Chapter 1
General introduction
Whether we move, and how much we sit, greatly influences our health. Not being regularly active as well as sitting too much or too long will increase one’s risk for major non-communicable diseases and all-cause mortality. And according to recent estimates, a large part of the population can be described as ‘inactive’ and/or ‘sedentary’. Knowing how many people are inactive/sedentary (the ‘prevalence’), and what factors are associated with these behaviours (the ‘correlates’), is needed to monitor change over time, target those at high risk, and evaluate preventive strategies. Therefore, this thesis aims to describe the prevalence and correlates of sedentary behaviour and physical activity in European adults.

This general introduction starts with introducing the two behaviours that are central in this thesis: physical activity and sedentary behaviour. Subsequently, the European ‘Determinants of Diet and Physical Activity’ (DEDIPAC) Knowledge Hub, from which this thesis originates, will be described. Specifically, DEDIPAC’s aim to study the prevalence and correlates of sedentary behaviour and physical activity in European adults will be explained, followed by an overview of the current literature. This will provide the context to introduce the aim and research questions of this thesis, after which the successive chapters of this thesis will be outlined.

**Physical activity**

Physical activity has been defined as “any bodily movement produced by skeletal muscles that results in energy expenditure”\(^1\) and is a well-known and established health-related behaviour. The term ‘physical activity’ includes a wide range of activities, including exercise but also daily activities. It can be structured, such as a yoga lesson, or unstructured, like a walk in the park. It can be planned, like a daily commute by bike, or unplanned, such as a run to catch the bus. Activities can vary in terms of frequency (cleaning the house every week versus skiing once a year) and duration (from using the stairs for less than a minute to a hike lasting multiple hours), as long as they are executed by our muscles and fuelled by our energy.

Physical activities are often classified using the domain in which the activity takes place, usually distinguishing between occupational (such as heavy labour), transportation (such as walking or biking to get from and to places), household (such as cleaning or gardening) and leisure-time (such as playing or exercising) physical activities. In addition, physical activity can be classified by its intensity, usually using Metabolic Equivalents (METs). METs are a measure of energy expenditure; 1 MET corresponds to the basal metabolic rate. Activities of an energy expenditure of 1.5-2.9 METs are defined as light intensity physical activity, activities of 3.0-5.9 METs as moderate intensity physical activity, and activities >6.0 METs as vigorous intensity physical activity. This means that during vigorous intensity physical activity, an individual will use at least six times more energy as compared to being at rest.\(^2\)
In 2010, the World Health Organization (WHO) published their “Global recommendations on physical activity for health”. According to these recommendations, adults (aged 18-64 years) should engage in at least 150 minutes of moderate intensity physical activity per week, or 75 minutes of vigorous intensity physical activity, or an equivalent combination. This activity should occur in bouts of at least 10 minutes. In addition, muscle-strengthening activities should be done at least 2 times per week. These recommendations also apply for older adults (≥65 years old). However, if they are not able to meet these recommendations due to their health, older adults are advised to be as active as possible.

Not meeting these physical activity recommendations is often defined as being physically inactive. Physical inactivity is a well-known health risk, known to increase the risk of cardiovascular disease, type 2 diabetes, breast- and colon cancer, and, consequently, premature death. According to recent estimates, one third of the world population is physically inactive. The WHO has identified physical inactivity as the fourth global risk factor for mortality, and physical inactivity is estimated to cause six to nine percent of worldwide premature deaths. Recently, the economic burden of physical inactivity was estimated to be at least 67.5 billion international Dollars worldwide, and 15.5 billion international Dollars in Europe.

**Sedentary behaviour**

In the last decade, sedentary behaviour has increasingly been recognised as a health risk. Sedentary behaviour has been defined as “any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture”. The term ‘sedentary behaviour’ covers a whole range of different activities. During a typical day, people can be sedentary while eating breakfast, driving a car or taking the train, studying or working at a desk, having a coffee, lunch, drinks or dinner, when they are watching television, using a computer or playing videogames, while reading a book, etcetera. Like physical activities, sedentary behaviours can be classified by the domain in which they take place, usually distinguishing educational/occupational (e.g. studying or working at a desk), transport (e.g. driving a car), household (e.g. doing administrative chores), and leisure-time (e.g. watching a movie) sedentary behaviours.

Even though the terms were used interchangeable in the past, sedentary behaviour is now regarded as distinct from physical inactivity. In its current use, the term ‘physical inactivity’ refers to insufficient levels of moderate to vigorous intensity physical activity, e.g. not meeting the physical activity recommendations, while sedentary behaviour refers to prolonged sitting. For example, people can be active for 150 minutes per week, but still spend (most of) the rest of the week sitting, which would classify them as being both physically active and highly sedentary.
Sedentary behaviour is increasingly recognised as a health-related behaviour. Global sedentary behaviour levels are estimated to be around five hours per day. A recent systematic literature review and meta-analysis by Biswas and colleagues reported positive associations between time spent sedentary and type 2 diabetes incidence, cancer incidence and mortality, cardiovascular disease incidence and mortality, and all-cause mortality. In addition, a meta-analysis by Chau and colleagues reported an increased risk of all-cause mortality if adults sit more than seven to eight hours per day. The associations between sedentary time and mortality seem to be attenuated by physical activity levels, and eliminated by very high levels of moderate to vigorous physical activity. This means that individuals that are both inactive and highly sedentary might be at highest risk for the associated health risks of these behaviours.

As sedentary behaviour is a relatively recently recognised health risk behaviour, there are currently no international guidelines on the maximum amount of sedentary behaviour people should engage in. However, some countries have included sedentary behaviour into their physical activity recommendations. The guidelines from the United Kingdom, for example, advise adults to minimise prolonged sedentary time, while the Australian guidelines recommend adults to minimise and break up their sitting time. But more research will be needed before more specific sedentary behaviour recommendations can be made.

**DEDIPAC Knowledge Hub**

In Europe, the high levels of physical inactivity, sedentary behaviour as well as unhealthy dietary behaviours, and the related non-communicable diseases, are of great concern. Therefore, the European Commission initiated the Joint Programming Initiative (JPI) ‘a Healthy Diet for a Healthy Life’ (HDHL). Joint Programming is a collaborative process in which European Union Member States define, develop and implement a strategic research agenda based on a shared vision of how to address major societal challenges that none of the countries can resolve independently. This is thought to increase the efficiency as well as the impact of the research conducted.

The vision of the JPI HDHL is “that in 2030 all Europeans will have the motivation, ability and opportunity to consume a healthy diet from a variety of foods, have healthy levels of physical activity and the incidence of diet-related diseases will have decreased significantly.” To contribute to realising this vision, three research areas were distinguished: 1) determinants of diet and physical activity, 2) diet and food production, and 3) diet-related chronic diseases.

In 2012, the ‘DEterminants of DIet and Physical ACtivity’ (DEDIPAC) Knowledge Hub was started as the first joint action of the JPI HDHL, to address the “determinants of diet and physical activity” research area. In this Knowledge Hub, twelve European Union Member States joined
forces to establish a research network to study dietary, physical activity and sedentary
behaviours and their determinants. The aim of DEDIPAC is to “understand the determinants of
dietary, physical activity and sedentary behaviours and to translate this knowledge into a more
effective promotion of a healthy diet and physical activity.”

The DEDIPAC Knowledge Hub has been described in detail by Lakerveld and colleagues. In short,
the research within DEDIPAC is divided into three Thematic Areas, aiming to 1) enable
standardised and continuous monitoring of dietary, physical activity and sedentary behaviours
across the life course, 2) explore the main correlates/determinants of these behaviours, and 3) learn from previous and ongoing interventions and policies. The research included in this thesis was conducted within the first two Thematic Areas, focused on the prevalence (Thematic Area 1) and correlates (Thematic Area 2) of sedentary behaviour and physical activity in European adults. The next paragraphs will explain these terms and provide an overview of the research to date.

**Prevalence**

‘Prevalence’ is an epidemiological term referring to the proportion of a population with a certain condition, for example the proportion of the Dutch adults meeting the WHO physical activity recommendations or the proportion of Europeans accumulating more than seven hours of sedentary time per day. Prevalence data can be used to monitor population levels and study trends over time, compare and benchmark across countries, and evaluate public health interventions and policies.

Physical activity and sedentary behaviour can be measured subjectively, often using self-report
measures such as questionnaires or interviews, or objectively, usually using motion sensors like
pedometers or accelerometers. Both methods have advantages as well as disadvantages. Self-report measures, on the one hand, are easy to administer to a large group of people at low costs, and provide the opportunity to study the context of the behaviour. However, recalling these behaviours can be difficult, and self-report measures are prone to social-desirability bias, which can lead to under-reporting of sedentary behaviour and over-reporting of physical activity. Objective measures, on the other hand, are known to provide more accurate estimates of physical activity and sedentary behaviour levels, but are more expensive in use, carry a higher participant burden, might alter the behaviour under study, and do not provide contextual information. Because of these disadvantages of objective measurements, and mostly because of the high costs, most surveillance data is based on self-report measures.

Global population levels of physical inactivity are monitored regularly, but estimates differ. In 2012, Hallal and colleagues reported that 31 percent of the global adult population was physically
inactive. In 2014, the WHO reported that this was 23 percent. European levels of physical activity are reported less often and estimates vary more widely. While Hallal and colleagues concluded that 35 percent of European adults were inactive, the 2013 Eurobarometer survey reported that 54 percent of the respondents did not do any vigorous physical activity, and 44 percent did not do any moderate physical activity in the week before completing the survey.

Less is known about the population levels of sedentary behaviours, as systematic surveillance is lacking. The International Prevalence Study included 20 countries around the globe and concluded that the median sitting time was 300 minutes, or 5 hours, per day. In addition, 66 countries provided sedentary behaviour data in the study by Hallal and colleagues, and they estimated that 42 percent of adults spent 4 hours or more per day sedentary. In the European countries, this was 64 percent. In addition, the 2013 Eurobarometer survey reported that 11 percent of the respondents reported to sit more than 8.5 hours per day.

**Correlates**

In this thesis, the term ‘correlate’ refers to a variable or characteristic that is statistically and meaningfully associated with an outcome; in this case with physical (in)activity and/or sedentary behaviour. Knowledge of correlates can help identify high-risk populations with low levels of physical activity and/or high levels of sedentary behaviour, and provide access points for targeted interventions and policies to increase physical activity and/or reduce sedentary behaviour.

Sedentary behaviour and physical activity are influenced by multiple correlates, on multiple levels. For example, whether someone will bike to work may depend on individual factors like enjoyment of biking and physical condition, but also on contextual factors such as distance to work, the weather, availability of bike paths along the route, encouragements of friends and family, parking facilities at work, etcetera. In addition, some of these factors might be interrelated; whether someone will enjoy the ride might depend on the availability of bike paths. Therefore, the correlates of health behaviours are often described and depicted in so-called socio-ecological models which take these contextual factors, and the interrelatedness of the different factors, into account. These models usually distinguish between individual, social, organisational, environmental and policy correlates of health-related behaviours.

With regards to physical activity, a lot of different potential correlates have been investigated to date. In their systematic literature review, Trost and colleagues presented an extensive overview of the current evidence base of biological, demographic, psychological, cognitive, emotional, behavioural, social, cultural, physical environment and physical activity characteristics-related correlates of physical activity in adults. More than half of the identified correlates were on the
individual level. In addition, evidence for these individual-level correlates also seemed to be most consistent, especially for gender, age, socio-economic status and self-efficacy.\textsuperscript{22} These results are comparable to the 2013 Eurobarometer survey, in which gender, age and occupation were also shown to be important correlates of physical activity in European adults.\textsuperscript{20}

Less is known about the correlates of sedentary behaviour. The existing studies are mainly focused on individual-level correlates, as indicated by systematic literature reviews by Rhodes and colleagues (2012)\textsuperscript{23} and O’Donoghue and colleagues (2016).\textsuperscript{24} However, O’Donoghue and colleagues did identify some more recent studies focusing on intrapersonal (e.g. marital status) and environmental (e.g. presence or proximity of green spaces) correlates of sedentary behaviour.\textsuperscript{24} In addition, the 2002 and 2005 Eurobarometer surveys reported associations between sedentary time and individual (e.g. gender, age, socio-economic status) as well as environmental (e.g. urbanisation and country) correlates.\textsuperscript{25,26} According to O’Donoghue and colleagues, socio-economic status was among the most consistent correlates of sedentary behaviour of all individual factors that were identified.\textsuperscript{24}

**Research aim and questions**

In summary, both physical inactivity and sedentary behaviour are associated with a higher risk for the development of major non-communicable diseases and all-cause mortality. The DEDIPAC Knowledge Hub aims to investigate the prevalence and correlates of these behaviours in Europe, as this will help monitor and benchmark population levels, identify and target populations at risk, and evaluate interventions and policies. Currently, physical activity levels are regularly monitored but estimates vary, while systematic sedentary behaviour surveillance is lacking. In addition, most studies to date have focused on individual-level correlates of especially sedentary behaviour, largely ignoring contextual factors. The aim of this thesis is to add to the current knowledge base by using existing data to assess the prevalence and correlates of sedentary behaviour and physical activity of adults in Europe.

Specifically, this thesis aims to answer four research questions:

- What is the prevalence of sedentary behaviour in European adults?
- What is the prevalence of physical activity in European adults?
- What are correlates of sedentary behaviour in European adults?
- What are correlates of physical activity in European adults?

As less is currently known about the prevalence and correlates of sedentary behaviour, most studies in this thesis will focus on sedentary behaviour.
Chapter 1

Thesis outline

The first two chapters after this introduction will focus solely on the prevalence of sedentary behaviour and physical activity. These chapters consist of systematic literature reviews on the variation in population levels of sedentary time (chapter 2) and physical activity (chapter 3) in European adults according to cross-European studies. The aims of these reviews were to provide an overview of all existing cross-European prevalence studies, to describe the (variation in) population levels according to these studies, and to discuss the impact of the measurement methods used. By doing so, these reviews provide a clear overview of the current state of cross-European surveillance of sedentary behaviour and physical activity in adults.

All subsequent chapters study both the prevalence and correlates of sedentary behaviour and physical activity. Data from the 2013 Eurobarometer survey are used in chapter 4 to study the prevalence and correlates of self-reported sitting time in all 28 European Union Member States. As this is the largest dataset currently available in Europe, it enabled the study of a large number of countries and a wide range of potential correlates. In chapter 5, accelerometer data from national population-based studies in four European countries (England, Norway Portugal and Sweden) were pooled, which allowed the comparison of objectively measured levels of sedentary time and physical activity across those countries. Chapter 6 focuses on a different continent altogether, using data from the 2007/08, 2011/12 and 2014/15 Australian Health Surveys to study prevalence trends as well as correlates of self-reported sitting time in Australian adults. Finally, chapter 7 focuses on the Netherlands, where data from the Healthy Life in an Urban Setting (HELIUS) study were used to describe and compare objectively measured levels of sedentary time in five ethnic groups living in the city of Amsterdam.

The thesis is finalised with a general discussion (chapter 8) in which the results of the different studies are summarised, discussed, and put in a broader perspective. In addition, the strengths and limitations of the research included in this thesis are discussed, and recommendations are made for future research and practice.
References
