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Faculteit Geneeskunde en Levenswetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

The cross-sectional relationship between objectively measured sedentary time and cardiometabolic biomarkers among healthy first bachelor university students

Ann-Sofie Andries

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :

Prof. dr. Dominique HANSEN

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MASTER'S THESIS

THE CROSS–SECTIONAL RELATIONSHIP BETWEEN OBJECTIVELY MEASURED SEDENTARY TIME AND CARDIOMETABOLIC BIOMARKERS AMONG HEALTHY FIRST BACHELOR UNIVERSITY STUDENTS

Research question:

- "What is the relationship between objectively measured sedentary time among healthy first bachelor university students, aged between 18 and 20, and blood lipid profile, body composition, blood pressure and glycaemic control?"

Highlights:

- Objective measurements of sedentary time were performed and individual cardio-metabolic biomarkers were investigated.
- Unfavourable associations were found between increments in sedentary time and fasting glucose concentration, insulin sensitivity and triglyceride concentrations.
- Data of the current study reinforces the notion that efforts should be directed at reducing the amount of time spent sedentary for the maintenance of the metabolic health of young people, and more specific first bachelor university students.

Student: Ann-Sofie Andries

Promoter: Prof. Dr. Dominique Hansen

PREFACE

The past 10 months have been building up to this moment; writing the preface is the last mile to finishing up this master's thesis, written with the graduation as Physiotherapist in mind. The past 10 months were an intensive, yet educational period for me, in which I acquired and practiced loads of skills within the domain of sedentary behaviour research.

Nevertheless, one cannot finish a master's thesis alone; this thesis is a result of a close collaboration between several parties with differing insights. As I am grateful these people stood by me during the development of this dissertation, I'd like to take the opportunity to express my gratitude towards them, having played an important role in the process of conducting the research and processing the findings.

First of all, I'd like to thank all students participating in this study, having freed up their time to perform all necessary measurements. I'd also like to express my gratitude to my promoter, prof. Dr. Dominique Hansen, having given me the chance to complete this master's thesis. My sincere gratitude also goes towards my fellow physiotherapy students Jochen Wilmaerts and Stijn Pauwels, as well as to Anne Bogaers for having played an indispensable role in planning and executing the measurements. I'm grateful for the Research and Rehabilitation Center (REVAL) for making available all necessary measuring devices and research rooms.

Also, my special appreciation goes to my parents, Jan and Brigitte. First of all for giving me the opportunity to complete this study program, but also for their unconditional trust and support, not only during the writing of this master's thesis, but during all of my studentship.

And last but not least, I'd especially want to thank my boyfriend Nick, for the love, support and the constant encouragement I've gotten during the sometimes difficult and quite stressful periods. I undoubtedly could not have done this without him.

I hope you enjoy reading.

Ann-Sofie Andries

Begijnendijk, August 2017

RESEARCH CONTEXT

This master's thesis is situated in the context of the cardiovascular and metabolic rehabilitation, which is part of the study programme "Rehabilitation Science and Physiotherapy" at the University of Hasselt. Today, sedentarism, i.e. prolonged sitting during the day, poses a significant threat to human health. Due to the rapid development of the society in the past century, human activity has been altered dramatically to be of a less demanding physical nature [1]. In particular, changes have occurred in four different domains including transportation, the workplace, leisure time and the home [2-4]. As a consequence of these developments, many working-aged adults are currently 'forced' to follow a sedentary profession [5]; students too have to sit a substantial amount of time per day while following lessons and doing their homework [6].

Today, emerging evidence suggests that sedentary behaviour is adversely associated with health outcomes. Previously published studies have reported that more time spent sitting can be associated with a poorer cardiometabolic health [7], the development of musculoskeletal complaints [8] and even an increased risk of premature mortality [9]. However, to date, it is unknown which parameters change first and which negative effects seem to arise later. This is important to better understand which specific risk factors should be influenced or targeted to prevent more health problems at a later age. Moreover, investigation is needed to determine whether the progression of the unfavourable effects of this sedentary behaviour is influenced by several individual characteristics such as age, gender and energy intake. This can be important to determine which people require a more extensive prevention program in order to achieve a higher cost efficiency in the health care sector.

To get a better understanding of the relationship between sedentary behaviour and the risk factors for both cardiometabolic diseases and musculoskeletal problems, the University of Hasselt, and more specifically the Research- and Rehabilitation center REVAL, has started a new research project called: "Healthy movement behaviour in sedentary professions". This research project consists of two main research protocols and focuses on individuals (employees and students) who are 'forced' to sit during prolonged periods of the day.

Protocol 1 focuses on healthy individuals starting a profession for which a considerable amount of sitting throughout the workday is required, and on first bachelor students from the University of Hasselt, who are forced to sit during prolonged periods in order to follow lectures and do their homework. Protocol 1 will be divided into two studies, one focusing on a working population and the other focusing on first bachelor students. In both studies the relationship between the amount of sedentary time and several health outcomes such as lipid profile, body composition, glycaemic control, cardiorespiratory fitness, muscle force and musculoskeletal complaints will be examined. Follow-up measurements will be performed at 6 – 12 – 18 and 24 months following baseline measurements.

In protocol 2, individuals who have already been following a sedentary profession for several years (different durations of employment are allowed), are measured in order to investigate the relationship between the degree and duration of sedentarism and the same health outcomes as mentioned in protocol 1.

This master's thesis is part of protocol 1 and is a cross-sectional study focussing on the first bachelor students of the University of Hasselt and the relationship between objectively measured sedentary time and the following cardiometabolic biomarkers: blood lipid profile, blood pressure, glycaemic control and body composition.

Regarding the research protocol, students were provided with a global description of the measurements that had to be performed within the entire research project. It was the student's task to refine this protocol and to select the tests that were needed to find an answer on their self-determined research question. The recruitment of participants as well as the planning and execution of the measurements were all performed by the students, in collaboration with Anne Bogaers. Since I had an obligatory internship of 15 successive weeks (February-May) during the entire measurement period, two other members of the research team (Jochen Wilmaerts and Stijn Pauwels) have performed all the measurements. The statistical procedures were elaborated by myself and further refined based on the advice I received from Prof. Dr. Dominique Hansen. Also the interpretation of the results and the academic writing process was the responsibility of the student. Finally, this master's thesis was conducted under the supervision of Prof. Dr. Dominique Hansen, who was available if needed to give the student useful advice and feedback during the writing process.

TABLE OF CONTENTS

1. Abstract

Background: Since students are often forced to sit for prolonged periods at school, a clear understanding in how sedentary time relates to health in these individuals has emerged and become more important. Therefore the aim of the current study was to investigate the relationship between objectively measured sedentary time among healthy first bachelor university students, aged between 18 and 20, and the following individual cardiometabolic biomarkers: lipid profile, body composition, blood pressure and glycaemic control.

Participants: 50 healthy first bachelor students (20 men, 30 women) of the University of Hasselt, aged between 18 and 20 years old, participated in this cross-sectional study.

Methods: Lipid profile (TC, HDL-C, LDL-C, TG), resting blood pressure (SBP, DBP), body composition (WC, %FM, %FFM) and glycaemic control (FG, FI, HOMA-%S) were measured. Accelerometers were worn for 7 days to assess sedentary time (ST; <100 cpm). Pearson correlations and multiple linear regression models were used to examine the associations between sedentary time and the selected outcomes. Covariates included: accelerometer wear-time, sex, energy intake, MVPA, BMI and WC.

Results: The results demonstrate that higher levels of sedentary time are significantly associated with detrimental levels of FG concentration (β=0.151, p=0.001), HOMA-%S (β=-0.141, p=0.036) and TG concentration (β=0.281, p=0.002). While the association for TG concentration was independent of all confounders, the significant negative relationship between sedentary time and HOMA-%S lost its significance after models were controlled for MVPA and BMI/WC. Finally, the relationship between sedentary time and FG concentration survived nearly all adjustments including MVPA, but became non-significant after additional adjustments for BMI/WC.

Discussion and conclusion: More time spent sedentary has a negative impact on the insulin sensitivity as well as on the FG en TG concentrations among first bachelor university students. These data suggest that the negative impact of sedentary behaviour not only strikes 'older people', but even young people are at risk to compromise their health.

Important key words: sedentary time, accelerometry, cardiometabolic health, students

2. Introduction

Today, children in Belgium have to complete a long school trajectory in order to be prepared for the labour market. The majority of these children starts their school career at the age of three in preschool, followed by primary school and high school when they are about seven and twelve years old, respectively. After finishing high school, some adolescents will immediately start working, while others will make the transfer to College or University (Vlaams Ministerie van Onderwijs en Vorming). In recent years a growing number of adolescents elect to pursue higher education [10]. This transition to higher education can be considered as a process, which is unique for each individual and mostly involves a significant life changing as many students start to live apart from their home. While making the transition, students often get more freedom, resulting in a loss of routines and habits that were established at high school and the creation of a new personal life style [11]. Within this college/university population, recent data show that students frequently adopt less healthy lifestyle habits. For example, they consume a less than recommended amount of fruit and vegetables and increasing amounts of high-fat foods and alcohol during their first year at University [12, 13]. Data also indicates there is a significant decline in physical activity [10] and an increase in sedentary time [14] during the transition period.

More specific for Belgian students, there is evidence for a significant decrease in all types of physical activity, including active transportation (-98.01 min/week), educational related physical activity (-65.74 min/week), leisure-time related physical activity (-48.96 min/week) and total physical activity (-162.35 min/week) [15]. De Bonte I., 2010 also reports a significant difference in meeting the physical activity recommendation guidelines for vigorous and moderate intensity physical activity between the first year at University (33.0% and 10.2%, respectively) and the last year at high school (44.4% and 19.1%, respectively) [15]. These downward trends seem to begin in the late adolescence and to continue into young adulthood [12].

Students also become more sedentary [14]. However, in contrast to physical activity, not all sedentary behaviours will increase; some behaviours may also decrease during the transition period [15, 16]. For example Belgian first bachelor university students report a decline in TV/DVD viewing time (-66.40 min/week) and time spent in sedentary leisure

activities (-58.62 min/week) in comparison to their senior year at high school. Also a downward trend is observed for driving a car or being driven (-59.62 min/week). In contrast, a significant increase is observed in computer use (internet, emailing, chatting) (+89.09 min/week) and time spent making homework (+102.81 min/week), resulting in a global increase in the amount of sedentary time during first year at university [15].

The above-mentioned unhealthy behaviours are not only a problem during the first year at university but also remain throughout the adulthood as well [15]. Therefore, investigating the consequences of these behaviours on students' health has become more popular in health research. In particular, the impact of College/University students' eating behaviours on several body composition outcomes has already been extensively investigated. In general, unhealthy eating patterns, often combined with an excessive alcohol consumption during the first year at university result in a significant weight gain, an increased BMI, a higher waist circumference, higher levels of % fat mass and a decline in % fat free mass [17, 18]. Nevertheless – to my knowledge – there are no studies, investigating the impact of the amount of time spent sedentary on the students' health during the first year at university. Moreover no single study has measured the changes in sedentary time, and the impact on the students' health during the 5-year university period until the senior year. Nevertheless, measuring these changes can be useful to determine in which specific period intervention programs to reduce the amount of sedentary time are the most needed and probably the most effective.

Therefore, the University of Hasselt has started a new research project to track the changes in sedentary time and several health outcomes among healthy students from their first year until their senior year at university, with follow up measurements every 6 months. The current study will be the first study within this research project and will examine the cross-sectional associations between objectively measured sedentary time, and the blood lipid profile, body composition, blood pressure and glycaemic control among healthy first bachelor university students, aged between 18 and 20.

3. Methods

3.1. Study design

This cross-sectional study was conducted to answer the following research question: 'What is the relationship between objectively measured sedentary time and blood lipid profile, body composition, blood pressure and glycaemic control among healthy first bachelor university students, aged between 18 and 20?' Measurements were performed between 6 February 2017 and 28 April 2017; data was analysed and written down from the beginning of May 2017 until the end of May 2017 and from the beginning until the end of July 2017.

Approval for the present study, including the informed consent document, was obtained from the Medical Ethics Committee of the Jessa Hospital of Hasselt (16.107/reval16.11 Hasselt, 21/11/2016). Participation was completely voluntary, and participants had the opportunity to opt out at any moment or to refuse any of the physical tests. The informed consent as well as the documents for the Medical Ethics Committee can be found in appendix 3 and 1, respectively.

3.2. Participants

Participants for this cross-sectional study were recruited from 1 February until 31 March. All participants had to be first bachelor students from the University of Hasselt and were recruited via flyers, word-of-mouth, and an announcement on Facebook or an invitation by mail. A website (http://www.sedentarisme-project-uhasselt.be) with detailed information concerning the research context and required measurements was especially developed for this study. Students who wanted to participate were able to contact the research team via mail (info.sedentarisme-project@uhasselt.be) or telephone.

All registered students were screened by the research team on inclusion and exclusion criteria. Only students meeting the following inclusion criteria were contacted by the research team to participate in the present study: aged between 18 and 20, apparently healthy, not having problems in understanding the Dutch language, first bachelor students at the University of Hasselt, and enrolled in a full-time curriculum, with lectures from Monday till Friday and weekend days as leisure. Participants were excluded from the study

if they reported any of the following items: pregnancy or breast-feeding, diagnosed metabolic or cardiorespiratory diseases or musculoskeletal problems.

From the 71 students recruited, 21 were excluded based on the above-mentioned inclusion and exclusion criteria: 5 of the 21 excluded students were too old (age ranged from 22 to 24 years) and 16 students were no first bachelor students (see Appendix 2: Flowchart). Finally 50 students were included to participate in the present study. The vast majority of the students (29, 58%) were majoring in Rehabilitation Science and Physiotherapy. The remaining students were studying Medicine (7, 14%), Biomedical Science (6, 12%), Engineering (3, 6%), Economics (2, 4%), Architecture (2, 4%) and Law (1, 2%).

3.3. Sequence of tests

All participants who met the inclusion criteria were invited for a visit to the Research- and Rehabilitation Center REVAL in Diepenbeek. Measurements were mostly performed on Tuesdays and Fridays, depending on the availability of the measurement equipment and the research team. Since fasting blood samples were required, all participants were scheduled to start their measurements between 7:00 and 10:00.

After reading and signing the informed consent, each participant underwent a well-defined sequence of measurements. Fasting blood samples were performed first, followed by anthropometric, body composition and blood pressure measurements. After these tests participants were asked to fill in a questionnaire concerning general information such as age, gender, medication use and medical history.

At the end of their visit, participants were instructed on the accelerometer protocol and the correct use of a 3-day food diary. Participants were asked to wear the accelerometer for 7 consecutive days, while filling in the food diary on two weekdays and one weekend day. A second visit to the Research- and Rehabilitation Center was scheduled after the accelerometer was worn for 7 consecutive days. During this visit the accelerometer and the food diary were returned to the research team.

3.4. Performed measurements

3.4.1. Fasting blood samples

Markers of cardiometabolic health were measured, including fasting glucose concentration, fasting insulin concentration, triglyceride concentration, total cholesterol concentration, LDL-cholesterol concentration and HDL-cholesterol concentration. Venous blood samples were obtained from each participant between 7:00 and 10:00 after participants had fasted [19] and abstained from smoking, alcoholic and caffeinated beverages for 12 hours prior to extraction. Within this period water consumption and usual mediation intake were allowed [19]. To ensure all participants were well informed concerning the fasting requirements, every participant was sent a reminder with instructions concerning the required fasting period a few days before their appointment at the Research- and Rehabilitation Center. All the blood draws were performed by a trained nurse and were brought to the clinical laboratory of the Jessa hospital in Hasselt for analysis. Analyses were performed using standard diagnostic tests; More specific, fasting glucose concentrations were obtained using the colorimetric hexokinase–glucose-6-phosphate dehydrogenase method on a Beckman Coulter AU 2700 chemical analyser; Beckman Coulter. Insulin concentrations were measured by direct chemiluminescence sandwich ELISA on ADVIA Centaur XP; Siemens, and fasting triglyceride concentrations were measured by enzymatic colorimetry [20]. Next, fasting insulin concentrations and fasting glucose concentrations data were used to calculate the Homeostasis Model Assessment insulin sensitivity (HOMA-%S) [21] using the University of Oxford (2004) HOMA calculator (http://www.dtu.ox.ac.uk/homacalculator/download.php).

3.4.2. Anthropometric measurements

Anthropometric measurements were performed with participants lightly clothed and barefoot. Height was measured to the nearest 0.1 cm by using a wall-mounted stadiometer (Seca) and body weight was measured to the nearest tenth using a calibrated digital scale (Seca). For the height measurements, participants were instructed to stand erect on the floor with their back against the wall-mounted stadiometer, heels against the wall, feet or knees together and the head positioned in the Frankfort Horizontal plane [22]. Waist circumference was measured at the midpoint between the superior border of the iliac crest

and the lowest rib, using a flexible non-stretching tape placed directly to the skin [23]. Participants were asked to stand relaxed, with the arms folded comfortable across the chest and breathing normally. Measurements were performed at the end of a normal expiration and results were recorded with an accuracy of 0.1 cm [24]. To reduce the risk of measurement error, waist circumference was measured twice and the average of both values was noted as the waist circumference. If the value of those two readings differed by >0.5 cm, an additional third reading was performed and the average of the two values that were closest to each other was used as the waist circumference [25].

3.4.3. Body composition

Fat-mass (%FM) and fat-free mass (%FFM) were determined using a whole-body dual X-ray absorptiometry (DXA; Lunar DPXL, WI, USA) [20, 26]. Participant instruction and DXA measurements were performed by a trained nurse of the Research- and Rehabilitation Center. For all the scans, participants were lightly clothed and had to remove all metal objects (such as zippers, belt buckles) or jewellery from their body, since these objects could interfere with the X-ray images and give an invalid result. Participants were asked to take place on the X-ray table in supine position with the head in a neutral position; arms and legs were extended next to the body, with hands in a pronated flat position and feet slightly internally rotated. Participants were not allowed to move while the scans were performed. The whole procedure took no longer than 10 minutes.

3.4.4. Blood pressure

Resting systolic blood pressure (mmHg) and resting diastolic blood pressure (mmHg) were measured using a Panasonic diagnostic EW-BU15 sphygmanometer. Readings were taken in a quiet room, while participants were lying in supine position with legs uncrossed [27] and their arm supported at the reference level of the right atrium and positioned in a straight position with the ante-cubital fossa 'facing upwards' [28, 29]. Participants were asked to relax and refrain from talking in the period before and during the measurements [28]. To provide a stabilization of the diastolic and systolic blood pressure, at least 5 minutes had to elapse in this setting before readings were taken. [28]. Since it is recommended to take more than one reading in order to strengthen the accuracy of the blood pressure measurements, both the systolic and diastolic blood pressure were measured twice at an

interval of at least one minute. The average of these two measurements was considered to represent the participant's systolic/diastolic blood pressure. If the difference between the first two readings was >5 mmHg, one or two additional readings were performed [28].

3.4.5. Physical activity measurements

As described in my master's thesis part 1 [1], physical activity and sedentary time were measured using a tri-axial accelerometer (type ActiGraph GT3X) [30], which converts raw accelerations of the human body, recorded in three planes, into activity counts [31]. For this study, the accelerometer was programmed to record the acceleration data in 1-minute intervals [32]. Participants received the instruction to wear the accelerometer for a period of 7 consecutive days while maintaining their regular activity pattern. This period of 7 days was chosen to ensure the accelerometer data were reliable, as research has shown that an accelerometer-monitoring period of 3 to 5 days is sufficient to estimate the habitual physical activity at a reliability level of 0.80 [33]. Moreover, an uninterrupted period of 7 days enabled the researchers to measure the physical activity on weekdays (school days) as well as on weekend days (rest days), which is important to account for the considerable amount of day-to-day variability in physical activity, existing between weekdays and weekend days [33, 34] and between Saturdays and Sundays [35].

During their visit to the research center, participants were instructed on proper placement and use of the accelerometer. First of all participants had to wear the accelerometer fastened with an elastic tape on the midaxilary line of their right hip [33] during the entire day, from the moment they woke up in the morning, until they went to sleep in the evening, with removal only for showering, bathing or other water-related activities. All the respondents were blind for all data while they were wearing the accelerometer. After the monitoring period participants were asked to return the accelerometer to the research center, where the stored data were downloaded to a computer (Actigraph software) and reduced before analysis. Data reduction was carried out as follows: first, the amount of wear-time (minutes/day and %wear-time) and the periods of non-wear time (minutes/day and %non-wear time) were calculated for each day the accelerometer was worn. Non-wear time was defined as "any interval of at least 60 consecutive minutes with zero accelerometer counts, with an allowance for 1-2 minutes of detected counts between 0 and 100"[2, 32]. The next step consisted of counting all valid and invalid measurement days [36].

A valid day was defined as a day with at least 10 hours of accelerometer wear-time [32]. Since the researchers were interested in measuring behavioural patterns, only data of participants with at least 4 valid days of 10 hours wear-time, including one weekend day were included for analysis [2, 32]. Finally, the recorded accelerometer counts were used to define three physical activity categories: sedentary time (ST), light intensity physical activity (LIPA) and moderate-to-vigorous physical activity (MVPA). To define these 3 physical activity categories, the widely used Freedson cut-off points were used:

- ST was defined as any continuous, uninterrupted period with <100 counts/min
- LIPA was defined as any continuous, uninterrupted period with ≥100-1951 counts/min
- MVPA was defined as any continuous, uninterrupted period with ≥1952 counts/min

Next, the average number of minutes per day spent in each category was calculated for each individual. The accumulated activity data were analyzed as mean minutes per day. Due to limitations of the software, breaks in sedentary time could not be calculated, and were therefore not included in this master's thesis.

3.4.6. Energy intake

At the end of their visit, all participants were instructed on how to fill out the food diary correctly. Since research has shown that food patterns are significantly different between weekdays and weekend days [37], participants were asked to write down a thorough overview of the foods consumed on two weekdays (i.e. Tuesday and Thursday) and one weekend day (i.e. Saturday). The food diary had to be returned to the research team, together with the accelerometer. For each participant, diary data was converted into energy and nutrient equivalents using the NEVO (Nederlands Voedingsstoffenbestand) nutrient database before being analysed. Next, the energy intake (kcal) as well as the amount of carbohydrates (%CH), proteins (%P) and lipids (%L) were calculated for each day. Finally, using the data from the three recorded days, the average amount of kcal %lipids, %carbohydrates and %proteins per day was calculated for each participant. An example of the 3-day food diary can be found in Appendix 4.

3.5. Covariates

Regression models were adjusted for potential confounders, including accelerometer wear-time, sex, energy intake, BMI, WC and time spent in MVPA. Accelerometer wear-time as well as the amount of time spent in MVPA were calculated using the 7-day accelerometer data and were both expressed in mean min/day. Sex (male/female) was recorded using questionnaires and BMI (kg/m^2) was calculated as the body weight in kilogram divided by the height in meters squared [38]. Finally energy intake and waist circumference were measured as previously described in the method section and were expressed in kcal/day and cm, respectively.

3.6. Statistical analyses

Statistical analyses were performed using SPSS version 24. For all analyses, statistical significance was set at an alpha level of 0.05. Data was screened on normality (Shapiro-Wilk test) and outliers were double-checked (boxplot) for writing errors and measurement errors. Descriptive statistics were performed to describe the baseline characteristics of the current study population. Continuous variables were expressed as means ± standard errors (SE) and categorical variables were expressed as n (%).

Next, correlations between sedentary time (independent variable) and each biomarker (dependent variable) were calculated by using the Spearman's rank correlations test.

To investigate the independent associations of sedentary time with the selected outcomes, a series of multiple linear regression models, with the amount of sedentary time as the independent variable, were fitted for the following assessed health outcomes: waist circumference, % fat mass, % fat free mass, fasting glucose concentration, fasting insulin concentration, insulin sensitivity (HOMA-%S), triglyceride concentration, HDL-cholesterol concentration, LDL-cholesterol concentration, total cholesterol concentration, the systolic blood pressure and the diastolic blood pressure. The assumptions for multiple linear regression were checked using graphs and statistical tests. More specific, data was screened on independency, linearity (Scatterplot), normality (Normal probability plot, Shapiro-Wilk test), homoscedasticity (Scatterplot) of variance and multicollinearity. For the current study all the required assumptions were met. However, due to their skew distribution, the

following variables underwent a log-transformation before being analysed: fasting glucose concentration, triglyceride concentration, % fat mass, % fat free mass, WC, BMI, sedentary time, accelerometer wear-time and MVPA. To aid interpretation, these data were back-transformed from the log-scale for presentation in results.

To determine which variables could have a confounding influence on the association between sedentary time and a particular biomarker, automatic linear modelling was applied for each dependent variable in combination with all the possible confounders (age, sex, accelerometer wear-time, energy intake (kcal/day, %lipids, %proteins, %carbohydrates) time spent in MVPA, BMI and WC). Only covariates showing a significant association (sex, accelerometer wear-time, energy intake (kcal/day), time spent in MVPA, BMI and WC) were included in the multiple linear regression models as covariates. Finally for each dependent variable, six linear regression models, which were progressively adjusted with the significant confounding covariates, were constructed:

- Model 1: simple associations with sedentary time (mean min/day)
- Model 2: controlled for accelerometer wear-time (mean min/day)
- Model 3: further adjusted for sociodemographic covariates (sex)
- Model 4: further adjusted for behavioural covariates (energy intake, kcal/day)
- Model 5: further adjusted for time spent in MVPA (mean min/day)
- Model 6: further adjusted for BMI and WC (WC was not included as a covariate in the model with WC as the dependent variable)

4. Results

4.1. Physical characteristics of the study population

From the 50 participants included (20 men, 30 women) a total of 42, including 15 men and 27 women, provided valid measurements of sedentary time and physical activity. This is 82% of the initially included study population. The majority of the excluded participants (4 men, and 4 women) failed to meet the minimum required accelerometer wear-time of ≥4 days of ≥10 hours accelerometer-wear time, including one weekend day. Also, one participant (1 men), who did not return his accelerometer, had to be excluded from the current study. Finally, the data of one woman, who was diagnosed with hyper-cholesterolemia, could not be used for analysis since we focussed on a healthy population. Therefore, the study sample finally included 40 participants (15 men, 25 women) for the analyses (see appendix 2: Flowchart).

Mean age of the participants included for the analyses was 18.9 ± 0.5 years (♂ 19.1 ± 0.7 years, ♀ 18.8 ± 0.4 years), while the mean BMI was 21.5 ± 1.8 kg/m^2 (♂ 21.9 ± 2.0 kg/m^2, ♀ 21.3 ± 1.6 kg/m^2). All anthropometric variables differed between men and women (table 1). In general, women reported a lower energy intake and also a lower percentage intake of carbohydrates, proteins and lipids than men. More specific, significant gender differences were observed for height, WC, %FFM and energy intake, with women having in general lower values than men, and for %FFM, BM, total-C, HDL-C and LDL-C, with women having higher levels than men. When analysing the cardiometabolic biomarkers, women mainly showed a poorer cardiometabolic health than men.

Concerning the accelerometer measurements, men showed more accelerometer wear-time than women. Participants spent on average 586.8 ± 67.8 min/day sedentary, 206.3 ± 59.7 min/day were spent in LIPA and 30.8 ± 17.9 min/day in MVPA. Also, men reported more sedentary time than women (♂ 607.1 ± 67.7 min/day, ♀ 574.5 ± 66.1 min/day), however they spent more time in MVPA in comparison to women (♂ 33.0 ± 18.0 min/day, ♀ 29.5 ± 18.2 min/day).

The demographic, anthropometric and accelerometer characteristics of the included participants are presented Appendix 5, table 5.1, 5.2, 5.3 and 5.4.

4.2. Univariate correlations

Sedentary time showed a significant and positive correlation with fasting glucose concentration (r=0.155, p=0.036) and triglyceride concentration (r=0.194, p=0.012). A significant but negative correlation was found between sedentary time and insulin sensitivity (HOMA-%S) (r=-0.141, p=0.036). Fasting insulin concentration (r=0.218, p=0.072), waist circumference (r=0.034, p=0.833), % fat mass (r=0.128, p=0.430), LDL-cholesterol concentration (r=0.001, p=0.996), total cholesterol concentration (r=0.210, p=0.897), the systolic blood pressure (r=0.094, p=0.565) and the diastolic blood pressure (r=0.150, p=0.356), where positively correlated with sedentary time but could not reach statistical significance. Also no statistical significance was obtained in the negative correlations found between sedentary time and % fat free mass (r=0.128, p=0.430) and between sedentary time and HDL-cholesterol concentration (r=-0.013, p=0.936). An overview of these correlations can be found in Appendix 6.

4.3. Multiple linear regression models

Several linear regression models, each adjusting for specific covariates, were developed to determine the presence and magnitude of an association between sedentary time and several cardio-metabolic biomarkers. In general, significant positive associations were found between sedentary time and fasting glucose concentrations, insulin sensitivity (HOMA-%S) and triglyceride concentrations.

More specific, in the simplest model (**Model 1** – in which no covariates were included) higher levels of sedentary time were associated with detrimental levels of fasting glucose concentration (β=0.151, p=0.001), HOMA-%S (β=-0.141, p=0.036) and triglyceride concentration (β=0.281, p=0.002). With exception of % fat free mass – which showed a non-significant negative association – all the remaining cardiometabolic biomarkers were positively associated with sedentary time, however these associations could not reach statistical significance. It is also worth mentioning that the found relationships between sedentary time and each biomarker were very small, as was indicated by the adjusted R^2 values (range from 0.000 to 0.304). More specific, an R^2 value of 0.304, 0.116 and 0.231 shows that only 0.3%, 0.1% and 0.2% of the variability in fasting glucose concentration, insulin sensitivity and triglyceride concentration, respectively, was explained by the model.

In **Model 2**, in which the accelerometer-wear time was the only covariate, sedentary time was still significantly associated with fasting glucose concentration (β=0.109, p=0.003), HOMA-%S (β=-0.164, p=0.030) and triglyceride concentration (β=0.221, p=0.011), however the significance level attenuated from p=0.002 to p=0.011 in the adjusted association between sedentary time and triglyceride concentration.

When socio-demographic (sex, **Model 3**) and behavioural covariates (energy intake, **Model 4**) were included, all the associations remained significant, more specific: for fasting glucose concentration β=0.103, p=0.002 (model 3) and β=0.092, p=0.005 (model 4), for HOMA-%S β=-0.178, p=0.035 (model 3) and β=-0.157, p=0.039 (model 4), and for triglyceride concentration β=0.222 (model 3), p=0.012 and β=0.215, p=0.015 (model 4).

In **Model 5**, where the associations were additionally controlled for MVPA, sedentary time was still significantly associated with fasting glucose concentration (β=0.038) and triglyceride concentration (β=0.103) however, the significance level declined for fasting glucose concentration from 0.005 to 0.033 and for triglyceride concentration from 0.015 to an almost borderline significance level of 0.045. In contrast, the association between sedentary time and HOMA-%S did not survive the adjustments for MVPA (β=-0.171, p=0.110).

After final adjustments for BMI/WC (**Model 6**), the association (β=0.024) with fasting glucose concentration lost its statistical significance (p=0.052, borderline non-significant) while the association with triglyceride concentration (β=0.075) became slightly more significant (p=0.022).

Looking across the six successive models (Appendix 7), a pattern for the R^2 values to gradually increase is apparent for all the eleven examined biomarkers. When focussing on the significant associations, the R^2 values for fasting glucose concentration increase from 0.304 in Model 1 to 0.371 in Model 6, for insulin sensitivity (HOMA-%S), the R^2 values change from 0.116 in Model 1 to 0.188 in Model 6 and finally for triglyceride concentration there is an increase in R^2 value from 0.231 in Model 1 to 0.307 in Model 6. These gradual increases in R^2 values indicate that the more complex models better explain the variation in cardiometabolic biomarkers.

5. Discussion

5.1. Reflections on the findings in function of the current study

This cross-sectional study is the first study to examine the associations between accelerometer derived sedentary time and several cardiometabolic biomarkers among healthy first bachelor university students. It was expected that increments in sedentary time would be related to the development of fat accumulation as well as a worsening in blood lipid profile, body composition and glycaemic control.

Evidence was found for associations between more time spent sedentary and harmful influences on several cardiometabolic biomarkers. More specific, a significant positive association was found between sedentary time and triglyceride concentration, independent of all confounders, including accelerometer wear-time, sex, energy intake, MPVA, BMI and WC. However, the association became less significant after controlling for energy intake, MVPA, and BMI/WC. Also a positive significant association was found between higher levels of sedentary time and fasting glucose concentration, even after adjustments for accelerometer wear-time, sex, and energy intake. Nevertheless, the association weakened when MVPA was included in the models and finally lost its statistical significance after additional adjustments for BMI/WC. Lower levels of insulin sensitivity (HOMA-%S) were significantly associated with higher sedentary time, independent of accelerometer wear-time, sex and energy intake. When the association was further controlled for MVPA and subsequently for BMI/WC, the association attenuated to a non-significant level.

To my knowledge, this is the first study in literature examining the relationship between sedentary behaviour and individual cardiometabolic biomarkers among a very specific healthy student population, which precludes a comparison with other studies focussing on the same population. Today, the vast majority of the studies, examining the relationship between sedentary time and cardiometabolic health, have focussed on working-aged 'non-healthy' populations.

More specific, for **triglyceride concentration**, to date sixteen studies [39-54] have investigated the relationship between objectively measured sedentary time and triglyceride concentrations among working-aged adults. Twelve studies reported a significant positive

association, eight following adjustments for MVPA, but only three following additional adjustments for BMI/WC. In general, these results are in line with the findings of the current study. However, comparisons have to be made with caution since there are major methodological as well as population-based differences between these studies and the current study. For example there are major differences in the way sedentary time was measured [40, 42, 49, 54], defined [42, 45, 48, 49, 54] and analysed [44, 46, 48, 50, 54]. Moreover, almost none of the investigated populations could be considered as healthy. In particular, many studies included participants who were diagnosed with Type 2 diabetes [40, 41, 46, 48] and participants with a mean BMI ≥25 kg/m^2 (overweight) [47, 49, 50, 52] or ≥30 kg/m^2 (obese) [48]. Some studies did not even report on the BMI [40, 41, 46, 54] or metabolic heath of their participants [44, 52, 54]. However, reporting the participants' health seems to be very important since it is known that individuals diagnosed with Type 2 diabetes or the metabolic syndrome are different from healthy individuals because they have a poorer cardiometabolic health [7]. Based on the above-mentioned items, fifteen [40-54] out of sixteen studies were deemed unsuitable for comparison with the current study so that only one study remains [39]. In their study, Aadland et al. 2013, found an association of 0.24 to 0.25 ($p<0.047$) between increments in sedentary time and triglyceride concentration, among a population with a mean age of 40.5 ± 10.6 years [39], which confirms our data ($\beta=0.281$, $p=0.002$). The fact that the association found in our study was a little bit stronger (0.041) may be explained by the amount of time participants spent sedentary in both studies. While in the study of Aadland et al. 2013, participants spent on average 563.5 ± 85 min/day sedentary, the average amount of sedentary time in the current study was 586.8 ± 67.8 min/day. It is also worth mentioning that changes in triglyceride concentration do not only occur in adult populations, as confirmed by the study of Aadland et al. 2013, but also very young and more specific student populations (mean age: 18.9 ± 0.5 years) experience harmful changes in their triglyceride concentrations when they sit for prolonged periods.

For **fasting glucose concentration**, eleven cross-sectional studies [40, 41, 43, 45-48, 50-52, 54], have investigated the impact of objectively measured sedentary time on working-aged adult populations. Ten [40, 41, 43, 45-48, 50, 51, 54] out of these eleven cross-sectional analyses reported no association between sedentary time and fasting glucose

concentration. The authors of the only remaining study [52], found a very small significant, but clinical non relevant, positive association (β=0.01, p=0.001). It is worth mentioning that the results of the latter study were found in an overweight population (mean BMI >28kg/m^2) and that the authors did not report the mean age or metabolic health of their participants, making a clear comparison with the current study very difficult. It thus seems that our study is the first to find a significant positive association (β=0.151, p=0.001) between objectively measured sedentary time and fasting glucose concentration, even after adjustments for MVPA (β=0.038, p=0.033), in a healthy (and young) student population. Future studies, using a comparable methodology and population, are needed to confirm our results. The fact that our results are in great contrast with the results of other studies published in literature, can be due to unknown confounders or to a lack of adherence of the participants to the 'fasting-protocol'. Participants were asked to fast and to abstain from smoking and alcoholic and caffeinated beverages for 12 hours prior to their appointment at the Research- and Rehabilitation Center. It is possible that some participants have consciously or unconsciously not followed these instructions correctly, which may have biased their fasting glucose concentrations.

Finally for **insulin sensitivity**, five cross-sectional studies [40, 46, 50, 52, 55] have investigated the associations between objectively measured sedentary time and insulin sensitivity, among working-aged populations. All five studies found evidence for a significant negative association between sedentary time and insulin sensitivity, three following adjustments for MVPA and only one following additional adjustments for WC, which is in line with the findings of the current study. Unfortunately, when analysing the methodological and population based characteristics, none of these studies was suitable for a comparison with the current study. Further research, using a similar methodology and population, is needed to confirm our results.

Further, there were no significant associations found between sedentary time and many other investigated cardiometabolic biomarkers including HDL-cholesterol concentration, LDL-cholesterol concentration, total cholesterol concentration, the diastolic blood pressure, the systolic blood pressure, % fat mass, % fat free mass and the waist circumference. It thus follows that in healthy first bachelor university students, aged between 18 and 20, sedentary behaviour is not yet related to too many unfavourable changes in

cardiometabolic biomarkers. More research is needed to verify this hypothesis and to determine if more years spent (sedentary) at university, will negatively influence more cardiometabolic biomarkers and to which degree. This will enable researchers to identify periods in which students are at risk to spend large amounts of time sedentary and thus compromise their health. In this way, the application of intervention programs to reduce the amount of sedentary time among university students can be timed more precisely.

Finally, the results of the current study indicate the more complex models, adjusting for many covariates, better explain the variation in cardiometabolic biomarkers. When analysing the impact of each covariate on the investigated associations it can be concluded that the amount of time spent sedentary can be considered as an independent predictor for triglyceride concentrations, among a healthy student population, since the association between sedentary time and triglyceride concentration successfully survived all adjustments. However, it is worth mentioning that the amount of time spent in MVPA may have had an influence on this relationship, since it strongly reduced the strength of the association. For fasting glucose concentration, MVPA seemed to have a similar influence on the found association, while final adjustments for BMI/WC weakened the association to a non-significant level, suggesting that BMI/WC can be considered as an important mediator in the relationship between sedentary time and fasting glucose concentration. Likewise, MVPA can be considered as a mediator in the relationship between sedentary time and insulin sensitivity, since this association did not survived adjustments for MVPA. Taking into account the above-mentioned items, these results suggest that intervention programs should not only try to reduce the amount of sedentary time, but should also target the covariates, which can be acting as mediators in the relationship between sedentary time and the selected outcomes.

5.2. Physiological mechanisms

The potential physiological mechanisms underlying the detrimental association between increments in sedentary time and elevated **triglyceride** concentrations have already been studied extensively. Today, researchers believe that with prolonged periods of sitting, a decrease in local contractile stimulation may result in a suppression of lipoprotein lipase (LPL) activity [56-58]. LPL is a plasma enzyme, that is primarily synthesized by muscle cells

and adipocytes [59], and plays an important role in capturing fat out of blood by facilitating the uptake of free fatty acids into muscle cells, so it can be used as energy substrate during exercise, or into adipose tissue for storage [57, 60]. Increments in plasma triglyceride concentrations and a rapid decrease in plasma HDL cholesterol concentrations can be associated with lower levels of LPL activity [57, 58, 60], resulting in a higher risk on cardiovascular diseases [57]. Today many studies have investigated the relationship between sedentary behaviour and LPL activity, and concluded that short periods (acute), as well as prolonged periods (chronic) of sedentary behaviour can be responsible for a decline in LPL activity [61-63]. It is worth mentioning that it is not just a loss in muscle contraction that is responsible for the decline in LPL activity, but there seems to be a difference between fibre types. In particular, studies have found in that among rats, LPL activity is higher in red oxidative muscles, which are necessary for postural support, in comparison to white glycolytic muscles [59, 64]. This difference disappears when there is a reduction in the normally high level of postural support of the oxidative muscles during ambulatory activities, suggesting that the decrease in LPL activity is mainly caused by a lack of activity of the oxidative muscles, in sedentary people. [62]. Moreover, low LPL activity and also TG-derived fatty acid uptake seem to be related to muscle energy demand. It thus follows that, since the energy demand of the muscles is strongly reduced in sedentary individuals [65], inactive muscles may reduce their lipid uptake to avoid unnecessary lipid accumulation and to prevent a possible lipotoxicity [62]. Finally, there is a qualitative difference between the effect of sedentary behaviour and the effect of physical activity on the LPL-activity [66]. First of all, while the negative effects of sedentary behaviour predominantly influence the LPL activity of oxidative muscles, increases in LPL activity following physical activity are largely restricted to the most glycolytic skeletal muscles, and are rarely seen in oxidative ones [62, 66]. Secondly, the influence of sedentary behaviour on the LPL suppression in oxidative muscles is 4-fold higher than the beneficial impact of vigorous exercise on the LPL activity in glycolytic muscles. In particular, sedentary behaviour causes a ≥10-fold lower LPL activity in red oxidative fibres, while the LPL activity of glycolytic muscle fibres is 2.5-fold greater following vigorous exercise [62, 66]. Finally, while the higher LPL activity following exercise is due to a 2.5-fold consistent increase in LPL mRNA [59], neither acute, nor chronic sedentary time seems to influence LPL mRNA gen expression [62, 66], but it is thought that

the transcription of an inhibitory gene suppresses the LPL activity by a posttranslational mechanism [66].

Taking all the above-mentioned items together, it can be assumed that the mechanisms between sedentary behaviour and LPL activity are distinct from those between physical activity and LPL activity. It thus follows that intervention programs targeting people with elevated plasma triglyceride concentrations, should mainly focus on reducing the amount of time spent sedentary, instead of augmenting the time spent in MVPA-activities. This is confirmed by the results of the current study, since the associations between sedentary time and plasma triglyceride concentrations were independent of time spent in MVPA.

Further, sedentary behaviour not only affects the LPL activity, but also has a negative influence on the carbohydrate metabolism, as is suggested by the increased **fasting glucose** concentrations and reduced **insulin sensitivity**, found in the current study. Today, it is well know that several types of glucose uptake transporters (GLUT) are responsible for the uptake of glucose into different types of cells [67]. More specific for muscle cells, GLUT 1 regulates the basal glucose uptake in rest, whereas GLUT-4 is responsible for the insulin- and the exercise-dependent glucose uptake [57]. The GLUT-1 transporters and insulin-dependent GLUT-4 transporters are permanently positioned at the muscle cell membrane while the GLUT-4 transporters, who are activated during exercise, have to make a translocation to the muscle cell surface before they can transport glucose into the muscle cell. This translocation only occurs while muscles are contracting [67]. It thus follows that the significant reduction in the amount of muscle contractions performed by a sedentary individual may be responsible for a reduced glucose uptake by the muscle cells through an impaired translocation of the GLUT-4 glucose transporters to the skeletal muscle cell surface [58]. Consequently, since skeletal muscles are one of the most important sites for clearance of carbohydrates from blood plasma [47], it is very likely reductions in muscle contractions may lead to elevated blood glucose concentration levels and in a later stage to insulin resistance and finally to type 2 diabetes. On the contrary, it is well known that physical activity enhances insulin sensitivity in a dose-response manner [55, 68]. More specific dramatic increases in muscle GLUT-1 and GLUT-4 proteins content are seen in response to even very low intensity exercise in individuals who are likely to exhibit very high levels of sedentary behaviour [69, 70]. For example, among people with an incomplete spinal cord

injury, 6 months of body weight exercise treadmill training at a speed of 0.6 km/h resulted in a 126% increase in muscle GLUT-4 content [69]. It thus seems that, since even minor increases in contractile activity result in major increases in muscle GLUT-1 and GLUT-4 content, replacing sedentary time by light intensity physical activities (LIPA) can be sufficient to maintain the homeostasis within the glucose metabolism among students.

A second potential physiological mechanism underlying the unfavourable association between sedentary time and the carbohydrate metabolism may be a reduction in contraction stimulated capillary recruitment [7]. Skeletal muscle blood flow is known to increase when muscles are contracting, for example, during intense dynamic exercises, blood flow can be 20-fold higher than in rest [67]. In addition to this exercise-induced increase in blood flow, exercise also induces the recruitment of capillaries surrounding the muscle, resulting in an increased surface area for glucose delivery and glucose uptake to the contracting muscle. Since both the increased blood flow as the recruitment of the capillaries are important contributors to the increased amount of muscle glucose uptake during exercise [67], it can be assumed that prolonged sitting disturbs these mechanisms and thus contributes to the impaired glucose homeostasis.

Finally, metabolic dysfunction, characterised by increased triglyceride concentrations, lower levels of HDL-cholesterol concentration, and impaired insulin sensitivity [57], is one of the most important consequences of sedentary behaviour. The results of the current study indicate that even very young people (18.9 ± 0.5 years) and more specific students, are likely to have an increased metabolic risk, when they are sitting during prolonged periods per day. It is thus important, even for young people, to bear in mind that prevention is key and sedentary behaviour should be avoided at any age.

5.3. Strengths and limitations of the current study

5.3.1. Strengths

This study has several strengths expanding the current literature concerning the relationship between sedentary time and cardiometabolic health.

First of all, this cross-sectional study expands the current literature, since it is – to my knowledge – the first study in literature investigating the impact of objectively measured

sedentary time on cardiometabolic biomarkers among a ***healthy student population***. Data of the current study indicate that even young students can compromise their metabolic health when they sit for prolonged periods. Further research is needed in other similar cross-sectional datasets, with similar methodology, to replicate these findings.

Secondly, while many studies in literature have investigated the relationship between sedentary time and global measures of cardiometabolic health (for example risk on type 2 diabetes), the current study focussed on ***individual cardiometabolic biomarkers***, such as for example fasting glucose concentration. Where global measures may be more relevant to patients and clinicians, individual cardiometabolic biomarkers help researchers to better understand the poorly understood underlying physiology of sedentary behaviour [7].

Also, sedentary time as well as the other intensities of the physical activity spectrum (LIPA, MVPA) was measured using ***a validated and objective measurement method*** (i.e. accelerometry), which is a major advantage in comparison to studies relying on self-reported measures. As extensively described in my masters' thesis part one [1] accelerometers are currently the most valid and reliable tools for measuring sedentary time [31, 33, 71], and have several advantages in comparison to subjective measures. However subjective measures provide information concerning the type of sedentary behaviour and the social and environmental contexts in which they occur [31], they are prone to recall [31, 72] and social desirability bias [73], making them less suitable for association studies. In contrast, accelerometry significantly reduces the risk on these errors and is able to record incidental, intermittent or any other form of spontaneous physical activity [31], which is out of the scope of self-reported measures. For a thorough overview of the advantages and disadvantages of both accelerometers and self-reported questionnaires, I'd like to refer to my masters' thesis part one, and more specific to section 5.3.2. [1].

Finally, this study ***statistically controlled for numerous covariates***, including accelerometer wear-time, sex, energy intake, BMI, WC and time spent in MVPA. If these covariates would not have been included, they could have influenced the obtained associations. Previously published studies, usually control for age, sex, BMI, WC and time spent in MVPA [39, 41, 54, 55], but they forget to include accelerometer wear-time and energy intake as covariates. Controlling for energy intake seems to be important since a study of Ketano et al. 2011,

investigating the relationship between lifestyle habits and the prevalence of cardiometabolic risk factors, has shown that a greater amount of total energy intake is independently and significantly related to the number of cardiometabolic risk factors (i.e. higher blood pressure, dyslipidemia, impaired glucose tolerance and obesity) [74]. Concerning accelerometer wear-time, research has shown that minutes of sedentary time are presumably influenced by the amount of valid wear-time. Therefore it is recommended to adjust the analyses for accelerometer wear-time or to express the physical activity variables as proportions of the total wear-time (%SED, %LIPA, %MVPA) [75]. Adjustments for sex seemed to be recommended since the majority of the anthropometric variables differed between men and women. Controlling for sex differences was preferred above a split up of the analyses in men and women, due to the very small sample size. Analyses were also controlled for time spent in MVPA, since MVPA may act as an important mediator when examining the associations between sedentary time and several cardiometabolic biomarkers [44].

5.3.2. Limitations

Although accelerometers have numerous advantages in comparison to other methods they also have some limitations in their accuracy for measuring sedentary time and other intensities of the physical activity spectrum, which may have influenced the results of the current study.

First of all, accelerometers rely on the categorisation of acceleration and therefore cannot make a clear distinction between sitting, lying or standing behaviours [7]. In this context, accelerometers tend to consider motionless-standing activities as sedentary behaviours, which consequently may lead to ***an overestimation of the actual amount of sedentary time*** [76]. Further, some non-step based modes of physical activity, such as for example cycling, swimming and activities, which only require a movement of the upper extremity, are poorly captured by accelerometers [48, 76]. As a consequence, variations in these behaviours (sitting, lying, standing) and activities (cycling, swimming) throughout the current study population may have influenced the study findings through an ***underestimation of the actual performed physical activity*** [77]. An underestimation may also have occurred due to the fact that participants had to remove the accelerometer during water-based activities, resulting in an amount of light physical activity, which is incorrectly classified as non-wear

time instead of LIPA [78]. Such a biases could have been minimized by using a combination of objective measures (accelerometry) and subjective measures (activity diaries), providing complementary data on the total amount free-living physical activity and sedentary time. On the one hand, accelerometers can objectively measure and quantify a wide range of physical activity intensities, including sedentary behaviour, light intensity physical activity and moderate-to-vigorous physical activity (Hills et al. 2014, Migueles et al. 2017). On the other hand, by using activity diaries, every minute registered by the accelerometer can be matched with the diary reported type and context of activity. In this way, researchers are able to adjust the recorded amount of sedentary time and MVPA for self-reported amount of swimming and cycling time. For this master's thesis, the research team decided, before the start of the measurements, to use the combination of an accelerometer and the Sparrows-app, which is an activity diary app, developed by the Institute for Mobility (IMOB) from the University of Hasselt, to measure sedentary time and physical activity. Unfortunately, due to technical problems, the development of the app was not completed by the start of the measurements. As a consequence, in the current study, measurements of sedentary time and physical activity were only performed by accelerometers, which can be seen as a limitation.

Secondly, for this study, participants were included for analysis if they had ≥4 days of ≥10 hours of accelerometer wear-time including one weekend day, which is in line with the current recommendations for adults [33]. However, a recent review of Aadland et al. 2015 has reported that using ≥7 days (5 weekdays and 2 weekend days) of ≥10 hours of accelerometer wear-time a day is necessary to obtain reliable results (ICC = 0.80). In this study, ***a measurement period of 7 consecutive days*** was used to measure sedentary time and physical activity. It is thus very unlikely that this period of 7 days actually results in 7 valid (i.e. ≥10 hours wear-time/day) measurement days. As such, a longer accelerometer-monitoring period, with respect to the 7 measurement days that are at this very moment considered as a standard and were also used in the current study, would have been better [39]. Unfortunately, due the limited number of available accelerometers and the high number of participants that had to be measured in a very short time interval, a monitoring period of more than 7 days was practically not achievable for this study.

It is also worth mentioning that the accelerometer data collection period of 7 days took place after the cardiometabolic biomarkers were measured. Taking into account the acute effects of physical activity on certain biomarkers, such as for example blood glucose concentration, the ***results*** of the current study ***are reliant on the extent to which participants engaged in a typical week of physical activity*** [79].

Moreover***, measuring sedentary time during only one week may not reflect the habitual activity level*** of the individual since daily [34, 35], and seasonable [80] related variability in physical activity may also have an influence on the reliability of the individual physical activity estimates and can therefore be a source of error. For the current study, the fact that some participants were measured during the school weeks and others during Easter holiday may have caused that for some participants not the habitual activity level was recorded. More longitudinal studies with different measurement moments seem to be necessary to examine the contribution of the different categories of physical activity to the long-term regulation of the measured outcomes (for this study, i.e. the cardiometabolic biomarkers).

Further, the widely used ***Freedson cut-off points of <100 counts per minute*** were used ***to define sedentary time***. This threshold is commonly proposed as a cut-off point for adults when using the ActiGraph accelerometer, however they are not empirically derived [31]. The choice of cut-off points seems to be very important, since Pedisic et al. (2015) has revealed that possible findings seem to be highly dependent on the chosen cut-off points. The implementation of different cut-off points may lead to differences in prevalence estimates and intensity-specific activity levels. The selection may also have an impact on the associations between the estimated physical activity/sedentary time and different health outcomes [71]. More specific for this study, Kozey-Keadly et al. (2001) reports that the choice of cut-off points influences the reliability of the ActiGraph GT3X accelerometer. When measuring sedentary time, the cut-off point of 150 cpm seems to have the lowest bias, with a reported overestimation of 1.8%. In comparison, the frequently used cut-off point of 100 cpm significantly underestimates sedentary time by 4.6% [81]. Since the current study used <100 counts per minute to define sedentary time, the ***actual amount of sedentary time is probably higher than reported***.

Also, despite the adjustments made for the previously mentioned covariates, ***residual confounding*** may have occurred ***through unknown or non-measured confounders***, such as alcohol consumption and smoking status of the participants. Concerning the alcohol consumption, research has shown there is a significant increase in alcohol consumption during the transition period from high school to university (Deforche et al. 2015). This increase in alcohol consumption leads to a significant increase in body weight, not only because of the large amount of calories the drinks add, but also because the unhealthy and excess eating that co-occurs (Deforche et al. 2015). Since a study of Lloyd Richardson et al. 2009 indicates that nearly 50% of university students reports overeating and making unhealthy food choices following drinking [82], measuring and including alcohol consumption as a covariate could have led to more precise results in the current study. Also the smoking status of the students should have been questioned and included as a covariate since smoking has a negative impact on several biomarkers; for example, HDL-cholesterol concentrations decrease rapidly after smoking just a few cigarettes. Nevertheless, there is a relatively quick re-increase of the HDL-cholesterol concentrations after stopping smoking, but there is again a decrease upon resumption of smoking. In contrast, smoking has no impact on LDL-cholesterol or triglyceride concentrations (Lüdicke et al. 2015). It thus follows that smoking disturbs the lipid metabolism and affects the HDL/LDL homeostasis and may therefore have caused a bias in the measured HDL-concentrations of the participants who were active smokers at the moment of the measurements.

Further, this master's thesis may be prone to some biases. First of all, all participants volunteered to engage in the current study, which may have caused an ***enrolment bias*** since active people are probably more interested in this type of study than more passive people, which may be reflected by the large proportion of participants studying Rehabilitation Science and Physiotherapy (58%) in comparison to the proportion of participants majoring in other disciplines. Moreover, it has been suggested that individuals volunteering in clinical studies report a better physical activity level in comparison to the general population [83]. Secondly, because participants were aware they were being monitored, an ***observer bias*** may be caused by behaviour adjustment of the subject being measured (Hawthorne effect).

There may also be a ***lack of generisability of the study results***, due to the recruitment of a relatively small (n=50) convenience sample of volunteers (students) of the University of

Hasselt. This small sample size may have resulted in unstable study results and therefore should be interpreted with caution. Also, due to the well-defined inclusion criteria, the current study population was very homogenous, for example all participants were in good health and none of them were diagnosed with overweight (BMI ranged from 18.5 kg/m^2 to 25.0 kg/m^2) or had poor cardiometabolic outcomes. Therefore, the results of the current study should be interpreted as preliminary, and must be confirmed by larger and more diverse study populations of young students.

Another limitation of the current study is that the ***cross-sectional measurements*** were performed ***at the beginning of the second semester*** of the first bachelor year (more specifically, between February and April), resulting in a lack of information concerning the health status of the students at the beginning of the first semester. Since the results of the current study will be used as baseline measurements for other follow-up studies, as is described in the research context of this masters' thesis, it would have been better if the baseline measurements were performed at the beginning of the first semester, in order to provide future follow-up studies with a better starting point to measure the gradual evolution in sedentary time and the cardiometabolic biomarkers among university students, during their entire 5 year University career. Moreover, research has shown that the greatest changes in behavioural patterns, including sedentary behaviour, take place during the first semester at university [15]. It can thus be concluded that the results of the current study cannot be considered as true baseline measurements, since for many students the amount of time spent sedentary will probably have undergone significant changes in the period between the start of the first semester and the moment they were measured in the current study. Taking into account the above-mentioned items, the results should be used and interpreted with caution in follow-up studies.

Finally, this study was ***cross-sectional in nature, which precludes causal inferences***. It can thus not be concluded that more sedentary people will consequently have higher fasting glucose and triglyceride concentrations and a lower insulin sensitivity than less sedentary people and vice versa.

5.4. Recommendations for further research

In order to improve further research on the relationship between sedentary time and cardiometabolic biomarkers, several recommendations can be made.

First of all, since the current study was the first study to investigate the relationship between objectively measured sedentary time and cardiometabolic biomarkers, among a healthy student population, future studies, focussing on a similar population, are needed to confirm our results. In particular, it is recommended that these studies should focus on larger and more diverse student populations, in order to get more stable and generalizable results, respectively.

Also, sedentary behaviour and physical activity should preferably be measured using a combination of complementary objective (accelerometers) and subjective (activity diaries) measurement tools in order to obtain more detailed information concerning the amount and type of sedentary behaviour and physical activity. Matching the results of objective and subjective measurement tools in time will future researchers enable to determine which specific sedentary behaviours (for example, 'doing homework', 'transportation') are mainly responsible for the large amounts of time spent sedentary among students and thus need to be targeted in intervention programs.

Further, it should be avoided that some participants are measured during school periods while others are measured during holidays, since activity patterns during holidays may not resemble the true habitual activity pattern of the students. Also alcohol consumption and smoking status should be questioned and included as covariates in order to rule out their potential confounding influence.

Finally, in general, methods for measuring, defining and analysing sedentary behaviour should be standardised in order to enable more precise comparisons between studies investigating the relationship between sedentary behaviour and cardiometabolic health.

6. Conclusion

The data of the current study show that more time spent sedentary has a negative impact on the insulin sensitivity as well as on the fasting glucose and fasting triglyceride concentrations among healthy university students. It thus can be concluded that the negative impact of sedentary behaviour not only strikes 'older people', but even young, apparently healthy, populations are at risk to compromise their metabolic health. Finally, the data of the current study reinforce the notion that efforts should be directed at reducing the amount of time spent sedentary among young people (more specific students).

7. References

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8. Appendices

8.1. Appendix 1: Study approval – Medical Ethics Committee

CORRESPONDENTIEADRES
Campus Virga Jesse
Stadsomvaart 11
3500 Hasselt

JESSA ZIEKENHUIS

Ethische Toetsingscommissie

ADVIESFORMULIER

- ■ studieprotocol
- □ amendement protocol
- □ medical need program

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ONS KENMERK
16.107/reva16.11

Hasselt, 21 november 2016

Titel protocol: Gezond Bewegingsgedrag bij Sedentaire Beroepen – **SHEBA**
Protocolnummer:
Belgisch registratien°: B243201630226
Onderzoeker: Annick Timmermans
Dominique Hansen

VOORLOPIG ADVIES ETHISCHE TOETSINGSCOMMISSIE JESSA

Geachte collega,

De Ethische Toetsingscommissie van het Jessa Ziekenhuis heeft het hierboven vermeld protocol bestudeerd. Volgende documenten met betrekking tot het protocol kwamen aan bod:

- ■ indieningsbrief, dd. 26/10/2016
- ■ aanvraagformulier
- ■ patiënteninformatie en –toestemmingsformulier, versie oktober 2016
- ■ protocol en protocol synopsis, versie oktober 2016
- ■ patiëntenvragenlijsten
- ■ verzekeringsattest

Het advies van de Ethische Toetsingscommissie luidt dat de studie ethisch verantwoord is, mits rekening gehouden wordt met volgende opmerkingen:

- Gelieve het adres van de opdrachtgever te vermelden in het informatieformulier, UHasselt, Martelarenlaan 42, 3500 Hasselt.
- In het protocol dient men te specificeren hoe de aanpak van verschillende groepen zal gebeuren. Advies over bijv. gezonde voeding, ... wordt best per beroepsgroep aangepast.

Hieronder vindt u bijkomende motivering van het advies in het kader van de wet inzake experimenten op de menselijke persoon (template FAGG).

		JA	NEE	NVT
1	**Maatschappelijke waarde**			
1.1	De beoogde doelgroep is goed afgelijnd.	■	□	□
2	**Wetenschappelijke validiteit**			
2.1	De onderzoeker en zijn/haar medewerkers zijn professioneel competent.	■	□	□

2.2	De faciliteiten en infrastructuur waarbinnen het onderzoek plaatsvindt, zijn adequaat.	☒	☐	☐
2.3	Het onderzoek is wetenschappelijk onderbouwd.	☒	☐	☐
2.4	Het onderzoek heeft een correct statistisch design.	☒	☐	☐
2.5	Het onderzoek draagt bij tot de kennis eigen aan de uitoefening van de gezondheidszorgberoepen.	☒	☐	☐
2.6	Het onderzoek draagt potentieel bij tot een betere gezondheidszorg voor de beoogde doelgroep (onmiddellijk of in de toekomst).	☒	☐	☐
2.7	Tijdens het onderzoek krijgen de deelnemers de standaard medische zorg.	☒	☐	☐
2.8	Indien er een placebogroep is dan is dit methodologisch absoluut noodzakelijk en ethisch aanvaardbaar.	☐	☐	☒
2.9	Indien het een gerandomiseerde studie betreft, is er geen verschil tussen de behandelwijzen in de verschillende armen[1].	☐	☐	☒
3	**Correcte deelnemerselectie**			
3.1	De onderzoekspopulatie is op een wetenschappelijk verantwoorde wijze gekozen binnen het kader van het onderzoek.	☒	☐	☐
3.2	De onderzoekspopulatie is zo gekozen dat het risico voor de deelnemers minimaal is.	☒	☐	☐
3.3	Duidelijke maatregelen worden genomen om de bijzonder kwetsbare groepen te beschermen.	☐	☐	☒
3.4	De potentiële fysische, psychologische, sociale en economische risico's van het onderzoek voor de individuele deelnemers zijn in de mate van het mogelijke gekwantificeerd en de probabiliteit van het voorkomen ervan, gegeven de beschikbare data, in overweging genomen.	☐	☐	☒
4	**Informatie- en toestemmingsformulier**			
4.1	De informatie is volledig en in een begrijpelijke taal weergegeven	☒	☐	☐
4.2	Een korte en in een duidelijke taal opgestelde samenvatting van maximaal vier A4 pagina's is bij het geïnformeerde toestemmingsformulier gevoegd.	☒	☐	☐
4.3	De onderzoeker verbindt er zich toe informatie zowel mondeling als schriftelijk mee te delen.	☒	☐	☐
4.4	Het geïnformeerde toestemmingsformulier vermeldt de eventuele gezondheidseffecten op de partner en de omgeving van de deelnemer aan het onderzoek, met de voorzorgsmaatregelen die daaromtrent moeten worden genomen.	☐	☐	☒
4.5	Het geïnformeerde toestemmingsformulier vermeldt dat een potentiële deelnemer kan weigeren om aan het onderzoek deel te nemen, of op elk moment uit het onderzoek kan stappen zonder enig gevolg voor de relatie met de gezondheidszorgbeoefenaar	☒	☐	☐

[1] Hiermee wordt bedoeld dat er, wat de baten-risico verhouding betreft, geen verschil mag zijn tussen de verschillende armen.

4.6	Indien de potentiële voordelen voor een patiënt kleiner zijn dan de nadelen, dan is er een ethisch gerechtvaardigde reden, en wordt dit gecommuniceerd aan de patiënt.	☐	☐	☒
4.7	Indien er geen potentieel voordeel is voor een vrijwilliger, zijn de risico's beperkt en ethisch aanvaardbaar, en wordt dit gecommuniceerd aan de vrijwilliger.	☐	☐	☒
5	**Specifieke studiepopulaties**			
5.1	Bij inclusie van minderjarigen: * de toestemming van de ouders of van de voogd wordt verkregen * een aangepast ICF wordt opgesteld * de uitdrukkelijke wil van de deelnemer zal worden onderzocht en nageleefd * er is een rechtstreeks verband met de klinische toestand van de minderjarige of het experiment kan enkel op minderjarigen worden uitgevoerd * het experiment houdt enig direct voordeel in voor de groep van patiënten.	☐	☐	☒
5.2	Bij inclusie van meerderjarigen die onbekwaam zijn hun toestemming te verlenen: * de toestemming van de wettelijke vertegenwoordiger wordt verkregen * de uitdrukkellijke wil van de deelnemer zal worden onderzocht en nageleefd * er is een rechtstreeks verband met een levensbedreigende of gezondheidsondermijnende klinische toestand waarin de deelnemer verkeert * de risico's voor de deelnemer zijn niet buiten verhouding ten aanzien van het voor die persoon verhoopte voordeel	☐	☐	☒
5.3	In het geval van hoogdringendheid waarbij de toestemming van de deelnemer niet kan verkregen worden: * er is een rechtstreeks verband met een levensbedreigende of gezondheidsondermijnende klinische toestand waarin de deelnemer verkeert * de toestemming van de deelnemer of zijn vertegenwoordiger zal bekomen worden van zodra het mogelijk is	☐	☐	☒
6	**Respect voor deelnemers**			
6.1	Na beëindiging van het onderzoek en in het geval de studiemedicatie therapeutisch voordelig is voor de deelnemer en de studiemedicatie geen goedgekeurd equivalent heeft op de markt, bezorgt de sponsor de studiemedicatie aan de deelnemer zolang deze medicatie nog niet op de markt is of tot de ontwikkeling wordt gestopt	☐	☐	☒
6.2	In het geval van codering van de gegevens van de deelnemers is gekend wie verantwoordelijk is voor de codering en het beheer ervan	☒	☐	☐
6.3	De manier waarop deelnemers worden gerekruteerd en geselecteerd, is aanvaardbaar.	☒	☐	☐
7	**Verzekering**			
7.1	Er is een "no-fault" verzekering afgesloten	☒	☐	☐
7.2	De regels en bedragen voor compensatie en/of schadevergoeding wanneer een deelnemer ten gevolge van een experiment letsel oploopt of overlijdt, zijn aanvaardbaar	☒	☐	☐
8	**Financiële regelingen**			

8.1	Vergoedingen aan de deelnemer – indien van toepassing – zijn proportioneel	☐	☐	☑
8.2	Bij commerciële studies is de onderzoeker onafhankelijk van de opdrachtgever.	☐	☐	☒
8.3	Betalingen en vergoedingen aan de onderzoeker zijn proportioneel	☐	☐	☑
8.4	De overeenkomst(en) tussen de opdrachtgever en de locatie(s) zijn aanvaardbaar	☐	☐	☑

Graag ontvangen wij de gewijzigde documenten (MET track changes), waarna er een definitieve goedkeuring van de Ethische Toetsingscommissie zal gegeven worden.

In haar advies heeft de Ethische Toetsingscommissie rekening gehouden met de adviezen van UHasselt.

De Ethische Toetsingscommissie is georganiseerd en handelt volgens de richtlijnen van GCP/ICH.

Na het uitbrengen van het advies over het initieel dossier door de Ethische Toetsingscommissie, kan er gedurende 3 maanden geen amendement voor het toevoegen van een nieuwe onderzoekslocatie worden ingediend.

De Ethische Toetsingscommissie vraagt aan de onderzoeker op de hoogte te worden gehouden van:

- *het verloop van de studie.*
- *eventuele wijzigingen in het studieprotocol, het informed consent, ... Amendementen moeten worden goedgekeurd door de commissie.*
- *het einde van de studie (einddatum, aantal behandelde patiënten, eventuele complicaties en mijn globale indruk).*
- *eventuele publicaties.*

In bijlage vindt u de ledenlijst van de Ethische Toetsingscommissie.

Met vriendelijke groeten,

Ter goedkeuring,

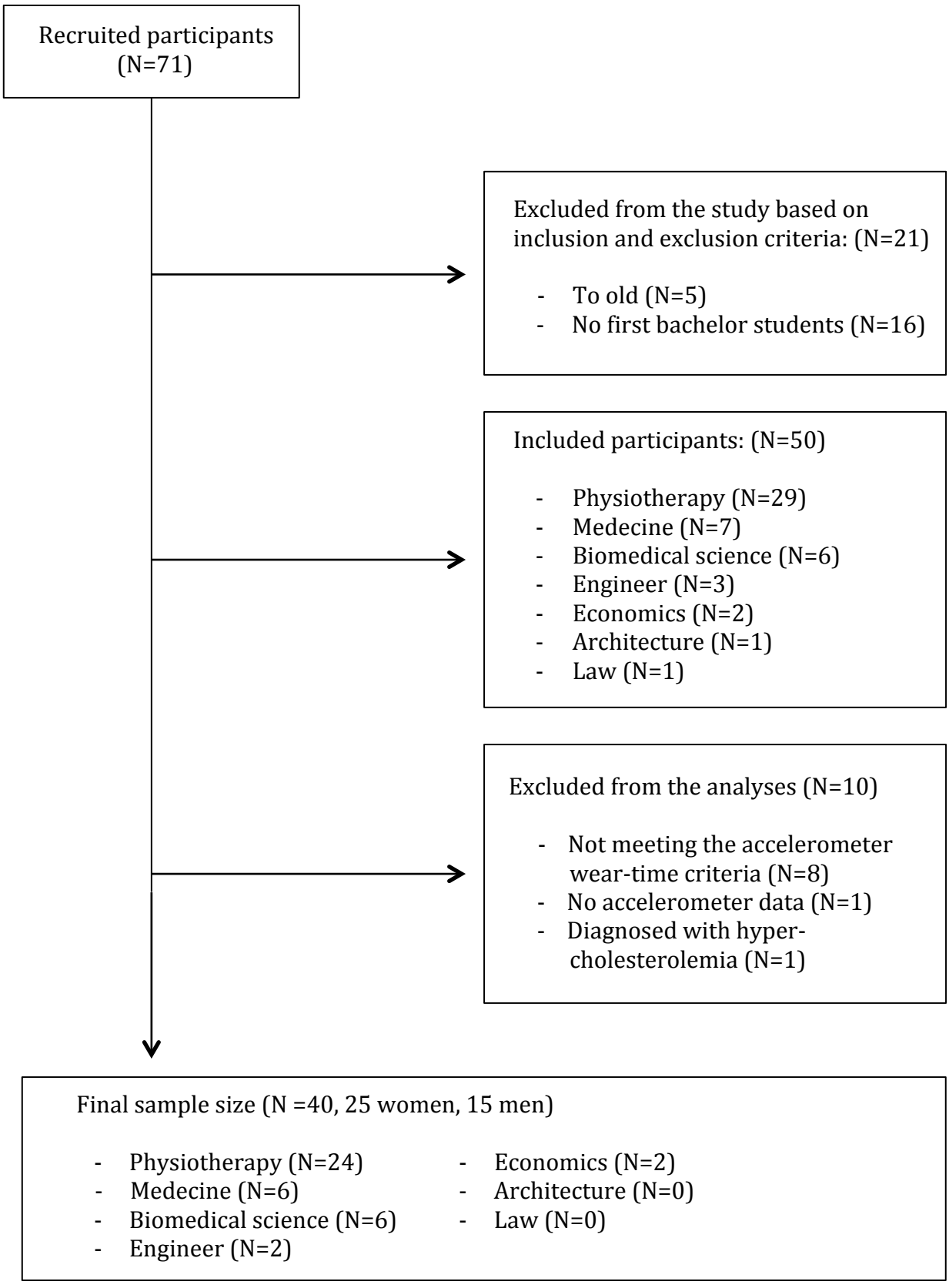
Dr. Koen Magerman
Voorzitter Ethische Toetsingscommissie
Jessa Ziekenhuis

21 november 2016

Leden Ethische Toetsingscommissie 2016
Dr. Koen Magerman, voorzitter – klinisch bioloog
Dr. Brigitte Maes, secretaris – klinisch biologe
Dr. Johan Vanwalleghem, ondervoorzitter – nefroloog
Dr. Ruth Achten – anatoom-patholoog en master in biostatistiek
Mevr. Mieke Bieghs – apotheek
Mevr. Inge Dreesen - apotheek
Mevr. Nathalie Cardinaels – psychologe
Mevr. Aleksandra Czesak – verpleegkundige
Mevr. Petra De Smet – ethicus, master in de filosofie en geloofswetenschappen
Mevr. Katrien Jaemers – management assistant
Dr. Herman Kuppers – huisarts
Mevr. Hilde Maes – hoofdverpleegkundige
Mevr. Fabienne Mertens – hoofdverpleegkundige
Dr. Bjorn Stessel – anesthesist
Dhr. Pros Vanhelmont – jurist
Dr. Pascal Vranckx – cardioloog

De vzw Jessa Ziekenhuis is een fusie tussen het Virga Jessezíekenhuis en het Salvator-St.-Ursulaziekenhuis
Maatschappelijke zetel: Salvatorstraat 20, 3500 Hasselt

8.2. Appendix 2: Flowchart



8.3. Appendix 3: Example of the informed consent

Patiëntinformatie en toestemmingsformulier

Titel van de studie: **Gezond bewegingsgedrag bij sedentaire beroepen**

Opdrachtgever van de studie: *Universiteit Hasselt, Martelarenlaan 42, 3500 Hasselt*

Onderzoeksinstelling: Universiteit Hasselt – Jessa Ziekenhuis

Ethisch comité: *UHasselt en Jessa Ziekenhuis*

Plaatselijke onderzoekers:

- Prof. Dr. Frank Vandenabeele (UHasselt): frank.vandenabeele@uhasselt.be
- Prof. Dr. Annick Timmermans (UHasselt): annick.timmermans@uhasselt.be
- Prof. Dr. Dominique Hansen (UHasselt, Jessa ZH): dominique.hansen@uhasselt.be
- Nele Willems, MP2-student: nele.willems@student.uhasselt.be
- Ann-Sofie Andries, MP2-student: ann-sofie.andries@student.uhasselt.be
- Pauwels Stijn, MP2-student: stijn.pauwels@student.uhasselt.be
- Wilmaerts Jochen, MP2-student: jochen.wilmaerts@student.uhasselt.be

Dit document bestaat uit **2 delen**:

1. Essentiële informatie die u nodig heeft voor het nemen van uw beslissing (het **informatiedocument**)
2. Uw schriftelijke toestemming (de **toestemmingsverklaring**)

Dit document zal worden opgemaakt in tweevoud, waarvan u een exemplaar van ontvangt.

Geachte heer/mevrouw,

U wordt uitgenodigd om deel te nemen aan een observationele klinische studie waarbij de risicofactoren voor uw gezondheid en uw bewegingsgedrag tijdens uw beroepsactiviteit in kaart worden gebracht.

Voordat u akkoord gaat om aan deze studie deel te nemen, vragen wij u om kennis te nemen van wat deze studie zal inhouden op het gebied van organisatie, zodat u een welbewuste beslissing kunt nemen. Dit wordt een "geïnformeerde toestemming" genoemd.

Wij vragen u de volgende pagina's met informatie aandachtig te lezen. Hebt u vragen, dan kan u terecht bij de arts-onderzoeker of zijn of haar vertegenwoordiger.

Als u aan deze studie deelneemt, moet u weten dat:

- Deze klinische studie opgesteld is na evaluatie door één of meerdere ethische comités.
- Uw deelname is vrijwillig; er kan op geen enkele manier sprake zijn van dwang. Voor deelname is uw ondertekende toestemming nodig. Ook nadat u hebt getekend, kan u de arts-onderzoeker laten weten dat u uw deelname wilt stopzetten.
- De gegevens die in het kader van uw deelname worden verzameld, zijn vertrouwelijk. Bij de publicatie van de resultaten is uw anonimiteit verzekerd.
- Er is een verzekering afgesloten voor het geval dat u schade zou oplopen in het kader van uw deelname aan deze klinische studie.
- Indien u extra informatie wenst, kan u altijd contact opnemen met de arts-onderzoeker of een medewerker van zijn of haar team.

Deel I - Informatiedocument

Wanneer de werknemer het grootste gedeelte van de dag zittend doorbrengt, spreekt men van een sedentair beroep. Het in stand houden van de cardiorespiratoire en musculoskeletale gezondheid van personen met een sedentair beroep wordt een uitdaging in de toekomst, vooral omdat sedentarisme zich in een groot deel van de bevolking manifesteert tijdens zowel beroepsactiviteit als tijdens de vrije tijd.

Het begrijpen en in kaart brengen van de risicofactoren voor onze gezondheid, zowel op cardiovasculair als op musculoskeletaal vlak, die gepaard gaan met dit sedentair gedrag, vormen een belangrijke uitdaging voor wetenschappelijk onderzoek.

Enerzijds is het doel van deze studie om startende werknemers uit sedentaire beroepen (administratie, vrachtwagenchauffeurs) nauwgezet van bij de start van het beroep (para)medisch op te volgen voor 24 maanden (metingen bij de start van de studie en om de 6 maanden) om een dieper inzicht te verwerven in de consequenties van het sedentarisme dat werknemers beroepshalve ondergaan, evenals de effecten te onderzoeken van adviezen voor gezond bewegingsgedrag (protocol 1).

Anderzijds is het een opportuniteit om werknemers (administratie, vrachtwagenchauffeurs) die reeds langer beroepsactief zijn te onderzoeken betreffende de relaties tussen hun beroep en hun gezondheid. Het onderzoeken van deze verbanden gebeurt op basis van metingen (zie protocol 1) bij al de deelnemers aan dit tweede deel van de studie. Bij aanwezigheid van musculoskeletale problemen ter hoogte van schouder, nek, en/of lage rug zullen gepersonaliseerde oefeningen en adviezen met betrekking tot gezond bewegingsgedrag aangereikt worden (programma 12 weken). Hierbij wordt geëvalueerd in welke mate dit programma de aanwezige klachten kan verbeteren (metingen cfr protocol 1: voor de interventie, na 6 weken, en na 12 weken) (protocol 2).

Doelstellingen en beschrijving van de studie

Langdurig zitgedrag , ook wel 'sedentair gedrag' genoemd, heeft een belangrijk effect op de gezondheid en verhoogt het risico op ziekte. Het in stand houden van de cardiorespiratoire en musculoskeletale gezondheid van personen met een sedentair beroep wordt een uitdaging in de toekomst, vooral omdat sedentarisme zich in een groot deel van de bevolking manifesteert tijdens zowel beroepsactiviteit als vrije tijd. Het begrijpen en in kaart brengen van de risicofactoren voor onze gezondheid, zowel op cardiovasculair als op musculoskeletaal vlak, die gepaard gaan met dit sedentair gedrag, vormt een belangrijk werkpunt voor wetenschappelijk onderzoek.

Deze klinische studie is georganiseerd voor **twee doelgroepen** van **werknemers uit sedentaire beroepen** (werknemers die het grootste gedeelte van de dag zittend doorbrengen):

Doelgroep 1: **startende werknemers**.

Zij zullen nauwgezet worden opgevolgd van bij de start van het beroep gedurende **24 maanden** (metingen bij de start van de studie en om de 6 maanden) om een dieper inzicht te verwerven in de ontstaanswijze van gezondheidsklachten en negatieve effecten gerelateerd aan 'zittend' beroep.

Daarnaast zullen de effecten worden onderzocht van adviezen in verband met houding en gezond bewegingsgedrag op uw gezondheid.

Deze effecten zullen worden beoordeeld aan de hand van volgende onderzoeken en metingen (**protocol 1**):

1) een **nuchter** bloedstaal (bloedsuikerspiegel, cholesterolprofiel, …),
2) het meten van uw **bloeddruk** en **hartfrequentie**,
3) het meten van uw **buikomtrek** en **lichaamsgewicht**,
4) het bepalen van uw **lichaamsamenstelling** aan de hand van eenvoudige klinische parameters zoals **lengte**, **gewicht**, **buikomtrek**; maar ook via een **DEXA-scan** die een onderscheid maakt tussen vetmassa en vetvrije massa (spiermassa),
5) uw **uithoudingsvermogen** aan de hand van een maximale en submaximale **inspanningsproef op een fiets** waarbij hart- en longfunctie continu worden gevolgd,
6) het evalueren van uw **lichaamshouding**,
7) het bepalen van uw **spierkrach**t aan de hand van een isokinetische dynamometer,
8) een maandelijks in te vullen **vragenlijst** (PASIPD) waarin wordt geïnformeerd naar uw fysieke activiteit (vrije tijd, huishouden, werk-gerelateerd)
9) een registratie van uw **bewegingsgedrag** via een sensor (accelerometer) bevestigd aan de broeksriem (meten van uw activiteitenniveau) en via de een app (registratie van een gps-signaal) op uw smartphone (meten van het verplaatsingsgedrag),
10) een 3-dagen **eetdagboek**

Doelgroep 2*:* **werknemers die reeds langer beroepsactief zijn**.

Bij deze doelgroep zullen de relaties worden onderzocht tussen hun activiteitenniveau (duurtijd/ graad van het sedentarisme), persoonskenmerken (cardiovasculair risico, uithoudingsvermogen, lichaamsamenstelling) en de gezondheid (musculoskeletale klachten), ongeacht de carrière duur. Daarnaast zal worden nagegaan of het mogelijk is om de musculoskeletale klachten te beïnvloeden door een 12 weken durende interventie die bestaat uit het aanmoedigen van gezond bewegingsgedrag, een goede lichaamshouding en oefeningen ter bevordering van mobiliteit, spierkracht en motorische controle.

Beschrijving van de risico's en van de voordelen

Uw deelname aan deze studie houdt geen enkel gezondheidsrisico in. Ook moet u niet verwachten dat uw deelname aan deze studie u persoonlijke voordelen zal opleveren. U moet begrijpen dat uw deelname aan deze studie ervoor zal zorgen dat wij de risicofactoren voor onze gezondheid die gepaard gaan met "sedentair" gedrag beter begrijpen en bijgevolg in de toekomst betere behandelingen kunnen voorstellen en/of preventieve acties kunnen ondernemen om schadelijke effecten te voorkomen.

Intrekking van uw toestemming

U neemt vrijwillig deel aan deze studie en u hebt het recht om uw toestemming voor gelijk welke reden in te trekken. U hoeft hiervoor geen reden op te geven. Als u uw toestemming intrekt, zullen de gegevens bewaard blijven die tot op het ogenblik van uw stopzetting werden verzameld. Dit om de geldigheid van de studie te garanderen. Er zal geen enkel nieuw gegeven aan de opdrachtgever worden gegeven.

Als u aan deze studie deelneemt, vragen wij om:

- Tenvolle mee te werken voor een correct verloop van de studie.
- Geen informatie over uw gezondheidstoestand, de geneesmiddelen die u gebruikt of de symptomen die u ervaart te verzwijgen.
- De hoofdonderonderzoeker of zijn team op de hoogte te brengen als men u voorstelt om aan een andere studie deel te nemen zodat u met hem/haar kan bespreken of u aan deze studie kunt deelnemen en of uw deelname aan de huidige klinische studie moet worden stopgezet.
- Het toestemmingsformulier te ondertekenen en terug te bezorgen aan de onderzoekers.
- De vragenlijsten zo volledig mogelijk in te vullen en terug te bezorgen aan de onderzoekers.

Goedkeuring door het ethisch comité

Deze studie werd geëvalueerd door twee onafhankelijk ethisch comités die een gunstig advies hebben uitgebracht, namelijk de Ethische Toetsingscommissie van het Jessa Ziekenhuis en de CME UHasselt. De ethische comités hebben als taak de personen die aan klinische studies deelnemen te beschermen. Ze controleren of uw rechten als patiënt en als deelnemer aan een studie gerespecteerd worden, of de studie wetenschappelijk relevant en ethisch verantwoord is. Hierover brengen de ethische comités een advies uit in overeenstemming met de Belgische wet van 7 mei 2004. U dient het positief advies van de Ethische Comités in geen geval te beschouwen als een aansporing om deel te nemen aan deze studie.

Vrijwillige deelname

Aarzel niet om alle vragen te stellen die u nuttig vindt voordat u tekent. Neem de tijd om er met een vertrouwenspersoon over te praten, als u dit wenst. U heeft het recht om niet deel te nemen aan deze studie of met deze studie te stoppen zonder dat u hiervoor een reden hoeft te geven, zelfs al hebt u eerder toegestemd om aan deze studie deel te nemen. Uw beslissing zal in geen geval uw relatie met de onderzoeker en de voortzetting van uw therapeutische behandeling veranderen. Als u aanvaardt om aan deze studie deel te nemen, ondertekent u het toestemmingsformulier. De onderzoeker zal dit formulier ook ondertekenen en zal zo bevestigen dat hij u de noodzakelijke informatie voor deze studie heeft gegeven. U zult het voor u bestemde exemplaar ontvangen.

Kosten in verband met uw deelname

U zult geen vergoeding krijgen voor uw deelname aan deze studie. Uw deelname zal echter voor u geen bijkomende kosten met zich meebrengen.

Vertrouwelijkheidgarantie

Uw deelname aan de studie betekent dat u ermee akkoord gaat dat het onderzoeker en zijn team gegevens over u verzamelt en dat de opdrachtgever van de studie die gebruikt voor onderzoek en in het kader van wetenschappelijke en medische publicaties.

U hebt het recht om aan het onderzoeker en zijn team te vragen welke gegevens hij/zij over u heeft verzameld en waarvoor ze gebruikt worden in het kader van de studie. Deze gegevens hebben betrekking op uw huidige klinische situatie maar ook op uw medische voorgeschiedenis en op de resultaten van onderzoeken die werden uitgevoerd voor de behandeling van uw gezondheid volgens de geldende zorgstandaard. U hebt het recht om deze gegevens in te kijken en om verbeteringen te laten aanbrengen indien ze foutief zouden zijn[1].

De onderzoeker en zijn team is verplicht om deze verzamelde gegevens vertrouwelijk te behandelen. Dit betekent dat hij zich ertoe verbindt om uw naam nooit bekend te maken in het kader van een publicatie of een conferentie en dat hij uw gegevens zal coderen (uw identiteit zal worden vervangen door een identificatiecode in de studie) voordat hij ze doorgeeft aan de beheerder van de databank. De persoonlijke onderzoeksgegevens kunnen enkel door daartoe gemachtigde medewerkers vd betreffende onderzoeksinstelling (REVAL, MSK/CRI Revalidatie onderzoeksteam), de CME en het betreffende Ziekenhuis (Jessa ZH) worden ingezien.

De onderzoeker en zijn team zullen gedurende de volledige klinische studie de enige personen zijn die een verband kunnen leggen tussen de overgedragen gegevens en uw medisch dossier [2].De overgedragen persoonlijke gegevens omvatten geen combinatie van elementen waarmee het mogelijk is u te identificeren [3].

De door de opdrachtgever aangestelde beheerder van de onderzoeksgegevens kan u niet identificeren op basis van de overgedragen gegevens. Deze persoon is verantwoordelijk voor het verzamelen van de gegevens die door alle artsen-onderzoekers die deelnemen aan de studie zijn

1 Deze rechten zijn bepaald door de wet van 8 december 1992 tot bescherming van de persoonlijke levenssfeer ten opzichte van de verwerking van persoonsgegevens en door de wet van 22 augustus 2002 betreffende de rechten van de patiënt.

2 De wet verplicht om voor klinische studies dit verband met uw dossier gedurende 20 jaar te bewaren.

3 De database met de resultaten van de studie zal dus geen elementen bevatten zoals uw initialen, uw geslacht en uw volledige geboortedatum (dd/mm/jjjj).

verzameld en voor de verwerking en de bescherming van die gegevens in overeenstemming met de Belgische wet betreffende de bescherming van de persoonlijke levenssfeer.

Om de kwaliteit van de studie te controleren, kan uw medisch dossier worden ingekeken door personen die gebonden zijn aan het beroepsgeheim zoals vertegenwoordigers van de ethische comités, van de opdrachtgever van de studie of een extern auditbureau. Dit kan enkel gebeuren onder strikte voorwaarden, onder de verantwoordelijkheid van de arts-onderzoeker en onder zijn/haar toezicht (of van één van zijn/haar onderzoeksmedewerkers).

De (gecodeerde) onderzoeksgegevens kunnen doorgegeven worden aan Belgische of andere regelgevende instanties, aan de ethische comités, aan andere artsen en/of instellingen die samenwerken met de opdrachtgever.

Ze kunnen ook doorgegeven worden aan andere sites van de opdrachtgever in België en in andere landen waar de normen inzake de bescherming van persoonsgegevens verschillend of minder strikt kunnen zijn. Dit gebeurt dan steeds in gecodeerde vorm zoals hierboven uitgelegd [4].

Uw toestemming om aan deze studie deel te nemen betekent dus ook dat u akkoord gaat dat uw gecodeerde medische gegevens gebruikt worden voor doeleinden die in dit informatieformulier staan beschreven en dat ze worden overgedragen aan bovenvermelde personen en/of instellingen.

De opdrachtgever verbindt zich ertoe om de verzamelde gegevens enkel in het kader van deze studie te gebruiken.

Indien u uw toestemming tot deelname aan de studie intrekt, zullen de gecodeerde gegevens die al verzameld waren vóór uw terugtrekking, bewaard worden. Hierdoor wordt de geldigheid van de studie gegarandeerd. Er zal geen enkel nieuw gegeven aan de opdrachtgever worden doorgegeven.

4 De opdrachtgever verbindt zich ertoe om het bindend karakter van de Europese richtlijn en van de Belgische wetgeving inzake bescherming van de persoonlijke levenssfeer te respecteren.

Verzekering

In een observationele studie is het enige mogelijke risico een probleem met de maatregelen die werden genomen om de vertrouwelijkheid van uw persoonsgegevens te beschermen. De opdrachtgever is, ook indien er geen sprake is van fout, aansprakelijk voor de schade die u als deelnemer - of in geval van overlijden uw rechthebbenden - oplopen en die rechtstreeks of onrechtstreeks te wijten is aan de deelname aan deze studie. Hiervoor heeft de opdrachtgever een verzekeringscontract afgesloten (Ethias NV, Prins-Bisschopsingel 73 te 3500 Hasselt, polisnummer XXXXXXXX)[5].

Contact

Als u bijkomende informatie wenst, maar ook ingeval van problemen of als u zich zorgen maakt, kan u contact opnemen met de hoofdonderzoeker, Prof. Dr. Frank Vandenabeele (email: frank.vandenabeele@uhasselt.be; telefoon: +32(0)1126 93 01).

[5] Conform artikel 29 van de Belgische wetgeving inzake experimenten op de menselijke persoon (7 mei 2004)

Titel van de studie: **Gezond bewegingsgedrag bij sedentaire beroepen**

Deel I : Informatiedocument

Deel II - Geïnformeerde toestemming

Deel enkel bestemd voor de deelnemer

Hierbij bevestig ik, ondergetekende …… (*naam en voornaam van de deelnemer, voluit*) dat ik over de studie ben ingelicht en een exemplaar van het 'informatiedocument' en het 'toestemmingsverklaringsdocument' ontvangen heb. Ik heb de informatie gelezen en begrepen.

- Ik verklaar dat ik geïnformeerd ben over de aard, het doel, de duur, de eventuele voordelen en risico's van de studie en dat ik weet wat van mij wordt verwacht. Ik heb kennis genomen van het informatiedocument en de bijlagen ervan.
- Ik heb voldoende tijd gehad om na te denken en met een door mij gekozen persoon, zoals mijn huisarts of een familielid, te praten.
- Ik heb alle vragen kunnen stellen die bij me opkwamen en ik heb een duidelijk antwoord gekregen op mijn vragen.
- Ik begrijp dat mijn deelname aan deze studie vrijwillig is en dat ik vrij ben mijn deelname aan deze studie stop te zetten zonder dat dit mijn relatie schaadt met het therapeutisch team dat instaat voor mijn gezondheid.
- Ik begrijp dat er tijdens mijn deelname aan deze studie gegevens over mij zullen worden verzameld en dat de arts-onderzoeker en de opdrachtgever de vertrouwelijkheid van deze gegevens verzekeren overeenkomstig de Belgische wetgeving ter zake.
- Ik stem in met de verwerking van mijn persoonlijke gegevens volgens de modaliteiten die zijn beschreven in de rubriek over het verzekeren van de vertrouwelijkheid. Ik geef ook toestemming voor de overdracht naar en verwerking van mijn gecodeerde gegevens in andere landen dan België.
- Ik ga ermee akkoord / Ik ga er niet mee akkoord (doorhalen wat niet van toepassing is) dat de studiegegevens die voor de hier vermelde studie worden verzameld, later zullen worden verwerkt, op voorwaarde dat deze verwerking beperkt blijft tot de context van de hier vermelde studie voor een betere kennis van de ziekte en de behandeling ervan.
- Ik ga ermee akkoord / Ik ga er niet mee akkoord (doorhalen wat niet van toepassing is) dat mijn huisarts of andere specialisten die zich met mijn gezondheid bezighouden, indien nodig worden gecontacteerd om aanvullende informatie over mijn gezondheid te verkrijgen.

Naam, voornaam van de deelnemer: ……..

Datum: …/…/……

Handtekening van de deelnemer: ……..

Deel enkel bestemd voor het onderzoeksteam

- Ik ondergetekende …….. bevoegde onderzoeksmederwerker, verklaar de benodigde informatie inzake deze studie mondeling te hebben verstrekt evenals een exemplaar van het informatiedocument aan …… (*naam van de deelnemer, voluit*) te hebben verstrekt.

- Ik bevestig dat geen enkele druk op de deelnemer is uitgeoefend om hem/haar te doen toestemmen met deelname aan de studie en ik ben bereid om op alle eventuele bijkomende vragen te antwoorden.

- Ik bevestig dat ik werk in overeenstemming met de ethische beginselen zoals vermeld in de "Verklaring van Helsinki", de "Goede klinische praktijk" en de Belgische wet van 7 mei 2004 inzake experimenten op de menselijke persoon.

Naam, voornaam van de onderzoeker: ……

Datum: …/…/…..

Handtekening van de onderzoeker: ……

8.4. Appendix 4: Example of the 3-day food diary

3-daags

Voedingsdagboek

Naam deelnemer:

Dagen waarop de voeding genoteerd moet worden:

1.
2.
3.

Vergeet niet het gebruik van boter ed. (op brood of bij koken) te noteren.

Voor de rest geldt: hoe nauwkeuriger hoe beter!!!

Richtlijnen voor het invullen van het 3-daags voedingsdagboek

Tijdens deze studie zullen wij u enkele malen vragen om dit 3-daags voedingsdagboek in te vullen. Met behulp van dit voedingsdagboek kunnen wij de dagelijkse energieopname berekenen en bepalen in welke verhouding de macronutriënten (eiwitten, vetten en koolhydraten) aan deze energieopname bijdragen. Tevens kan berekend worden hoeveel vitamines en mineralen met de voeding worden opgenomen.

Om een zo goed mogelijk beeld te krijgen van de gebruikte voeding willen wij graag dat u gedurende drie dagen **alles** opschrijft wat u eet en drinkt. Ook bijvoorbeeld water en suikervrije kauwgom dient u te noteren. Probeer de voedingsmiddelen die worden genuttigd direct te noteren, vergeet daarbij de tussendoortjes niet!

De dagen zijn verdeeld in 7 eetmomenten beginnend vanaf "het ontbijt" tot "in de loop van de avond". Per eetmoment kunt u noteren wat en hoeveel u hebt gegeten of gedronken. Tevens vragen wij u om het **tijdstip** (in de kolom "tijd") te noteren waarop iets wordt geconsumeerd. De opschrijf dag begint steeds om 6 uur 's ochtends en eindigt de volgende morgen om 6 uur. Geef steeds een zo gedetailleerd mogelijke omschrijving van het geconsumeerde product. Schrijf bijvoorbeeld niet alleen op dat u brood heeft gegeten, maar geef ook het **soort** aan, bijv. meergranenbrood. Waar dit van toepassing is, kunt u ook **merknamen** opschrijven, bijv.: dieethalvarine - "Sense light". Dit noteert u in de kolom "omschrijving voedingsmiddel".

De **hoeveelheden** kunt u weergeven in huishoudelijke maten zoals kopjes, bekers, lepels, sneetjes, schaaltjes e.d. Wij verzoeken u de gebruikte producten zoveel mogelijk te wegen. Soms kan het gewicht ook afgeleid worden van gegevens op de verpakking. Dit noteert u dan in de kolom "hoeveelheid". De kolom "code" is alleen voor ons van belang, hier hoeft u dus niets in te vullen.

Bij het aangeven van de geconsumeerde hoeveelheden mag u gebruik maken van huishoudelijke maten. Omdat deze inhoudsmaten echter niet voor iedereen gelijk zijn, vragen wij u om de gebruikte huishoudelijke maten na te meten met een maatbeker. U vult dan bijv. een mok met water zoals u dat normaal met bijv. melk zou doen, en schenkt dit over in de maatbeker. De hoeveelheid kunt u vervolgens aflezen en noteren op blz. 13.

<u>Aandachtspunten bij het opschrijven van de warme maaltijd.</u>

- Noteer van uw eigen receptuur (bijv. puree of nasi) de **ingrediënten** voor het totale gerecht met bijbehorende hoeveelheden in de hiervoor gereserveerde ruimte. Geef ook aan **welk gedeelte** u zelf van dat gerecht daadwerkelijk gegeten heeft.

- Geef de geconsumeerde hoeveelheid aardappels aan in grammen, of indien afwegen niet mogelijk is, in stuks ter grootte van een kippenei.

- Geef de gebruikte hoeveelheid rijst of deegwaar (spaghetti e.d.) aan in grammen, of indien afwegen niet mogelijk is, in gebruikt gedeelte van de verpakking. Bijvoorbeeld 1/3 pak witte rijst.

- Geef de hoeveelheid vlees aan in grammen (rauw gewicht). Het gewicht staat vaak op de verpakking vermeld.

- Let goed op de gebruikte hoeveelheid margarine of bak- en braadproduct. Geef dit aan in grammen of, indien afwegen niet mogelijk is, in eetlepels of gedeelte van de verpakking (met behulp van streepjesverdeling op de verpakking).

- Schrijf ook de toegevoegde hoeveelheid water, melk en/of bindmiddel op die gebruikt is bij het maken van jus of saus.

Bekijk het voorbeeld op de volgende bladzijde goed. Het kan u helpen dit voedingsdagboek zo correct mogelijk in te vullen. Bedenk dat u nooit te veel op kunt schrijven!

U wordt verzocht om het ingevulde voedingsdagboek mee te brengen bij de eerst volgende test. Wanneer u vragen heeft, aarzel dan niet om contact op te nemen: Dominique Hansen (0497/87.58.66.).

Voorbeeld

Datum opschrijf dag 1: *dinsdag 11 januari 2013*

Naam deelnemer: *Dominique Hansen*

Avondmaaltijd

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid
	17.30	*Macaroni, gekookt*	*238 g*
		Tomatensaus	*197 g*
		± 1/3 deel van het totale recept	
		Water, 1 glas	*152 g*
		Magere vruchtenyoghurt (Melkunie)	*168 g*

Ruimte voor het noteren van eigen receptuur

Code	Omschrijving voedingsmiddel	Hoeveelheid
	Tomatensaus:	
	Margarine, pakje (Wayang)	*32 g*
	Rundergehakt	*380 g*
	Paprika, rood, schoongemaakt	*92 g*
	Ui, schoongemaakt	*78 g*
	Champignons,1 bakje, schoongemaakt	*238 g*
	Gepelde tomaten, 1 blik	*500 g*
	Mix voor macaroni, 1 zakje (Knorr)	*42 g*

DAG 1

Ontbijt

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Tussendoor 's morgens

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Lunch

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Tussendoor 's middags

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Avondmaaltijd

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

In de loop van de avond

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

DAG 2

Ontbijt

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Tussendoor 's morgens

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Lunch

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Tussendoor 's middags

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Avondmaaltijd

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

In de loop van de avond

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

DAG 3

Ontbijt

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Tussendoor 's morgens

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Lunch

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Tussendoor 's middags

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Avondmaaltijd

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

In de loop van de avond

Code	Tijd	Omschrijving voedingsmiddel	Hoeveelheid

Huishoudelijke maten

Wilt u de door u gebruikte huishoudelijke maten nameten met een maatbeker, en de uitkomsten hier noteren.

Huishoudelijke maat	Inhoud
Glas	.....ml
Theekopje	.....ml
Koffiekopje	.....ml
Beker/mok	.....ml
Dessertschaaltje	.....ml
.....	.....ml
.....	.....ml

8.5. Appendix 5: Descriptive statistics – Physical characteristics of the participants

5.1. Demographics

Variable	Women (n=25)		Men (n=15)		Total sample (n=40)	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Age (years)	18.8 ± 0.4	18.0 - 20.0	19.1 ± 0.7	18.0 - 20.0	18.9 ± 0.5	18.0 - 20.0
Weight (kg)	59.4 ± 5.7	50.0 - 77.5	71.2 ± 6.5	58.0 - 80.0	63.8 ± 8.3	50.0 - 80.0
Height (cm)	167.7 ± 5.2	158.6 - 181.8	180.6 ± 7.7	167.0 - 90.5	172.6 ± 8.8	158.0 - 190.5
Body mass index (kg/m^2)	21.3 ± 1.6	18.5 - 23.7	21.9 ± 2.0	19.1 - 25.1	21.5 ± 1.8	18.5 - 25.1
Fat mass (%)	29.3 ± 3.7	22.1 - 35.6	14.9 ± 5.1	9.5 - 28.4	23.9 ± 8.2	9.5 - 35.6
Fat free mass (%)	70.7 ± 3.7	64.4 - 77.9	85.1 ± 5.1	71.6 - 90.5	73.5 ± 8.2	64.4 - 90.5

5.2. Accelerometer data

Variable	Women (n=25)		Men (n=15)		Total sample (n=40)	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Sedentary time (min/day)	574.5 ± 66.1	477.0 - 745.5	607.1 ± 67.7	507.2 - 712.8	586.8 ± 67.8	477.0 - 754.5
Sedentary time (%)	71.8 ± 8.2	60.5 - 89.3	70.9 ± 6.9	60.8 - 81.6	71.5 ± 7.6	60.5 - 89.3
Light physical activity (min/day)	200.0 ± 62.4	69.5 - 300.0	261.6 ± 55.5	125.5 - 296.8	206.3 ± 59.7	69.5 - 300.0
Light physical activity (%)	25.0 ± 6.7	9.73 - 35.48	25.2 ± 6.0	16.2 - 34.6	25.1 ± 6.4	9.7 - 35.5
Moderate-to-vigorous activity (min/day)	29.5 ± 18.2	3.3 - 79.0	33.0 ± 18.0	13.0 - 67.2	30.8 ± 17.9	3.3 - 79.0
Moderate-to-vigorous activity (%)	0.9 ± 0.5	0.1 - 2.3	0.9 ± 0.5	0.4 - 1.9	0.9 ± 0.5	0.1 - 2.3
Accelerometer wear-time (min/day)	796.7 ± 70.0	639.5 - 912.5	857.8 ± 65.3	748.3 - 956.0	819.6 ± 73.8	638.5 - 856.0
Accelerometer wear-time (%)	55.3 ± 4.9	43.3 - 63.3	59.6 ± 4.5	51.9 - 66.4	56.9 ± 5.2	43.4 - 66.4
Accelerometer non-wear time (min/day)	644.5 ± 73.4	537.5 - 833.8	582.1 ± 65.3	484.0 - 691.8	621.1 ± 76.0	484.0 - 833.8
Total accelerometer wear time (min)	3186.8 ± 280.1	25580 - 3650.0	3431.2 ± 261.3	2993 - 3824	3278.5 ± 295.2	2558.0 - 3824.0

5.3. Cardiometabolic biomarkers

Variable	Women (n=25)		Men (n=15)		Total sample (n=40)	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Waist circumference	72.3 ± 3.5	65.7 - 80.5	78.4 ± 3.9	72.8 - 83.5	74.6 ± 4.6	65.7 - 83.5
Fasting glucose concentration (mmol/L)	80.4 ± 6.5	71.0 - 105.5	79.7 ± 6.2	70.0 - 91.0	78.0 ± 6.3	70.0 - 105.0
Fasting insulin (mmol/L)	76.8 ± 27.9	34.0 - 140.0	70.9 ± 20.4	30.0 - 110.0	74.6 ± 25.2	30.0 - 140.0
Insulin sensitivity (HOMA-%S)	83.8 ± 13.1	61.3 - 97.6	73.2 ± 18.6	66.5 - 94.8	85.7 ± 5.1	61.30 - 97.6
Triglyceride concentration (mmol/L)	74.8 ± 26.5	39.0 - 148.0	87.7 ± 34.5	53.0 - 167.0	79.6 ± 30.0	39.0 - 167.0
HDL-cholesterol (mmol/L)	65.7 ± 14.7	38.0 - 90.0	53.5 ± 16.3	26.0 - 94.0	61.1 ± 16.3	26.0 - 94.0
LDL-cholesterol (mmol/L)	89.9 ± 27.0	16.0 - 142.0	72.8 ± 23.3	38.0 - 106.0	83.5 ± 26.7	16.0 - 142.0
Total cholesterol (mmol/L)	170.2 ± 28.5	100.0 - 219.0	141.3 ± 28.5	98.0 - 190.0	159.3 ± 31.5	98.0 - 219.0
Systolic blood pressure (mmHg)	121.3 ± 8.0	107.7 - 137.0	126.2 ± 8.6	109.0 - 141.0	123.1 ± 8.5	107.7 - 141.0
Diastolic blood pressure (mmHg)	75.2 ± 6.4	60.33 – 86.7	77.4 ± 7.1	66.0 - 90.0	76.0 ± 6.7	60.3 - 90.0

5.4. Dietary intake

Variable	Women (n=25)		Men (n=15)		Total sample (n=40)	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Energy intake (kcal/day)	1782.3 ± 287.1	1243.0 -2431.0	2159.0 ± 323.9	1755.0 - 2831.0	1923.7 ± 349.9	1243.0 - 2831.0
Carbohydrates (%/day)	18.5 ± 4.2	8.7 - 26.10	20.4 ± 5.6	12.4 - 32.8	223.3 ± 57.1	72.1 - 349.1
Protein (%/day)	6.5 ± 2.2	3.4 - 13.8	7.0 ± 1.7	5.4 - 11.9	6.7 ± 2.0	3.4 - 13.8
Lipids (%/day)	6.4 ± 2.3	2.8 - 12.0	6.6 ± 2.4	2.4 - 9.9	6.5 ± 2.3	2.43 - 12.0

8.6. Appendix 6: Spearman rank correlations

Variable	**ST (min/day)**	
	Correlation	Sig. (2-tailed)
Waist circumference (cm)	0.034	0.833
Fat mass (%)	0.128	0.430
Fat free mass (%)	-0.128	0.430
Fasting glucose concentration (mmol/L)	**0.155***	**0.036**
Fasting insulin (mmol/L)	0.218	0.072
Insulin sensitivity (HOMA-%S)	**-0.141***	**0.036**
Triglyceride concentration (mmol/L)	**0.194***	**0.120**
HDL-cholesterol (mmol/L)	-0.013	0.936
LDL-cholesterol (mmol/L)	-0.001	0.996
Total cholesterol (mmol/L)	-0.21	0.897
Systolic blood pressure (mmHg)	0.094	0.565
Diastolic blood pressure (mmHg)	0.150	0.356

ST = sedentary time, LIPA (light physical intensity activity), MVPA (moderate-to-vigorous physical activity)

** significant at α <0.05*
*** significant at α <0.01*

8.7. Appendix 7: Multiple linear regression models

Biomarker	Model 1: Sedentary time			Model 2: Sedentary time + Accelerometer wear-time			Model 3: Sedentary time + Accelerometer wear-time + sex		
	R^2	β	p	R^2	β	p	R^2	β	p
WC	0.007	0.082	0.616	0.059	-0.025	0.890	0.411	-0.077	0.591
%FM	0.022	0.150	0.357	0.187	0.038	0.815	0.757	0.105	0.257
%FFM	0.022	-0.150	0.357	0.187	-0.038	0.257	0.815	-0.105	0.257
Fg	0.304	0.151	0.001**	0.315	0.109	0.003**	0.352	0.103	0.002**
FI	0.213	0.262	0.063	0.279	0.180	0.064	0.292	0.190	0.079
HOMA-%S	0.116	-0.141	0.036*	0.157	-0.164	0.030*	0.178	-1.55	0.035*
TG	0.231	0.281	0.002**	0.248	0.221	0.011*	0.248	0.222	0.012*
HDL-C	0.000	0.002	0.991	0.067	0.122	0.491	0.163	0.149	0.383
LDL-C	0.001	0.030	0.853	0.132	0.138	0.420	0.173	0.155	0.360
TC	0.001	0.036	0.825	0.198	0.169	0.303	0.301	0.197	0.208
SBP	0,110	0.107	0.512	0,380	0.031	0.864	0.086	0.012	0.948
DBP	-0.017	0.097	0.551	0.014	-0.011	0.948	-0.009	-0.097	0.923

*WC = waist circumference, %FM = % fat mass, %FFM = % fat free mass, Fg = fasting glucose concentration, FI = fasting insulin, HOMA-%S = Homeostatic Model Assessment insulin sensitivity, TG = triglyceride concentration, HDL-C = HDL cholesterol concentration, LDL-C = LDL cholesterol concentration, TC = total cholesterol concentration, SBP = systolic blood pressure, DBP = diastolic blood pressure * = significant at $\alpha < 0.05$, ** significant at $\alpha < 0.01$*

Biomarker	Model 4: Sedentary time + Accelerometer wear-time + sex + energy intake			Model 5: Sedentary time + Accelerometer wear-time + sex + energy intake + MVPA			Model 6: Sedentary time + Accelerometer wear-time + sex + energy intake + MVPA + BMI/WC		
	R^2	β	p	R^2	β	p	R^2	β	p
WC	0.412	-0.078	0.593	0.421	-0.159	0.386	0.631	0.021	0.891
%FM	0.757	0.105	0.257	0.774	-0.003	0.978	0.849	0.098	0.331
%FFM	0.757	-0.105	0.262	0.774	0.003	0.978	0.849	-0.098	0.331
Fg	0.359	0.092	0.005**	0.365	0.038	0.033*	0.371	0.024	0.052
FI	0.306	0.104	0.086	0.329	0.075	0.126	0.417	0.032	0.108
HOMA-%S	0.178	-0.157	0.039*	0.179	-0.171	0.110	0.188	-0.145	0.182
TG	0.252	0.215	0.015*	0.252	0.103	0.045*	0.307	0.075	0.022*
HDL-C	0.180	0.134	0.436	0.183	0.090	0.678	0.316	-0.034	0.873
LDL-C	0.196	0.173	0.313	0.217	0.293	0.173	0.279	0.295	0.183
TC	0.311	0.209	0.188	0.316	0.265	0.188	0.320	0.239	0.265
SBP	0.156	0.042	0.810	0.156	0.053	0.810	0.196	0.054	0.815
DBP	0.014	0.007	0.968	-0.002	-0.080	0.721	-0.057	-0.100	0.676

*WC = waist circumference, %FM = % fat mass, %FFM = % fat free mass, Fg = fasting glucose concentration, FI = fasting insulin, HOMA-%S = Homeostatic Model Assessment insulin sensitivity, TG = triglyceride concentration, HDL-C = HDL cholesterol concentration, LDL-C = LDL cholesterol concentration, TC = total cholesterol concentration, SBP = systolic blood pressure, DBP = diastolic blood pressure * = significant at $\alpha < 0.05$, ** significant at $\alpha < 0.01$*

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Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**
Jaar: **2017**

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