Anstrengende** Aktivitäten bezeichnen Aktivitäten, die starke körperliche Anstrengungen erfordern und bei denen Sie deutlich stärker atmen als normal. **Moderate** Aktivitäten bezeichnen Aktivitäten mit moderater körperlicher Anstrengung bei denen Sie ein wenig stärker atmen als normal.

[]

**Denken sie nur an die körperlichen Aktivitäten die Sie für *mindestens 10 Minuten* ohne Unterbrechung verrichtet haben. An wie vielen der vergangenen 7 Tage haben Sie anstrengende körperliche Aktivitäten wie Aerobic, Laufen, schnelles Fahrradfahren oder schnelles Schwimmen verrichtet?**

*

Ihre Antwort muss zwischen 0 und 7 liegen.
In diesem Feld darf nur ein ganzzahliger Wert eingetragen werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
Tage pro Woche

Für keine anstrengende Aktivität, "0" eintragen.

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit anstrengender körperlicher Aktivität verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war gleich oder größer als '1' bei Frage '39 [ipaq1]' ( Denken sie nur an die körperlichen Aktivitäten die Sie für mindestens 10 Minuten ohne Unterbrechung verrichtet haben. An wie vielen der vergangenen 7 Tage haben Sie anstrengende körperliche Aktivitäten wie Aerobic, Laufen, schnelles Fahrradfahren oder schnelles Schwimmen verrichtet? )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
Stunden pro Tag

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit anstrengender körperlicher Aktivität verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:** {(ipaq1.NAOK >= "1")}

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
Minuten pro Tag

[]

**Wie viel Zeit haben Sie für gewöhnlich an einem dieser Tage mit anstrengender körperlicher Aktivität verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:** {(ipaq1.NAOK >= "1")}

Bitte wählen Sie nur eine der folgenden Antworten aus:

O Ich weiß nicht / bin nicht sicher

[]

**Denken Sie erneut nur an die körperlichen Aktivitäten die Sie für *mindestens 10 Minuten* ohne Unterbrechung verrichtet haben. An wie vielen der vergangenen 7 Tage haben sie moderate körperliche Aktivitäten, wie das Tragen leichter Lasten, Fahrradfahren bei gewöhnlicher Geschwindigkeit oder Schwimmen bei gewöhnlicher Geschwindigkeit verrichtet? Hierzu zählt nicht zu Fuß gehen.**

*

Ihre Antwort muss zwischen 0 und 7 liegen.
In diesem Feld darf nur ein ganzzahliger Wert eingetragen werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
Tage pro Woche

Für keine moderate Aktivität, "0" eintragen.

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit moderater körperlicher Aktivität verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war gleich oder größer als '1' bei Frage '43 [paq3]' ( Denken Sie erneut nur an die körperlichen Aktivitäten die Sie für mindestens 10 Minuten ohne Unterbrechung verrichtet haben. An wie vielen der vergangenen 7 Tage haben sie moderate körperliche Aktivitäten, wie das Tragen leichter Lasten, Fahrradfahren bei gewöhnlicher Geschwindigkeit oder Schwimmen bei gewöhnlicher Geschwindigkeit verrichtet? Hierzu zählt nicht zu Fuß gehen. )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

Stunden pro Tag

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit moderater körperlicher Aktivität verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:** ((paq3.NAOK >= "1"))

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

Minuten pro Tag

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit moderater körperlicher Aktivität verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:** ((paq3.NAOK >= "1"))

Bitte wählen Sie nur eine der folgenden Antworten aus:

- Ich weiß nicht / bin nicht sicher

[]

**An wie vielen der vergangenen 7 Tage sind Sie *mindestens 10 Minuten* ohne Unterbrechung zu Fuß gegangen? Dieses beinhaltet Gehstrecken daheim oder in der Arbeit, gehen um von einem Ort zu einem anderen zu gelangen, sowie alles andere Gehen zur Erholung, Bewegung oder Freizeit.**

*

Ihre Antwort muss zwischen 0 und 7 liegen.
In diesem Feld darf nur ein ganzzahliger Wert eingetragen werden.

Bitte geben Sie Ihre Antwort hier ein:

Tage pro Woche

Für keine entsprechenden Wege zu Fuß, "0" eintragen.

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit Gehen verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:**
Antwort war gleich oder größer als '1' bei Frage '47 [paq5]' ( An wie vielen der vergangenen 7 Tage sind Sie mindestens 10 Minuten ohne Unterbrechung zu Fuß gegangen? Dieses beinhaltet Gehstrecken daheim oder in der Arbeit, gehen um von einem Ort zu einem anderen zu gelangen, sowie alles andere Gehen zur Erholung, Bewegung oder Freizeit. )

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

Stunden pro Tag

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit Gehen verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:** ((paq5.NAOK >= "1"))

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

Minuten pro Tag

[]

**Wie viel Zeit haben Sie für gewöhnlich an *einem* dieser Tage mit Gehen verbracht?**

**Beantworten Sie diese Frage nur, wenn folgende Bedingungen erfüllt sind:** ((lpaq5.NAOK >= "1"))

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ich weiß nicht / bin nicht sicher

[]

**Wie viel Zeit haben Sie in den vergangenen 7 Tagen an einem Wochentag mit Sitzen verbracht? Dies kann Zeit beinhalten wie Sitzen am Schreibtisch, Besuchen von Freunden, vor dem Fernseher sitzen oder liegen und auch sitzen in einem öffentlichen Verkehrsmittel.**

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
Stunden pro Tag

[]

**Wie viel Zeit haben Sie in den vergangenen 7 Tagen an einem Wochentag mit Sitzen verbracht? Dies kann Zeit beinhalten wie Sitzen am Schreibtisch, Besuchen von Freunden, vor dem Fernseher sitzen oder liegen und auch sitzen in einem öffentlichen Verkehrsmittel.**

In dieses Feld dürfen nur Zahlen eingegeben werden.

Bitte geben Sie Ihre Antwort hier ein:

[ ]
Minuten pro Tag

[]

**Wie viel Zeit haben Sie in den vergangenen 7 Tagen an einem Wochentag mit Sitzen verbracht? Dies kann Zeit beinhalten wie Sitzen am Schreibtisch, Besuchen von Freunden, vor dem Fernseher sitzen oder liegen und auch sitzen in einem öffentlichen Verkehrsmittel.**

Bitte wählen Sie nur eine der folgenden Antworten aus:

- ○ Ich weiß nicht / bin nicht sicher

## WHO-5

[]

**Die folgenden Aussagen betreffen Ihr Wohlbefinden in den letzten 2 Wochen. Bitte markieren Sie bei jeder Aussage die Rubrik, die Ihrer Meinung nach am besten beschreibt, wie Sie sich in den letzten 2 Wochen gefühlt haben.**

**In den letzten 2 Wochen...**

*

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

| | Die ganze Zeit | Meistens | Etwas mehr als die Hälfte der Zeit | Etwas weniger als die Hälfte der Zeit | Ab und zu | Zu keinem Zeitpunkt |
|---|---|---|---|---|---|---|
| ... war ich froh und guter Laune. | ○ | ○ | ○ | ○ | ○ | ○ |
| ... habe ich mich ruhig und entspannt gefühlt. | ○ | ○ | ○ | ○ | ○ | ○ |
| ... habe ich mich energisch und aktiv gefühlt. | ○ | ○ | ○ | ○ | ○ | ○ |
| ... habe ich mich beim Aufwachen frisch und ausgeruht gefühlt. | ○ | ○ | ○ | ○ | ○ | ○ |
| ... war mein Alltag voller Dinge, die mich interessieren. | ○ | ○ | ○ | ○ | ○ | ○ |

**PSS-10**

[]

**Die folgenden Fragen beschäftigen sich damit, wie häufig Sie sich während des letzten Monats durch Stress belastet fühlten.**

*

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

| | nie | selten | manchmal | häufig | sehr oft |
|---|---|---|---|---|---|
| Wie oft hatten Sie sich im letzten Monat darüber aufgeregt, dass etwas völlig Unerwartetes eingetreten ist? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie im letzten Monat das Gefühl, wichtige Dinge in Ihrem Leben nicht beeinflussen zu können? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie sich im letzten Monat nervös und „gestresst" gefühlt? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie sich im letzten Monat sicher im Umgang mit persönlichen Aufgaben und Problemen gefühlt? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie im letzten Monat das Gefühl, dass sich die Dinge nach Ihren Vorstellungen entwickeln? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie im letzten Monat das Gefühl, mit all den anstehenden Aufgaben und Problemen nicht richtig umgehen zu können? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie im letzten Monat das Gefühl, mit Ärger in Ihrem Leben klar zu kommen? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie im letzten Monat das Gefühl, alles im Griff zu haben? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie sich im letzten Monat darüber geärgert, wichtige Dinge nicht beeinflussen zu können? | ○ | ○ | ○ | ○ | ○ |
| Wie oft hatten Sie im letzten Monat das Gefühl, dass sich die Probleme so aufgestaut haben, dass Sie diese nicht mehr bewältigen können? | ○ | ○ | ○ | ○ | ○ |