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Sedentary behavior in individuals three months following stroke, and the association to physical function, cognitive function and mental health – The Nor-COAST study

Master thesis in Human Movement Science

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Sammendrag

Bakgrunn: Individer etter hjerneslag er mer stillesittende enn friske kontrollgrupper. Langvarig stillesitting har vist seg å være en uavhengig risikofaktor for kardiovaskulær sykdom og død. Hos individer etter hjerneslag kan det å redusere og bryte opp lange perioder i stillesittende være en mer realistisk tilnærming for å øke det daglige aktivitetsnivået, og oppnå helsegevinst, sammenlignet med det å øke intensitetsnivået. For å utvikle effektive strategier som reduserer og bryter opp lange perioder med stillesitting, trengs det mer kunnskap om faktorene som henger sammen med stillesittende atferd hos slagrammede.

Mål: Å undersøke stillesittende atferd blant individer tre måneder etter hjerneslag og hvordan fysisk funksjon, kognitiv funksjon og mental helse henger sammen med stillesitting.

Metode: 170 av deltakerne i Nor-COAST studien, som utførte tre måneders oppfølging ved St. Olavs Hospital i Trondheim, ble inkludert. Stillesitting ble målt over minimum fire døgn ved hjelp av en kroppsbåren aktivitetsmåler (ActivPAL™). Et MATLAB-script ble utviklet for å trekke ut antall og varighet på stillesittende perioder i våkentid mellom kl. 08.00-22.00, og plasserte periodene i èn av fire kategorier basert på varigheten: 1) ≥10 sek. til <30 min., 2) ≥30 til <60 min., 3) ≥60 til <90 min. og 4) ≥90 min i strekk. Kognitiv funksjon ble målt med Montreal Cognitive Assessment (MoCA), fysisk funksjon med Short Physical Performance Battery (SPPB) og mental helse med Hospital Anxiety and Depression Scale (HADS).

Resultat: Snittalderen til deltakerne var 72 år (SD 10.9), 38 % var kvinner og ved innleggelse var National Institutes of Health Stroke Scale (NIHSS) i snitt på 3.7 (SD 3.8). Ved tre måneders-oppfølgingen var SPPB-scoren i snitt 9.5 (SD 2.8), MoCA 24.4 (SD 4.5) og HADS 7.4 (SD 6.3). Deltakerne var i snitt stillesittende 69 % av våkentid (spennvidde 32-98%), og 41 % av dagen (spennvidde 7-95%) ble brukt i langvarige stillesittende perioder >30 minutt i strekk. Lavere SPPB-score var sterkt assosiert med høyere total og langvarig sittetid ($p<0.001$). Hverken MoCA eller HADS var signifikant assosiert med stillesitting.

Diskusjon/konklusjon: Stillesittende atferd varierte blant individer tre måneder etter hjerneslag. Fysisk funksjon var sterkt assosiert til stillesitting, men ikke kognitiv funksjon og mental helse. Slagpopulasjonen er svært ulik når det kommer til funksjons- og aktivitetsnivå, og ulike tilnærminger kan være essensielt for å bedre helsetilstanden i hele populasjonen.

Abstract

Background: Stroke survivors spend more time in sedentary behavior than healthy controls. Prolonged sedentary time is found to be an independent risk factor for cardiovascular disease and all-cause mortality. In the stroke population, breaking up prolonged sedentary bouts is suggested as more attainable to increase the daily activity level and health, compared to increasing the activity intensity level. In order to develop effective strategies to reduce sedentary time in the stroke population, more knowledge is needed about factors associated to sedentary behavior.

Aim: To assess sedentary behavior in individuals three months following stroke, and how physical function, cognitive function, and mental health are associated with sedentary time.

Methods: 170 participants from the Nor-COAST study, who underwent the three months follow-up at St. Olavs Hospital, were included. Sedentary time was monitored over a minimum of four days using a body worn activity monitor (ActivPAL^{TM}). A MATLAB script was developed to extract number and duration of sedentary bouts during waking hours (08.00-22.00), and placed them in one of four categories: 1) ≥10 sec. to <30 min., 2) ≥30 to <60 min., 3) ≥60 to <90 min. and 4) ≥90 min. Cognitive function was assessed by the Montreal Cognitive Assessment (MoCA), physical function by the Short Physical Performance Battery (SPPB) and mental health by the Hospital Anxiety and Depression Scale (HADS).

Results: Mean age was 72 years (SD 10.9), 38% were female, and National Institutes of Health Stroke Scale (NIHSS) at admission date was 3.7 (SD 3.8). At the three months follow-up, mean SPPB score was 9.5 (SD 2.8), MoCA 24.4 (SD 4.5) and HADS 7.4 (SD 6.3). Participants spent on average 69 % of waking hours in sedentary bouts [range 32-98%], and 41% of waking hours in prolonged sedentary bouts [range 7-95%]. SPPB was strongly associated with total and prolonged sedentary time (p<0.001). Neither MoCA nor HADS were significantly associated to sedentary time.

Discussion/conclusion: Sedentary behavior is diverse in individuals three months following stroke. Physical function, but not cognitive function or mental health, was strongly associated with sedentary time. The stroke population is highly diverse in both functional- and activity level, and different strategies may be needed to improve health in the overall population.

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Abbreviations

ADL – Activities of Daily Living

BMI – Body Mass Index

CIND – Cognitive Impairment Not classified as Dementia

CRF – Case Report Form

HADS – Hospital Anxiety and Depression Scale

HDL – High Density Lipoproteins

IBM - International Business Machines Corporation

LACI – Lacunar Infarct

LDL – Low Density Lipoproteins

MET – Metabolic Equivalent of Task

MoCA – Montreal Cognitive Assessment

mRS - modified Rankin Scale

NIHSS – National Institutes of Health Stroke Scale

Nor-COAST – The Norwegian Cognitive Impairment After Stroke

PACI – Partial Anterior Circulation Infarct

POCI – Posterior Circulation Infarct

PSD – Post Stroke Dementia

REK – Regional Committee for Research Ethics

SD – Standard Deviation

SPPB – Short Physical Performance Battery

SPSS - Statistical Package for the Social Sciences

SIS – Stroke Impact Scale

TACI – Total Anterior Circulation Infarct

ZPRED - Standardized Predicted Values

ZRESID - Standardized Residuals

1.0 Introduction

1.1 Stroke

Stroke is ranked as the second highest cause of death and the third leading cause of disability worldwide (1). In Norway, stroke financial costs are estimated between 7-8 billion NOK per year (2). The incidence of stroke increases with age (3), and the pooled cumulative risk of recurrent stroke is estimated to 39 % ten years after first stroke (4). Treatment following stroke emphasizes the importance of early mobilization, physical activity and task specific training to improve physical and cognitive function and health (5-8). Considering the aging population (9), number of stroke-affected individuals may increase in the years to come, and effective secondary prevention to obtain the recommended activity levels is crucial to improve and maintain function and health, and reduce recurrent strokes in the future (7, 10).

1.2 Sedentary behavior

However, stroke survivors tend to not reach the recommended activity levels (7, 11, 12), and spend approximately 75 % of waking hours in sedentary behavior (13-15), which is found to be 5-24 % more than healthy control groups (14, 16, 17). One study indicate that 67 % and 40 % of stroke survivors' daily sedentary time is spent in prolonged sedentary bouts lasting longer than respectively 30 and 60 minutes (14). This imply for 51 % of waking hours (14).

Sedentary behavior is defined as any waking behavior characterized by an energy expenditure ≤ 1.5 Metabolic Equivalent of Task (MET) while in a sitting, reclining or lying posture (18). In the general population, prolonged sedentary time, often defined as uninterrupted sedentary bouts with a duration >30 minutes (14, 19, 20), is found to be an independent risk factor for cardiovascular disease and all-cause mortality and morbidity (19, 21-23). In contrast, breaking up prolonged sedentary bouts is found as health beneficial in sedentary individuals without increasing the activity intensity level (22-27). This is due to a subsequent decrease in LDL cholesterol levels, waist circumference and inflammatory biomarkers, as well as an increase in insulin sensitivity and HDL cholesterol levels (24, 25, 27).

Being in activities of at least moderate intensity is reported as challenging among stroke survivors (7, 28), and reducing and breaking up prolonged sedentary time is therefore suggested as a more attainable approach to increase daily activity level and health status in the stroke population (24, 25, 27, 29).

1.3 Impairments following stroke

In the attempt to reduce sedentary behavior in the general adult and elderly population, several factors associated to increased sedentary time are revealed. Some of the factors most frequently reported are lower physical and cognitive function, mental health issues regarding depression and anxiety, older age, higher BMI and a lower educational level (24, 29-34). Among stroke survivors, similar factors are common (3, 35, 36), and post stroke impairments, affecting physical and cognitive function and mental health, are highly prevalent;

1.3.1 Physical impairments

In acute phase, muscle weakness in lower extremities is reported in 43 % of all stroke-survivors and more than half of stroke survivors have proprioceptive impairments (3, 37) leading to reduced motor control, balance and coordination, as well as increased muscle fatigue and challenges in activities of daily living (ADL) (3, 37, 38). In Norway 75 % of stroke survivors have independent ambulation abilities after three months (3).

1.3.2 Cognitive impairments

Approximately 60 % of stroke survivors get cognitive impairments (39). This include post-stroke dementia (PSD) and cognitive impairment not classified as dementia (CIND) (40). Ten percent of stroke survivors are indicated to have dementia before stroke onset, 10 % to develop dementia after first stroke and more than one third to have dementia after recurrent stroke (41). PSD is associated with reduced cognitive capacity and severity of stroke (40). CIND has a prevalence between 20-27 % among stroke survivors after three months (42), and is associated to dependency in daily life and poor survival (43).

1.3.3 Mental impairments

Impairment of mental health regarding depression and anxiety is also common after stroke; A meta-analysis found that depression is present in 31 % of stroke survivors during the first five years (44). The highest prevalence of 36 % is found between two and five months after stroke. Post stroke depression is associated with poor functional outcomes and higher mortality (45). Anxiety is prevalent in approximately 23 % of all stroke survivors one to five months after stroke (46, 47), and is associated to stroke severity and dependency in daily life (47, 48).

1.4 Factors associated to sedentary time among stroke survivors

Currently, there are limited knowledge of how physical, cognitive and mental impairments are related to sedentary behavior in stroke survivors. The few studies found, include participants two months to four years following stroke and exclude the most physically and cognitively impaired individuals (13, 20, 49). Lower score in parameters of physical function such as walking speed, independence in ADL, steps per day and balance were significantly associated to increased sedentary behavior (13, 20, 49). The association between sedentary behavior and cognitive function, assessed by the Montreal Cognitive Assessment (MoCA), was reported in two studies, showing no significant association (13, 20). Only one study assessed the association between sedentary behavior and mental health using the SIS (Stroke Impact Scale) emotional domain score. No significant association was found (20), although a study assessing free-living daily activity among stroke survivors, found positive significant associations to balance and mood (50).

1.5 Objective monitoring of sedentary behavior

All the reported studies utilized body-worn activity monitors to measure sedentary behavior in the stroke survivors (13-17, 20, 49). Objective activity monitoring is evaluated as more valid compared to self-reported questionnaires (51). The ActivPAL (PAL Technologies Ltd, Glasgow) provides accurate information of time spent in sitting/lying, standing and walking (52, 53), and is well-validated for measuring sedentary behavior in physically disabled populations, such as the stroke population (54, 55). The ActivPAL is one of the most frequently used activity monitors in the stroke population (13, 14, 20, 49), which may enable a valid comparisons across literature.

1.6 Purpose and aim

The fact that stroke survivors are found to be more sedentary than healthy controls (14, 16, 17) and simultaneously find it difficult to increase their activity intensity level (24, 25, 29), generates the suggestion of reducing and breaking up prolonged sedentary time as a more attainable approach to increase the daily activity level and health in the population, compared to increasing the activity intensity level. But, in order to develop effective strategies to reduce and break up sedentary time, more generalized knowledge is needed about stroke survivors sedentary behavior and the associated factors (13, 14, 16, 17, 20). Three months following stroke is found as the earliest stage to predict long-term survival after stroke (56), and may also provide insight in long-term behavior. In order to develop effective strategies to reduce sedentary behavior among stroke survivors in the long term, the primary aim of the present thesis is to assess sedentary behavior in individuals three months following stroke, and how impairments of physical function, cognitive function, and mental health are associated with sedentary time.

More specific, the thesis aims to answer the following research questions:

1) How much time do individuals three months following stroke spend in sedentary behavior per day?

2) What is the association between sedentary behavior and physical function assessed by the Short Physical Performance Battery in individuals three months following stroke?

3) What is the association between sedentary behavior and cognitive function assessed by the Montreal Cognitive Assessment in individuals three months following stroke?

4) What is the association between sedentary behavor and mental health assessed by the Hospital Anxiety and Depression scale in individuals three months following stroke?

The hypothesis is based on findings from previous literature, and suggest that stroke survivors are sedentary, and that increased sedentary behavior is associated with lower physical and cognitive function and mental health.

2.0 Methods and materials

2.1 Study design

The present thesis was a cross-sectional observational study, and a sub-study of the Norwegian Cognitive Impairment After Stroke study (Nor-COAST), a prospective, descriptive multi-centre cohort study. The Nor-COAST included 816 patients with acute stroke from five hospitals in south- and central-Norway, representing three out of four health regions in Norway. Participants were included while hospitalized with acute stroke and underwent follow-ups at 3 months, 18 months and 3 years after stroke onset. The present thesis utilized data three months following stroke collected at the main centre St. Olavs Hospital.

2.2 Participants

Only participants who completed the protocol tests needed for further analyses, and had valid activity monitoring for at least four consecutive days at the three months follow-up, were included in the present thesis. Inclusion criteria in the Nor-COAST were: hospitalized within 72 hours after stroke onset, diagnosed with acute stroke following the WHO criteria or with findings of acute infarction or intra-cerebral hemorrhage on MRI and CT and speak Norwegian. Exclusion criteria was life expectancy shorter than three months.

2.3 Data collection

Data were collected at the outpatient clinic at St. Olavs Hospital from 2015 to 2017 at the standard three months follow-up control. Appointments were arranged by mail and phone, and transportation was offered if necessary. Participants were guided though the test protocol by a trained research assistant following a standardized CRF (case report form). The assessment lasted for approximately 1.5-2 hours. When physical or cognitive capacity or available time impeded participants to finish the complete test protocol, clear guidelines were set to which tests that should be prioritized. The assessment was finished by attaching the activity monitor. Identical equipment and surroundings were used for all participants.

2.4 Outcome measures and procedure

2.4.1 Sedentary time

2.4.1.1 Instrument

The activity monitor used for measuring sedentary time was the ActivPAL3 Micro (3M) (PAL Technologies Ltd, Glasgow), which is a small device of 10 grams and 23.5 × 43.0 × 5.0 mm (Figure 2.1). An inbuilt three-axial accelerometer and inclinometer provides accurate information of time in sitting/lying, standing and walking position as well as transitions between postures (54, 55). With its 32 MB, the ActivPAL3M allows up to 14 days of monitoring. The default sampling frequency of 20 Hz was used (53) and a sedentary- or upright event needed to last for ≥ 10 seconds to be registered as a new event.

Figure 2.1: The ActivPAL3 Micro activity monitor wrapped in a nitrile sleeve and attached to the anterior thigh by an adhesive dressing.

2.4.1.2 Procedure

The ActivPAL monitor was attached to the mid anterior thigh of the non-affected leg (figure 2.1) (54). Activity monitoring started immediately after the session. Participants were asked to wear the ActivPAL3M for seven consecutive days. Waterproofing the device in a nitrile sleeve and a medical grade adhesive dressing enabled a 24-hour protocol (Figure 2.1). While wearing the device, participants were asked to act and move like normal, as if the device were not there. Only exceptions were not to go swimming and having a bath. Showering was allowed. After the seven days, participants returned the device in a stamped and addressed envelope. If the monitor fell off during the seven days, participants were told to register the time when the device fell off, and return it as if the seven days were finished.

2.4.1.3 *Data processing*

Data in the returned ActivPAL devices were downloaded and exported into Excel spreadsheets using the pre-classified algorithm in the ActivPAL™ Professional software (PAL Technologies Ltd 2012, Version 7.2.32) (53). All data were visually inspected to assure that invalid data and periods of non-wear time were not included in further analyses. The exact dates of participants first and last whole monitoring day (08.00-22.00) with valid ActivPAL data were registered in an Excel spreadsheet.

Two custom made MATLAB scripts (version R2016b, MathWorks. Natick, MA, USA) were developed. The first script created a new event file for each participant where only the valid monitoring days registered in the Excel spreadsheet were included. The script also compressed the event files by removing unnecessary rows and columns of data. The second MATAB script used the new ActivPAL event files to extract number and duration of sedentary bouts within a pre-defined time period between 08.00 and 22.00 (14 hours). The pre-defined time period was intended to represent waking hours, and was based on visual inspection of sedentary data in the original ActivPAL data files. Each extracted sedentary bout was exported into a collected Excel spreadsheet and placed in one of the four defined duration categories (Table 2.1). In Appendix A, the script processing steps are described in more detail. Quality assurance was performed using MATLAB, and compared extracted sedentary bouts from the defined time period to sedentary bouts in the continuous data.

Table 2.1: The four duration categories of extracted sedentary bouts.

Duration Category	From:	To:
1	≥ 10 sec	< 30 min
2	≥ 30 min	< 60 min
3	≥ 60 min	< 90 min
4	≥ 90 min	∞

The total number and duration of bouts in all four duration categories were defined as total sedentary time, and duration category 2-4 were defined as prolonged sedentary time. The included monitoring time ranged from 4 to 6 days in each participant. Descriptive statistics of total and prolonged sedentary time per day (mean hours and standard deviations (SD)) were calculated for each participant by the built-in formulas in Excel and presented in horizontal bar charts (figure 3.2 and 3.3). Time in upright position (standing and walking) was defined based on the remaining waking hours (14 hours – total sedentary time = upright position).

2.4.2 Cognitive function

Cognitive function was measured by the Montreal Cognitive Assessment (MoCA). The MoCA is a performance based screening tool for detecting mild cognitive impairment (57), and is well validated in vascular diseases such as stroke (58). The test score ranges from 0-30 (best score = 30), and evaluates attention, concentration, executive functions, memory, language, visuo-constructional skills, conceptual thinking, calculation, and orientation (Appendix B) (58). The MoCA was reported as a continuous variable in the analyses, and educational level was adjusted for by adding one point to participants with ≤ 12 years in school (57).

2.4.3 Physical function

Physical function was measured by the Short Physical Performance Battery (SPPB). SPPB is a performance based test, and well validated to assess physical function in elderly (59). The test is also used in hemiparetic stroke survivors (60). SPPB includes sub tests of balance, the sit-to-stand movement and walking speed (Appendix C). The sub tests range between 0-4 points, and the total SPPB score ranges between 0-12 points (best score = 12) (61). The SPPB was reported as a continuous variable in the analyses.

2.4.4 Mental health

Mental health status was measured by the Hospital Anxiety and Depression scale (HADS) (Appendix D) (62). HADS is a self-reported questionnaire containing of 14 questions rated from 0-3, giving a total score of 42 point (best score = 0). The HADS detects respectively depression and anxiety and is validated as sufficient in assessing mental impairment among stroke survivors (63). The HADS was reported as a continuous variable in the analyses.

2.4.5 Covariates and demographics

Type of stroke, categorized by the Oxfordshire Stroke Classification (64), educational level based on years in school, pre-stroke global function measured by the modified Rankin Scale (mRS) and severity of stroke measured by the National Institute of Health Stroke Scale (NIHSS) (65) were collected when participants were hospitalized in acute phase. Age, BMI and the need of helping aids were collected at the three months follow-up.

2.5 Statistical analyses

2.5.1 Descriptive analyses

Background characteristics in Table 3.1 were assess using descriptive and frequency analyses in IBM SPSS (Statistics version 25.0). Categorical variables (sex, type of stroke and walking aids) were reported as number and percent, while continuous variables (age, BMI, educational level, stroke severity and pre-stroke global function) were reported as mean and standard deviation and (if relevant) maximum- and minimum values. Differences in background characteristics between included and not included participants were assessed using the independent t-test in SPSS.

2.5.2 Linear regression analyses

Linear regression analyses were conducted to assess the associations between total and prolonged sedentary time (outcome variables) and the SPPB, MoCA, HADS and covariates. Prior to the analyses, all parameters were checked for assumptions regarding normal distribution and linearity, using histograms and Q-Q plots. Assumptions of homogeneity of variance and the presence of outliers were investigated in the outcome variables by plotting standardized residuals (ZRESID) against standardized predicted values (ZPRED). Standardized residuals were also checked for normal distribution. The occurrence of multicollinearity were assessed by conducting correlation tests between all parameters and by exporting variance inflation factors and tolerance values. Parameters of SPPB, MoCA and HADS had a skewed distribution against best score. All assumptions in the outcome variables were met and no multicollinearity was present in the data.

Bivariate linear regression analyses for total and prolonged sedentary time were conducted in SPSS against the SPPB, MoCA and HADS, and covariates of BMI, severity of stroke (NIHSS), educational level, age and gender. The unstandardized beta coefficients, the 95 % confidence interval and p-values were reported (tables 3.3 and 3.5). Associations with a p-value <0.05 were defined as significant.

Multivariable linear regression analyses were conducted using a forced entry method in SPSS. Separate analyses were conducted for total and prolonged sedentary time and respectively SPPB, MoCA and HADS. All six analyses were adjusted for covariates of BMI, severity of stroke (NIHSS), educational level, age and gender. Unstandardized and standardized beta coefficients, the 95 % confidence interval, p-values and adjusted R^2 were reported (table 3.4 and 3.6). Associations with a p-value <0.05 were defined as significant.

Secondary multivariable analyses of separated SPPB and HADS parameters were conducted by replacing SPPB with the sub parameters of walking speed, balance and the sit-to-stand movement, and by replacing HADS with the sub parameters of depression and anxiety. The two analyses were adjusted for covariates of BMI, severity of stroke (NIHSS), educational level, age and gender. The unstandardized beta coefficients, the 95 % confidence interval and p-values were reported (tables 3.7 and 3.8) in both bivariate and multivariable analyses. Associations with a p-value <0.05 were defined as significant.

2.6 Ethical aspects

The regional committee for research ethics (REK) approved the present sub study of the Nor-COAST (ref.nr.: 2017/1415). All the included participants had given their informed consent in prior of being tested, and had the right to withdraw at any time. A proxy based informed consent was given on behalf of the participants not able to give one themselves.

3.0 Results

3.1 Participant characteristics

400 participants with acute stroke were initially included at St. Olavs Hospital (Figure 3.1). Before the three months follow-up, 61 participants were excluded due to death, missing or decline in being tested. After the three months follow-up, 51 participants were excluded due to telephone interview which removed activity monitoring from the protocol, and 73 participants followed up at the outpatient clinic, were excluded because they refused or did not have the opportunity to wear the ActivPAL. Eight participants wearing the ActivPAL were excluded due to invalid data files and 37 were excluded due to missing data in one or more of the parameters needed for further analysis.

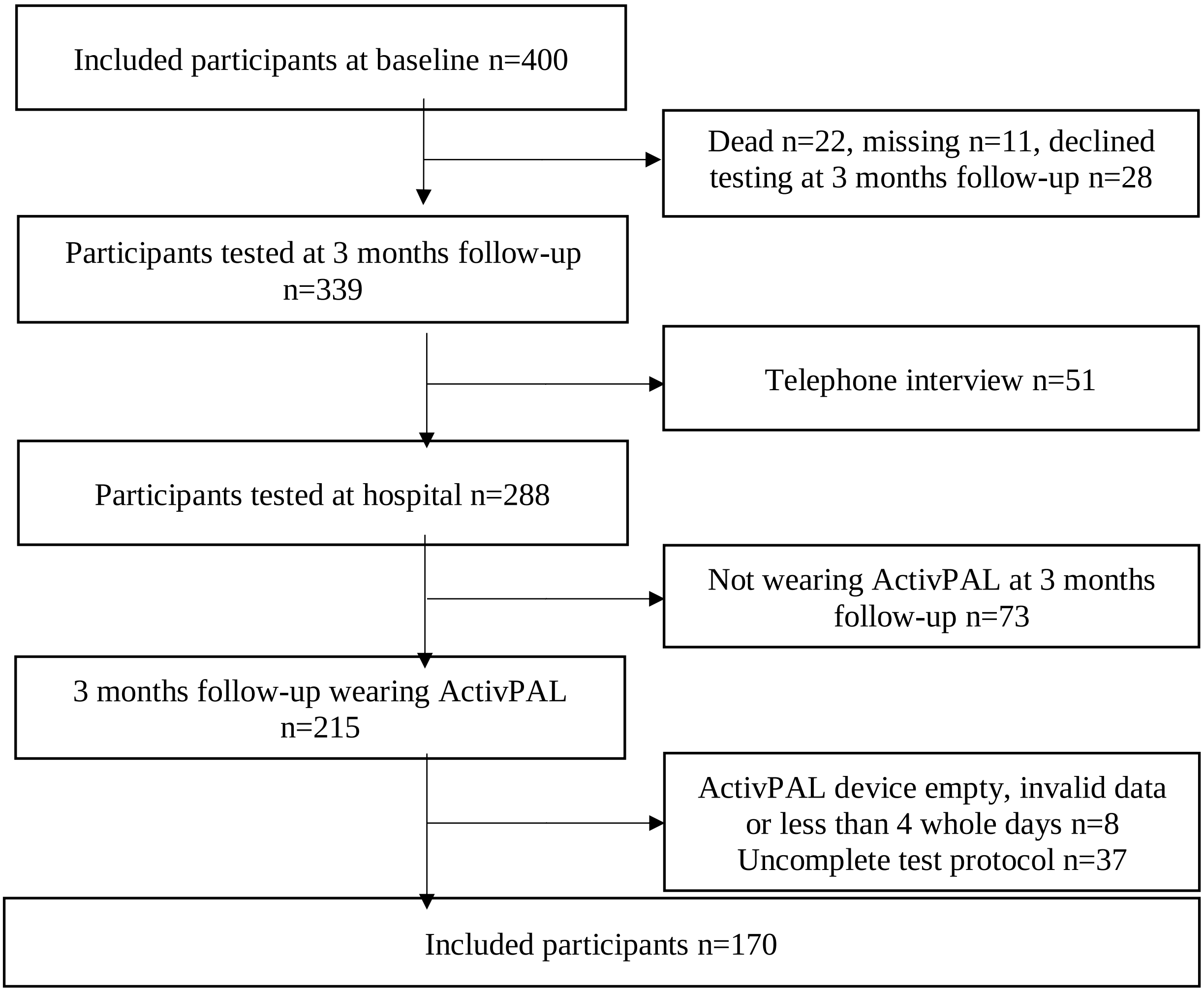

Figure 3.1: Float chart of included participants

Background characteristics of the 170 included participants and the 230 not included participants are presented in table 3.1. There were 12.8 % less females in the included participant group, indicating a significant difference between groups (p<0.001). Severity of stroke was significantly lower in the included participants (p<0.001), indicating mild stroke, while moderate stroke were implied in the not included group. Pre-stroke global function was

Table 3.1: Background characteristics of included and not included participants.

	Included participants (n=170)	Not included participants		
Characteristics	Mean (SD) [Range] / Number (%)	N	Mean (SD) [Range] / Number (%)	p-value
Age	72 (10.9) [37-92]	230	77 (10.1) [46-97]	<0.001
Female	64 (37.6)	230	116 (50.4)	0.011
BMI[a]	26.6 (4.1) [16.3-40.8]	91	26.5 (4.4) [15.2-38.1]	0.842
Type of stroke		230		0.384
Ischemia	154 (90.6)		202 (87.8)	
TACI[b]	6 (3.5)		25 (10.9)	
PACI[c]	31 (18.2)		40 (17.4)	
LACI[d]	48 (28.2)		61 (26.5)	
POCI[e]	36 (21.2)		42 (18.3)	
Not classified	33 (19.4)		34 (14.7)	
Haemorrhage	16 (9.4)		28 (12.2)	
Recurrent stroke	30 (17.6)		56 (24,3)	0.101
Education level	12.1 (3.6) [4-23]	230	10.6 (3.4) [6-20]	<0.001
≤ 7 years	14 (8)		53 (23)	
8 – 11 years	76 (45)		100 (43.5)	
12 – 23 years	80 (47)		77 (33.5)	
Severity of stroke (NIHSS[f])	3.7 (3.8) [0-19]	210	6.3 (7.5) [0-40]	<0.001
Mild stroke: 0-5	134 (79)		139 (66)	
Mild-moderate stroke: 6-10	25 (15)		31 (15)	
Moderate stroke: 11-15	5 (3)		13 (6)	
Moderate-severe stroke: 16-20	6 (3)		13 (6)	
Severe stroke: 21-42	0 (0)		14 (7)	
Pre-stroke global function (mRS[g])	1.06 (0.9)	229	1.87 (1.3)	<0.001
Walking aid	17	95	19	0.043
Crutch/stick	9		10	
Walker	8		9	
Missing	4		135	

[a]BMI: Body Mass Index, [b]TACI: Total anterior circulation infarct, [c]PACI: Partial anterior circulation infarct, [d]LACI: Lacunar infarct, [e]POCI: Posterior circulation infarct, [f]NIHSS: National Institutes of Health Stroke Scale at admission date, [g]mRS: modified Rankin Scale.

almost 20 % higher in the included participants, and a significant (p<0.001) difference were present between groups. Included participants were five years younger than the not included participants, although no significant difference was reported (p=0.531). No significant differences were present in BMI, type of stroke and educational level between the included and not included participants.

Table 3.2 reports mean test scores of the SPPB, MoCA and HADS. The included participants scored 9.5 (SD 2.8) of 12 points in the SPPB, which was significantly (p<0.001) higher than the not included participants. Mean MoCA score was 24.4 (SD 4.5) of 31 in the included participants and significantly (p=0.007) higher than the not included participants. Mean HADS score was 7.4 (SD 6.3) of 42 in the included participants. No significant difference was present between groups.

Table 3.2: Physical, cognitive and mental scores in included and not included participants.

	Included participants (N=170)	Not included participants		
Parameter (test)	Mean (SD) [Range]	N	Mean (SD) [Range]	p-value
Physical function (SPPB[a])	9.5 (2.8) [0-12]	99	7.5 (4.2) [0-12]	<0.001
Cognitive function (MoCA[b])	24.4 (4.5) [9-31]	108	22.4 (6.0) [6-31]	0.003
Mental health (HADS[c])	7.4 (6.3) [0-30]	84	8.3 (6.2) [0-26]	0.285

[a]SPPB: Short Physical Performance Battery (total range: 0-12), [b]MoCA: Montreal Cognitive Assessment (total range: 0-31), [c]HADS: Hospital Anxiety and Depression scale (total range: 0-42).

3.2 Descriptive statistics of total and prolonged sedentary time

3.2.1 Sedentary time during waking hours

Total and prolonged sedentary time are presented in figure 3.2. Participants spent on average 9.7 hours (SD 1.8) [range 4.5-13.8] per day in sedentary bouts, representing 69 % [range 32-98%] of waking hours. Of this, 5.7 hours (SD 2.3) [range 1.0-13.3] were spent in prolonged sedentary bouts, representing 41 % [range 7-95%] of waking hours. The least sedentary quartile of the sample spent 3.4 hours (SD 1.2) [range 1.0-5.3] in prolonged sedentary time per day, representing 24 % [range 7-38%] of waking hours, while the most sedentary quartile spent 8.2 hours (SD 1.9) [range 4.6-13.3] in prolonged sedentary time per day, representing 63 % [range 33-95%] of waking hours.

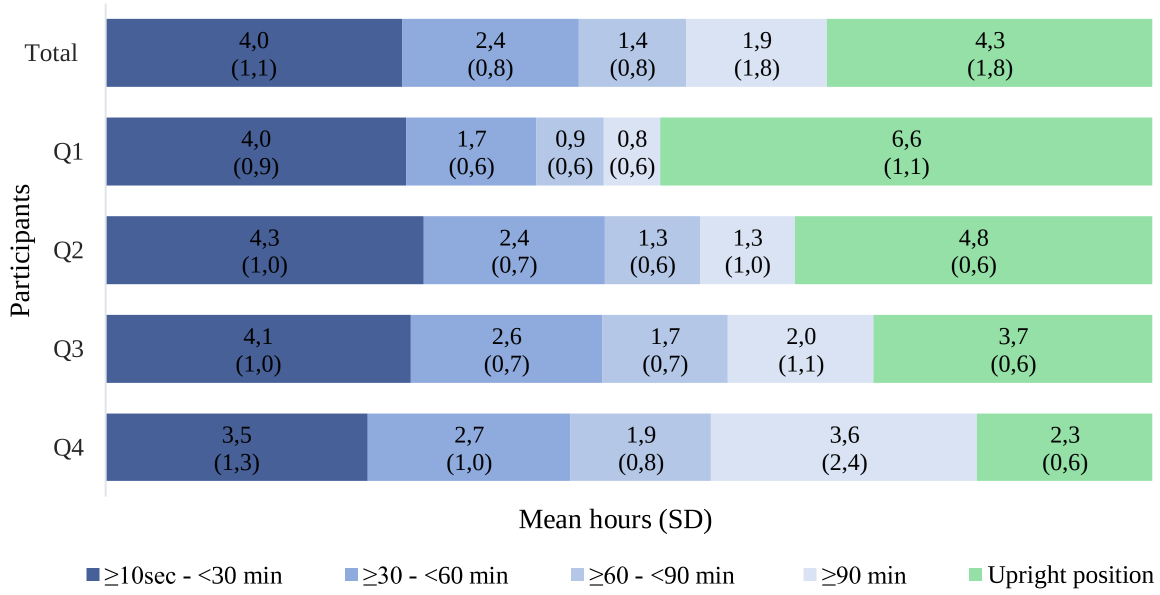

Figure 3.2: Mean hours spent in sedentary behavior during 14 waking hours (08.00-22.00). The upper bar present mean sedentary time in the complete participant group while the four lower bars present data from the least sedentary quartile to the most sedentary quartile of the sample. The four blue blocks to the left present mean sedentary time spent in each of the duration categories per day. The darkest blue blocks present sedentary bouts <30 min., and the mid three blocks presents hours spent in prolonged sedentary bouts. The green block to the right in each bar present mean hours spent in upright position per day.

3.2.2 Number and duration of sedentary bouts per day

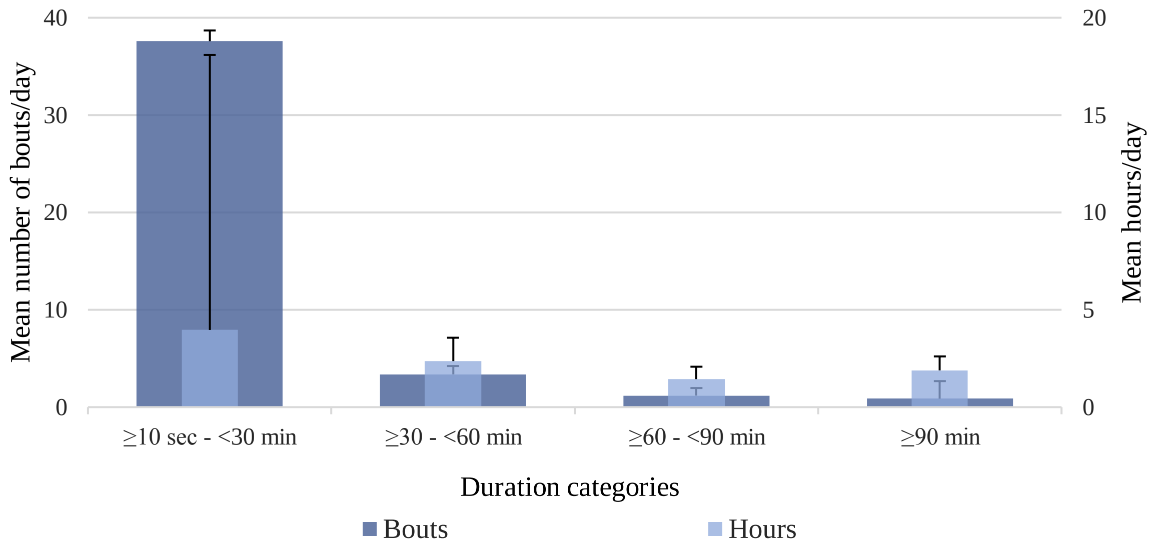

Figure 3.3: Mean number of sedentary bouts in each duration category during the 14 waking hours (08.00-22.00), and mean hours spent in each duration category per day. The left axis and the dark blue bars present mean number of sedentary bouts in each duration category per day, while the rights axis and light blue bars present mean hours spent in each duration category per day. The black lines define the standard deviations.

Mean number of sedentary bouts per day were 42.3. Of these, 5.6 bouts were prolonged, lasting longer than 30 minutes, and 36.7 bouts were shorter than 30 minutes (Figure 3.3). A negative relationship was found between the number and duration of sedentary bouts; the longer bouts, the fewer per day.

3.3 Regression analyses of total sedentary time

3.3.1 Bivariate analyses

The bivariate analyses in table 3.3 reported a significant association between total sedentary time and the SPPB (p<0.001), indicating total sedentary time to increase with 14.72 minutes to every test point missed in the SPPB. No significant associations were found between total sedentary time and the MoCA (p=0.070) or HADS (p=0.265), although analyses indicated lower cognitive function and mental health to increase total sedentary time by respectively 3.25 and 1.43 minutes to every test point missed in the MoCA and gained in the HADS. Increased total sedentary time was significantly associated with lower education level (p=0.03), higher BMI (p=0.039) and older age (p=0.007).

Table 3.3: Bivariate analyses of the associations between total sedentary time (min) and the SPPB, MoCA and HADS, and covariates of severity of stroke (NIHSS), education level, BMI, age and gender. Significant associations are highlighted.

Parameters	B[a]	95% lower CI[b]	95% lower CI	p-value
SPPB[c]	**-14.72**	**-20.02**	**-9.42**	**<0.001**
MoCA[d]	-3.25	-6.76	0.27	0.070
HADS[e]	1.43	-1.10	3.97	0.265
Covariates				
NIHSS[f]	2.66	-1.58	6.89	0.217
Education level	**-4.81**	**-9.18**	**-0.44**	**0.031**
BMI[g]	**4.07**	**0.21**	**7.93**	**0.039**
Age	**1.99**	**0.55**	**3.43**	**0.007**
Gender	14.11	-18.88	47.11	0.400

[a]B: Unstandardized regression coefficient, [b]CI: Confident Interval, [c]SPPB: Short Physical Performance Battery (total range: 0-12), [d]MoCA: Montreal Cognitive Assessment (total range: 0-31), [e]HADS: Hospital Anxiety and Depression scale (total range: 0-42), [f]NIHSS: National Institutes of Health Stroke Scale (Severity of stroke), [g]BMI: Body Mass Index.

3.3.2 Multivariable analyses

Multivariable analyses, adjusted for BMI, severity of stroke (NIHSS), educational level, age and gender (Table 3.4), reported a significant association between total sedentary time and the SPPB (p<0.001), indicating total sedentary time to increase with 13.42 minutes to every test point missed in the SPPB. No significant associations were found between total sedentary time and the MoCA (p=0.621) or HADS (p=0.417), although analyses indicated lower cognitive function and mental health to increase total sedentary time by respectively 1.01 and 1.04 minutes to every test point missed in the MoCA and gained in the HADS. The adjusted R^2 reported each of the multivariable regression models to explain respectively 17.8 % (SPPB), 8.2 % (MoCA) and 8.4 % (HADS) of the variance in total sedentary time.

Table 3.4: Multivariable analyses* of the associations between total sedentary time (min) and the SPPB, MoCA and HADS. Significant associations are highlighted.

Parameters	B[a]	95% lower CI[b]	95% upper CI	β[c]	p-value	aR^2
SPPB[d]	**-13.42**	**-19.43**	**-7.42**	**-0.36**	**<0.001**	**0.178**
MoCA[e]	-1.01	-5.01	3.00	-0.04	0.621	0.082
HADS[f]	1.04	-1.48	3.56	0.06	0.417	0.084

*The analysis for each parameter was adjusted for NIHSS (National Institutes of Health Stroke Scale), BMI (Body Mass Index), education level, age and gender.
[a]B: Unstandardized regression coefficient, [b]CI: Confidence Interval, [c]β: Standardized regression coefficient, [d]SPPB: Short Physical Performance Battery (total range: 0-12), [e]MoCA: Montreal Cognitive Assessment (total range: 0-31), [f]HADS: Hospital Anxiety and Depression scale (total range: 0-42).

3.4 Regression analyses of prolonged sedentary time

3.4.1 Bivariate analyses

Table 3.5: Bivariate analyses of the associations between prolonged sedentary time (min) and the SPPB, MoCA and HADS and covariates of severity of stroke (NIHSS), education level, BMI, age and gender. Significant associations are highlighted.

Parameters	B[a]	95% lower CI[b]	95% upper CI	p-value
SPPB[c]	**-19.69**	**-26.38**	**-12.99**	**<0.001**
MoCA[d]	-3.37	-7.87	1.13	0.141
HADS[e]	0.31	-2.92	3.55	0.849
Covariates				
NIHSS[f]	3.87	-1.51	9.26	0.158
Education level	-5.12	-10.71	0.47	0.072
BMI[g]	**5.62**	**0.72**	**10.53**	**0.025**
Age	**2.27**	**0.43**	**4.11**	**0.016**
Gender	5.78	-36.33	47.89	0.787

[a]B: Unstandardized regression coefficient, [b]CI: Confidence Interval, [c]SPPB: Short Physical Performance Battery (total range: 0-12), [d]MoCA: Montreal Cognitive Assessment (total range: 0-31), [e]HADS: Hospital Anxiety and Depression scale (total range: 0-42), [f]NIHSS: National Institutes of Health Stroke Scale, [g]BMI: Body Mass Index.

Bivariate analyses in table 3.5 reported a significant association between prolonged sedentary time and the SPPB ($p<0.001$), indicating prolonged sedentary time to increase with 19.69 minutes to every test point missed in the SPPB. No significant associations were found between prolonged sedentary time and the MoCA ($p=0.141$) or HADS ($p=0.849$), although analysis indicated lower cognitive function and mental health to increase prolonged sedentary time by respectively 3.37 and 0.31 minutes to every test point missed in the MoCA and gained in the HADS.

3.4.2 Multivariable analyses

Multivariable analyses, adjusted for BMI, severity of stroke (NIHSS), educational level, age and gender (Table 3.6), reported a significant association between prolonged sedentary time and the SPPB ($p<0.001$), indicating prolonged sedentary time to increase with 19.05 minutes to every test point missed in the SPPB. No significant association was found between total sedentary time and the MoCA ($p=0.775$), although analysis indicated prolonged sedentary time to increase by 0.74 minutes to every test point missed in the MoCA. No significant association was found between prolonged sedentary time and the HADS ($p=0.800$), and a one point reduction in the HADS (improved mental health) increased prolonged sedentary time by 0.42 minutes. Adjusted R^2 reported each of the regression models to explain 18.9 % (SPPB), 6.8 % (MoCA) and 6.8 % (HADS) of the variance in prolonged sedentary time.

Table 3.6: Multivariable analyses* of the associations between prolonged sedentary time (min) and the SPPB, MoCA and HADS. Significant associations are highlighted.

Parameters	B[a]	95% lower CI[b]	95% upper CI	β[c]	p-value	aR^2
SPPB[d]	**-19.05**	**-26.65**	**-11.45**	**-0.40**	**<0.001**	**0.189**
MoCA[e]	-0.74	-5.89	4.40	-0.03	0.775	0.068
HADS[f]	-0.42	-3.66	2.83	-0.02	0.800	0.068

*The analysis for each parameter was adjusted for NIHSS (National Institutes of Health Stroke Scale), BMI (Body Mass Index), education level, age and gender.
[a]B: Unstandardized regression coefficient, [b]CI: Confidence Interval, [c]β: Standardized regression coefficient
[d]SPPB: Short Physical Performance Battery (total range: 0-12), [e]MoCA: Montreal Cognitive Assessment (total range: 0-31), [f]HADS: Hospital Anxiety and Depression scale (total range: 0-42).

3.5 Secondary analyses of total and prolonged sedentary time

Bivariate analyses (Table 3.7) reported significant associations between total and prolonged sedentary time and the SPPB sub tests of balance, walking speed and the sit-to-stand movement. One point decrease in walking speed reported the highest increase in total and prolonged sedentary time, followed by balance and the sit-to-stand movement. Multivariable analyses (Table 3.8) of total and prolonged sedentary time reported significant associations to balance and walking speed but not the sit-to-stand movement. One point decrease in walking speed indicated the highest increase in both total and prolonged sedentary time, followed by balance and at last the sit-to-stand movement.

Table 3.7: Bivariate analyses of the associations between total and prolonged sedentary time and the sub parameters of SPPB[a] and HADS[b]. Significant associations are highlighted.

	Total sedentary time			Prolonged sedentary time		
Parameters	B[c]	95% CI[d]	p-value	B	95% CI	p-value
Walking speed	**-44.65**	**-(61.33-27.97)**	**<0.001**	**-58.90**	**-(80.01-37.77)**	**<0.001**
Balance	**-29.61**	**-(41.75-17.47)**	**<0.001**	**-35.44**	**-(51.04-19.85)**	**<0.001**
Sit-to-stand	**-18.97**	**-(30.71-7.24)**	**0.002**	**-29.40**	**-(44.11-14.64)**	**<0.001**
Depression	3.97	(-0.984)-8.916	0.116	2.54	(-3.80)-8.88	0.430
Anxiety	1.16	(-3.15)-5.48	0.595	-1.00	(-6.50)-4.50	0.720

[a]SPPB: Short Physical Performance Battery, [b]HADS: Hospital Anxiety and Depression scale,
[c]B: Unstandardized regression coefficient, [d]CI: Confidence interval.

Table 3.8: Multivariable analyses* of the associations between total and prolonged sedentary time and the sub parameters of HADS[a] and SPPB[b]. Significant associations are highlighted.

	Total sedentary time			Prolonged sedentary time		
Parameters	B[c]	95% CI[d]	p-value	B	95% CI	p-value
Walking speed	**-36.17**	**-(55.70-16.64)**	**<0.001**	**-46.61**	**-(71.60-21.62)**	**<0.001**
Balance	**-20.39**	**-(34.30-6.47)**	**0.004**	**-19.37**	**-(37.17-1.57)**	**0.033**
Sit-to-stand	4.64	(-8.92)-18.21	0.500	-4.19	(-21.55)-13.17	0.634
Depression	2.05	(-4.75)-8.85	0.553	1.72	(-7.02)-10.45	0.699
Anxiety	0.22	(-5.48)-5.93	0.938	-2.14	(-9.46)-5.18	0.565

*Each of the analyses were adjusted for NIHSS (National Institutes of Health Stroke Scale), BMI (Body Mass Index), educational level, age and gender.
[a]SPPB: Short Physical Performance Battery, [b]HADS: Hospital Anxiety and Depression scale,
[c]B: Unstandardized regression coefficient, [d]CI: Confidence interval.

Bivariate and multivariable analyses (Table 3.7 and 3.8) of total and prolonged sedentary time reported no significant findings to depression and anxiety, although stronger associations were reported for depression in all analyses. Both depression and anxiety were strongest associated to total sedentary.

4.0 Discussion

4.1 Main findings

The primary aim of the present thesis was to assess how much time individuals three months following stroke spent in sedentary behavior during waking hours, and how physical function, cognitive function, and mental health were associated with total and prolonged sedentary time. Main findings indicated participants to spend 9.7 hours (SD 1.8) [range 4.5-13.8] in sedentary behavior, representing 69 % [range 32-98%] of waking hours. Of this, 5.7 hours (SD 2.3) [range 1.0-13.3] were spent in prolonged sedentary bouts >30 minutes, representing 41 % [range 7-95%] of waking hours. Lower physical function, estimated by the SPPB, was significantly ($p<0.001$) associated to increased total and prolonged sedentary time. Cognitive function and mental health, estimated by the MoCA and HADS, were not significantly associated to sedentary time, although analyses indicated total and prolonged sedentary time to increase while cognitive function and mental health decreased. Findings contradict with the hypothesis, where all three parameters were assumed to be significantly associated with sedentary time.

4.2 Comparison with previous literature

4.2.1 Sedentary time in the stroke population

Several studies have assessed sedentary behavior among stroke survivors. Most frequently, sedentary time has been reported during a 24-hour time period (including sleeping hours) (16, 66-70) or in a limited part of the day (15, 49, 71, 72). Only two studies are found to assess sedentary time during waking hours, similar as in the present thesis (13, 14). Both studies used the ActivPAL activity monitor, and reported stroke survivors to spend 73-75 % of waking hours in sedentary behavior (13, 14), which reflect the 69 % found in the present thesis. English et al. was the only study reporting time spent in prolonged sedentary bouts and indicated stroke survivors to spend 51 % of waking hours in prolonged sedentary bouts (14). This was 10 % more of waking hours than found in the present thesis.

Compared to healthy control groups, previous studies indicate stroke survivors to spend 5-24 % more of their time in sedentary behavior (14, 16, 17). English et al. found stroke survivors to spend 2.7 hours more of waking hours in sedentary bouts compared to healthy controls, and the difference increased to 3.7 hours in prolonged sedentary bouts (14). The present thesis do not have a control group, although, similar findings as in English et al. (14) regarding daily sedentary time, indicate that similar differences may be present in relation to healthy controls.

4.2.2 Predictors associated to sedentary time

4.2.2.1 Physical function

Previous literature has most frequently reported associations between sedentary behaviour and parameters of physical function in stroke survivors, which also have provided the strongest associations. This support findings in the present thesis, where lower physical function was found to be the strongest associated parameter to increased total and prolonged sedentary time. Several parameters have been used to report physical function in previous literature; English et al. found significant associations between increased total, and especially prolonged, sedentary time and lower SIS (Stroke Impact Scale) physical domain score and walking speed. Lower independence in ADL (Activities of Daily Living) was also associated to increased sedentary time (20). Ezeugwu et al. found increased sedentary time to be significantly associated with slower walking speed and fewer daily steps (13). The SPPB test used in the present thesis includes sub-tests of balance, walking speed and the sit-to-stand movement. When separating the SPPB into three parameters in the secondary analyses, slower walking speed was the factor clearly most significant and strongest associated to increased total and prolonged sedentary time. Walking speed has previously been found as an important measure for predicting physical capacity and survival in older adults (73, 74), and findings in the present and previous studies emphasize the importance of improving walking speed in order to decrease sedentary time among stroke survivors (13, 20). Decreased balance was also significantly associated to increased sedentary time in the present thesis. The findings are supported by Alzahrani et al. who found decreased balance, measured by a modified version of the “Single leg-stance test”, to be a predictor for lower free-living physical activity (50). Joseph et al. found significant associations between higher sedentary time and if receiving outpatient rehabilitation had failed (49). This may emphasize the importance of guidance during stroke recovery in order to improve physical function and decrease sedentary behavior.

4.2.2.2 Cognitive function

Two studies are found to explore the association between cognitive function and sedentary time during waking hours (13, 20). As the present thesis, English et al. (20) and Ezeugwu et al. (13) estimated cognitive function using the MoCA. No significant associations between cognitive function and sedentary time were found, which reflect findings in the present thesis. English et al. explain some of the results due to high scores in the MoCA. As much as 78 % of the participants in the study obtained a MoCA score >22/30 points, which was defined as the cut-off to where cognitive impairment was present (20, 75). In the study of Ezeugwu et al., participants obtained a mean MoCA score of 24.3 (SD 4.8), while cognitive impairment was defined as present with ≤ 26 points (13). The mean score reflects the mean MoCA score of 24.4 (SD 4.5) in the present thesis. The elected cut-off score is, however, proclaimed as too high in previous validation studies (75), and rather indicate cognitive impairment to be present at a MoCA score <22/≤22 (75). All the studies mentioned had a mean score above the cut-off of ≤ 22 (75), and 73 % of participants in the present thesis obtained more than 22 points in the MoCA. This may, as English et al. argue, explain some of the insignificant finding between cognitive function and sedentary time, and further studies should possibly aim to include a greater proportion of cognitively impaired participants.

4.2.2.3 Mental health

In addition to the present thesis, English et al. is the only study found to report the association between mental health and sedentary time during stroke survivors' waking hours (20). The study estimated mental health using the SIS emotional domain score. No significant association was found, which correspond to findings in the present thesis. English et al. explain some of the results due to similar reasons as for cognitive function; that mean scores indicated participants to have a rather adequate mental health. In the present thesis, participants had a mean HADS score of 7.4 (SD 6.3) of 42 points, and only 16 % had a score above 14 points, which defined the cut-off to where mild mental impairment was implied as present (62). Alzahrani et al. reported an association between lower mood, measured by the 6-item self-report Short Depression-Happiness Scale, and reduced free-living physical activity (50), which may be an indirect estimate of sedentary behavior. In healthy populations, depression is more strongly associated to increased sedentary behavior than anxiety (33). When investigating separate parameters of depression and anxiety in the present thesis, findings indicated that depression also was the strongest associated factor to sedentary behavior in the stroke population, although still no significant findings were present.

4.3 Methodological aspects, strengths and limitations

4.3.1 Study design

With 170 participants, the present thesis is one of the largest to assess sedentary behavior among stroke survivors (12-14, 20). The large sample size and the objective activity monitoring used to measure sedentary behavior are considered as methodological strengths in the thesis. The cross-sectional study design limits insight in the causal relationships, and further research should focus on longitudinal studies to obtain predictive knowledge regarding factors increasing sedentary behavior.

4.3.2 Measuring sedentary time

4.3.2.1 The absence of energy expenditure

Validation studies proclaim objective activity monitoring as more valid and accurate compared to self-reported questionnaires (51, 76, 77). The ActivPAL provides highly accurate data of postural change (78), and is the most used and best validated activity monitor to estimate sedentary time among stroke survivors (12, 13, 54, 55). However, sedentary behavior is defined by an energy expenditure ≤ 1.5 MET while in a sitting, reclining or lying posture (18), and using the ActivPAL device with inaccurate estimates of energy expenditure, limits analyses to only estimate sedentary behavior based on postural data. Previous literature indicate that physically impaired individuals following stroke require an energy expenditure of approximately two times the amount of healthy controls when doing similar activities (79, 80). Postural data alone may therefore overestimate sedentary behavior by including sitting time with an energy expenditure >1.5 MET. The aspect proclaim the possibility of errors in the estimated sedentary time, and emphasize the importance of including energy expenditure.

4.3.2.2 Defining waking hours

Sedentary behavior is also defined during waking hours (18), and therefore from where sedentary time should be reported. A single ActivPAL device does not distinguish between sitting and lying because the device reports posture based on the thigh's position, which is horizontal in both positions. This, combined with no self-reported sleeping diaries in the present thesis (53, 81-83), challenged the opportunity for an accurate estimation of individual waking hours. Previous studies used sleeping diaries to estimate individual waking hours (14, 20), or to perform quality assurance of waking hours estimated by a custom made algorithm (13). The algorithm used in Ezeugwu et al. is described in Winkler et al. (81), and is the second attempt to make a valid automated estimation method of waking hours (82). The two methods are validated in detecting accurate waking hours among adult people. Still, both studies emphasize limitations due to elderly, mobility-impaired and highly sedentary populations (81, 82).

The stroke population fit all the three limitation-aspects, and since sleeping diaries were not included in the present thesis, waking hours were defined within a fixed time period between 08.00 and 22.00. The time period was based on visual inspection of a random sample of data files. The method may have caused some random error in the data. For instance is the amount of sedentary time excluded and sleeping time included, unknown. Nevertheless, without sleeping diaries as quality assurance, this was assumed to be the most valid method to define waking hours, and similar methods have been used previously (84). Additionally, inspection of the data files proclaimed a great proportion of the participants to have bad sleeping patterns with multiple awakenings through the night. Sleep disturbances are common in stroke survivors (85, 86), and would have caused further challenges in the attempt to develop a valid algorithm. The high sample size is assumed to minimize the random errors in the data. Also, the fixed 14 waking hours in the present study are approximately similar to the mean waking hours reported in Ezeugwu et al. and English et al., of respectively 15 and 14.2 hours (13, 14).

4.3.2.3 Using the ActivPAL software

The pre-classified ActivPAL software used to download and export the ActivPAL data files in the present thesis, contains of a black box algorithm (53), and what is actually done with the data is unknown (53). This may be seen as a methodological limitation, although several studies using the ActivPAL also utilize this software (13, 14, 20). The similarities in data processing may therefore become a strength in order to compare results across literature.

4.3.3 Measuring parameters

The SPPB, MoCA and HADS are all well-validated tests and questionnaires for estimating respectively physical and cognitive function and mental health (58, 59, 63). Still, they are only estimates, and provide a restricted interpretation of reality. Mental health, and especially cognitive function may be considered as more abstract than physical function, and providing sufficient estimates may be particularly challenged (87). The MoCA aims to detect the cognitive domains of attention, concentration, executive functions, memory, language, visuo-constructional skills, conceptual thinking, calculation and orientation (58). Executive functions include the ability to initiate to and control actions (88, 89), and may be crucial in the attempt to reduce sedentary behavior. In the MoCA, executive functions are estimated based on a short trail-making test (Appendix B). The test provides insight in the participants' executive functions. Still, several aspects will remain unknown (87), and the association between the MoCA and sedentary behaviour may be restricted. Further research should aim to provide more thorough estimates of the cognitive domains in order to detect the true relationships between sedentary behavior and the various aspects of cognitive function, which may be crucial in reducing sedentary behavior among some stroke survivors.

4.3.4 Generalizability

The studies of English et al. and Ezeugwu et al. included home-dwelling participants at least six months following stroke (mean 4.4 years, SD 10), and 3.6 (SD 1.1) months following stroke, and excluded the most physically and cognitively impaired individuals (13, 14, 20). The present thesis aimed to include all individuals, regardless of their physical and cognitive abilities. This indicate the present thesis to be one of the most diverse and generalized studies so far assessing sedentary behavior among stroke survivors. Three months following stroke is considered as the earliest stage where long-term survival can be predicted (56), and as the present thesis includes participants three months following stroke, it may provide crucial information about participants long-term prognosis, and possibly, behavior.

Still, as much as 230 participants from St. Olavs Hospital did not reach the inclusion criteria of a complete test battery (figure 3.1). When comparing background data from table 3.1, the included participants were found to be five years younger, have a milder stroke, have 20 % higher pre-stroke global function and include 12.8 % less females, compared to the not included group. The significant differences in several physical measurements may indicate that the efforts required to complete the test battery were impracticable for participants with lower physical and/or cognitive capacity. The intended generalizability in the thesis is therefore questionable, as the most impaired stroke survivors may not have been included after all.

4.3.5 The need of different strategies

Nevertheless, the included participants may be the stroke survivors most susceptible to behavioral change, and particularly the most sedentary participants (figure 3.2) would benefit in strategies to reduce and break up prolonged sedentary time. The least sedentary (i.e. most active) participants, on the other hand, would provide the greatest health benefits by increasing their activity intensity level. Of the individuals not included, several are assumed to be highly sedentary, and strategies to reduce and break up prolonged sedentary time would probably be health beneficial also in this group, although a more comprehensive approach may be crucial to succeed. The first attempt to reduce sedentary time among stroke survivors has already been conducted by English et al. (90). The randomized controlled trial focused on verbal counseling (91), and decreased daily sedentary time by more than 30 minutes in the intervention group – and in the control group (90). The study was found as safe and feasible to reduce sedentary time among stroke survivors, and is a promising start in the process of developing strategies to reduce sedentary behavior in the diverse stroke population.

4.4 Conclusion

The present thesis found sedentary behavior to be highly diverse in individuals three months following stroke. Lower physical function, and especially lower walking speed, tend to be strongly associated with increased total and prolonged sedentary time. Cognitive function and mental health showed insignificant associations to both total and prolonged sedentary time. The current findings suggest that improved physical function, and especially improved walking ability, may be important in the attempt to reduce and break up prolonged sedentary time in the stroke population. Still, the causal relationships are unknown, and longitudinal studies are needed for further insight. Additionally, as stroke survivors are highly diverse in both functional- and activity level, different and individualized strategies may be essential to improve health and reduce recurrent strokes in the overall stroke population in the future.

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Appendix A: MATLAB scripts

Script 1: Creating new ActivPAL event files

⇒ Import original ActivPAL event files into MATLAB.

⇒ Import excel spreadsheet file with dates for valid ActivPAL data.

ID-nr	Reelle data		Antall hele døgn	Kommentar
	Fra	Til		
B400014	25. sep.. 2015	29. sep.. 2015	4	Aktiviteten er redusert vel
B400015	6. okt.. 2015	12. okt.. 2015	6	
B400020	17. nov.. 2015	23. nov.. 2015	6	
B400022	14. okt.. 2015	20. okt.. 2015	6	

Figure 1: The Excel spreadsheet with valid dates. The first date represent first day with monitoring from 08.00. The last date is the last monitoring day until 08.00. Monitoring after 08.00 on the last date is not included.

⇒ Remove ActivPAL data not included in the excel spreadsheet from event files.

⇒ Compress event files:

- o Remove columns of unnecessary data.
- o Stepping events (ActivityCode = 2) are compressed from counting every single step, to count only the length of each walking interval in seconds.

Time	DataCount (samples)	Interval (s)	ActivityCode (0=sedentary, 1= standing, 2=stepping)	CumulativeStepCount	Activity Score (MET.h)	Abs(sumDiff)
15:59:47	0	3834,1	0	0	1,331285	5385
17:03:41	38341	6,2	1	0	2,41E-03	402
17:03:47	38403	3,5	2	1	2,08E-03	328
17:03:51	38438	7,8	1	1	3,03E-03	776
17:03:59	38516	1,5	2	2	1,31E-03	323
17:04:00	38531	1,7	2	3	1,38E-03	511
17:04:02	38548	2,4	2	4	1,66E-03	1121
17:04:04	38572	4,1	2	5	2,32E-03	1059
17:04:08	38613	1,5	2	6	1,31E-03	290
17:04:10	38628	3,3	2	7	2,01E-03	483
17:04:13	38661	5,4	2	8	2,82E-03	770
17:04:19	38715	1,8	2	9	1,42E-03	171
17:04:20	38733	9	1	9	0,0035	1057
17:04:29	38823	1,6	2	10	1,34E-03	281

Figure 2: Original ActivPAL event file.

Time	Intervals(s)	ActivityCode(0=seden.,1=stand,2=stepp.
25.09.2015	783,999995	0
25.09.2015	83	1
25.09.2015	176	0
25.09.2015	119	1
25.09.2015	2	2
25.09.2015	140	1
25.09.2015	81	0

Figure 3: New ActivPAL event file.

⇒ Export new ActivPAL event files

Script 2: Extracting sedentary bouts between 08.00-22.00

⇒ Import new ActivPAL event files

⇒ In each new ActivPAL event file: Find duration (seconds) and number of sedentary bouts (ActivityCode = 0) between 08.00 and 22.00.

⇒ Place sedentary bouts into four different duration categories, separately for each day:

1: ≥ 10 sec. to <30min.
2: ≥ 30 min. to <60min.
3: ≥ 60 min. to <90min.
4: ≥ 90 min.

⇒ Export a collected Excel file with duration and number of sedentary bouts per day:

ID	D1Z1N	D1Z1T(s)	D1Z2N	D1Z2T(s)	D1Z3N	D1Z3T(s)	D1Z4N	D1Z4T(s)
B400014	34	13837	4	11987	0	0	1	5555
B400015	60	20539	1	1906	2	7901	1	9623
B400020	33	16394	3	7514	2	8196	0	0
B400031	28	12785	2	5128,99999	0	0	1	5949
B400033	28	8607	4	10681	2	9641	1	9343
B400035	25	10511	4	10293	1	3685	3	19613
B400036	23	8813	6	14099	3	14436	0	0
B400038	56	17214	4	8731	1	4147	0	0

Figure 4: The collected file of exported sedentary data during the first day (D1).

- First column present participants ID-number.
- Column 2, 4, 6 and 8 present number (N) of sedentary bouts within the four duration categories (Z1-Z4) during the first day (D1).
- Column 3, 5, 7 and 9 present duration in seconds (T(s)) of the total number of bouts within each duration category (Z1-Z4) during the first day (D1).

D2Z1N	D2Z1T(s)	D2Z2N	D2Z2T(s)	D2Z3N	D2Z3T(s)	D2Z4N	D2Z4T(s)
52	17242	2	5269	3	11741	0	0
52	18758	6	14929	2	8504	0	0
38	14440	5	12393	2	7692	0	0
30	10475	2	5749	2	9870	0	0
9	6602,99999	2	4906	0	0	4	32635
23	11940	6	14175	1	5032	2	11521
19	6944	2	6595	2	7909	3	19165
36	12276	3	6614	2	8746	0	0

Figure 5: Number (N) and total duration in seconds (T(s)) of sedentary bouts within the four duration categories (Z1-Z4) during day two (D2) from the collected file.

Appendix B: MoCA

MONTREAL COGNITIVE ASSESSMENT (MOCA) norsk versjon 7.3.

Metode for innhenting av data:

- ☐ Klinisk undersøkelse
- ☐ Telefonintervju (start ved 5.)
- ☐ Testbar
- ☐ Ikke testbar

Årsak til ikke testbar:

- ☐ Afasi
- ☐ Redusert bevissthet
- ☐ Medisinsk ustabil
- ☐ Forstår ikke norsk
- ☐ Redusert kognitiv funksjon
- ☐ Demens

Annen årsak: ______________________________

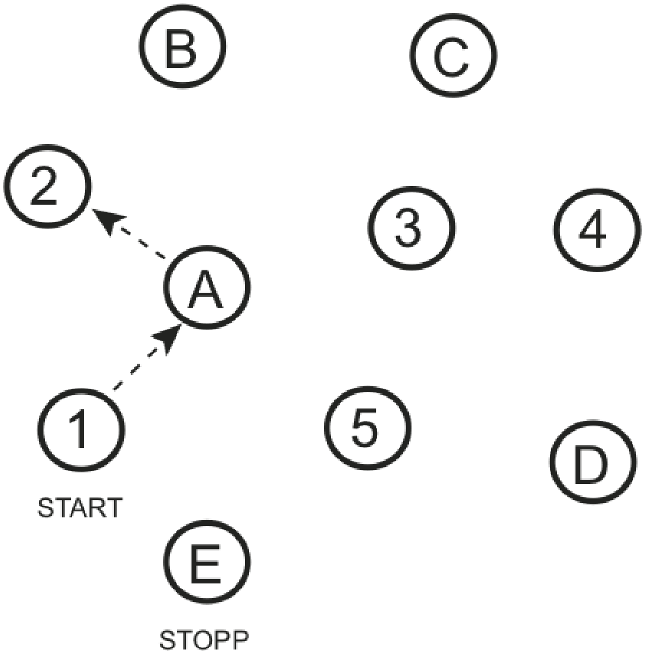
	POENG
1., 2. og 3. VISUOKONSTRUKTIV/EKSEKUTIV (utføres på eget ark) ☐ 1A2B… ☐ Kopier sylinder Tegn en klokke (ti over ni) ☐ Kontur ☐ Tall ☐ Visere	/5
4. BENEVNING Esel/muldyr ☐ Gris/svin ☐ Kenguru ☐	/3
5. HUKOMMELSE Les ordene, forsøksperson må gjenta dem. Gjør to forsøk, selv om første forsøk gjennomføres helt riktig. Gjør gjenkalling etter 5 minutter.	ingen poeng

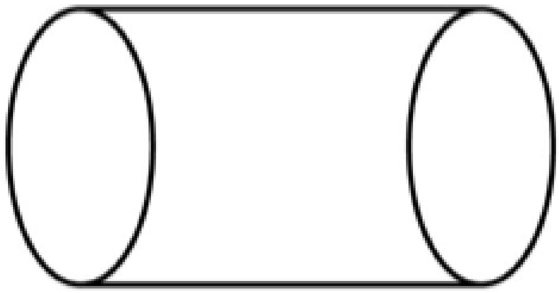
	TOG	EGG	HATT	STOL	BLÅ
1e forsøk					
2e forsøk					

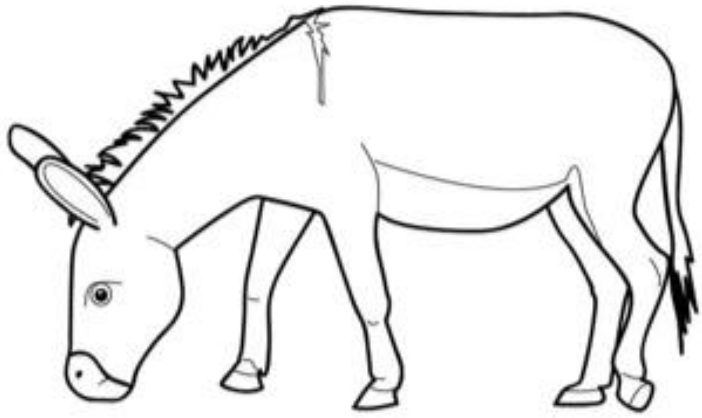
	POENG
6. OPPMERKSOMHET Les rekken med tall (1 tall/sekund) Forsøksperson skal gjenta i samme rekkefølge ☐ 5 4 1 8 7 Forsøksperson skal gjenta i baklengs rekkefølge ☐ 1 7 4	/2
Les listen med bokstaver. På hver bokstav A skal forsøkspersonen banke på bordet med hånden sin. Ingen poeng ved 2 feil ☐ F B A C M N A A J K L B A F A K D E A A A J A M O F A A B	/1
Seriell subtraksjon med 7, begynnende med 80 ☐ 73 ☐ 66 ☐ 59 ☐ 52 ☐ 45 4 eller 5 riktig: 3 png 2 eller 3 riktig: 2 png 1 riktig: 1png 0 riktig: 0 png	/3
7. SETNINGSREPETISJON Hun fikk vite at det var advokaten som tok ut søksmål ☐ De små jentene som ble gitt for mye godteri fikk vondt i magen ☐	/2
8. ORDFLYT Si så mange ord du kan komme på som begynner med B innenfor ett minutt Antall ord: ☐ ☐ (N ≥ 11 ord)	/1
9. LIKHETER Likhet mellom for eksempel en banan og en appelsin=frukt ☐ øye-øre ☐ trompet-piano	/2
10. UTSATT GJENKALLING	/5

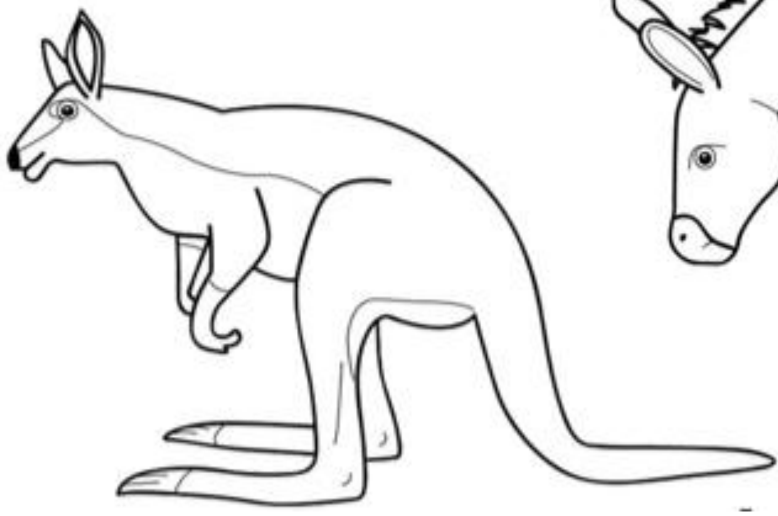
Kun poeng for gjenkalling uten stikkord.	TOG	EGG	HATT	STOL	BLÅ
	☐	☐	☐	☐	☐

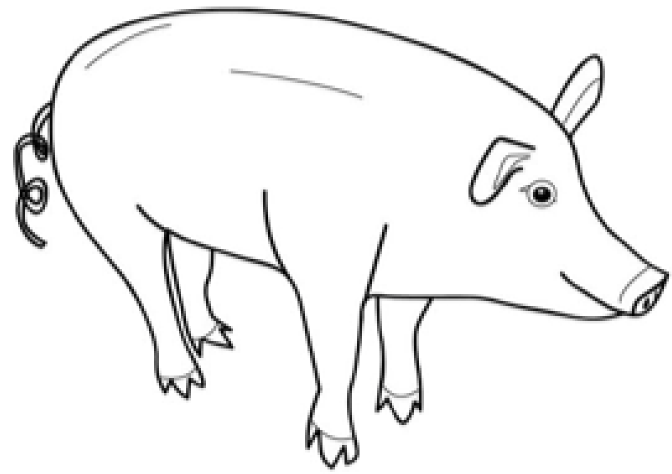
	POENG
11. ORIENTERING ☐ Dato ☐ Måned ☐ År ☐ Ukedag ☐ Sted ☐ By	/6
Normal ≥26/30 Total skår Legg til 1 poeng dersom ≤ 12 år utdanning	/30


B
C
2
3
4
A
1
5
D
START
E
STOPP









Appendix C: SPPB

1. Balansetest

☐ Gjennomført: ☐ Ikke i stand ☐ Missing

2.Samlede føtter
10 sekunder

↓

3.Semi-Tandem
10 sekunder

↓

4.Tandem
10 sekunder

2.	☐☐ (min)	☐☐ (sek)	☐☐ (tideler)
3.	☐☐ (min)	☐☐ (sek)	☐☐ (tideler)
4.	☐☐ (min)	☐☐ (sek)	☐☐ (tideler)

2.a Reise/ sette seg x 1

☐ Gjennomført: ☐ Ikke i stand ☐ Missing

2.b Reise/ sette seg x 5

☐ Gjennomført: ☐ Ikke i stand ☐ Missing

Tid 5 repetisjoner uten armbruk	☐☐ (min)	☐☐ (sek)	☐☐ (tideler)
Tid 5 repetisjoner med armbruk (hvis deltager ikke klarer uten armbruk)	☐☐ (min)	☐☐ (sek)	☐☐ (tideler)

3. 4m Gangtest

☐ Gjennomført: ☐ Ikke i stand ☐ Missing

Hvis mulig gjennomføres testen uten ganghjelpemidler

Ganghjelpemidler ved test (kryss av):

1. ☐ Uten
2. ☐ Krykke/stokk (er)
3. ☐ Rullator
4. ☐ Annet (spesifiser)____________________

Tid test 1:	☐☐ (min)	☐☐ (sek)	☐☐ (tideler)
Tid test 2:	☐☐ (min)	☐☐ (sek)	☐☐ (tideler)

Appendix D: HADS

HADS kan kun besvares av den slagrammede

Nedstemthet og engstelse er vanlig etter et slag. Her kommer noen spørsmål om hvordan du føler deg. For hvert spørsmål setter du kryss for ett av de fire svarene som best beskriver dine følelser ***den siste uken***. Ikke tenk for lenge på svaret – de spontane svarene er best.

1. Jeg føler meg nervøs og urolig

- ☐ 3 Mesteparten av tiden
- ☐ 2 Mye av tiden
- ☐ 1 Fra tid til annen
- ☐ 0 Ikke i det hele tatt

2. Jeg gleder meg fortsatt over tingene slik jeg pleide før

- ☐ 0 Avgjort like mye
- ☐ 1 Ikke fullt så mye
- ☐ 2 Bare lite grann
- ☐ 3 Ikke i det hele tatt

3. Jeg har en urofølelse som om noe forferdelig vil skje

- ☐ 3 Ja, og noe svært ille
- ☐ 2 Ja, ikke så veldig ille
- ☐ 1 Litt, bekymrer meg lite
- ☐ 0 Ikke i det hele tatt

4. Jeg kan le og se det morsomme i situasjoner

- ☐ 0 Like mye nå som før
- ☐ 1 Ikke like mye nå som før
- ☐ 2 Avgjort ikke som før
- ☐ 3 Ikke i det hele tatt

5. Jeg har hodet fullt av bekymringer

- ☐ 3 Veldig ofte
- ☐ 2 Ganske ofte
- ☐ 1 Av og til
- ☐ 0 En gang i blant

6. Jeg er i godt humør

- ☐ 3 Aldri
- ☐ 2 Noen ganger
- ☐ 1 Ganske ofte
- ☐ 0 For det meste

7. Jeg kan sitte i fred og ro og kjenne meg avslappet

- ☐ 0 Ja, helt klart
- ☐ 1 Vanligvis
- ☐ 2 Ikke så ofte
- ☐ 3 Ikke i det hele tatt

8. Jeg føler meg som om alt går langsommere

- ☐ 3 Nesten hele tiden
- ☐ 2 Svært ofte
- ☐ 1 Fra tid til annen
- ☐ 0 Ikke i det hele tatt

9. Jeg føler meg urolig som om jeg har sommerfugler i magen

- ☐ 0 Ikke i det hele tatt
- ☐ 1 Fra tid til annen
- ☐ 2 Ganske ofte
- ☐ 3 Svært ofte

10. Jeg bryr meg ikke lenger om hvordan jeg ser ut

- ☐ 3 Ja, jeg har sluttet å bry meg
- ☐ 2 Ikke som jeg burde
- ☐ 1 Kan hende ikke nok
- ☐ 0 Bryr meg som før

11. Jeg er rastløs som om jeg stadig må være aktiv

- ☐ 3 Uten tvil svært mye
- ☐ 2 Ganske mye
- ☐ 1 Ikke så veldig mye
- ☐ 0 Ikke i det hele tatt

12. Jeg ser med glede frem til hendelser og ting

- ☐ 0 Like mye som før
- ☐ 1 Heller mindre enn før
- ☐ 2 Avgjort mindre enn før
- ☐ 3 Nesten ikke i det hele tatt

13. Jeg kan plutselig få en følelse av panikk

- ☐ 3 Uten tvil svært ofte
- ☐ 2 Ganske ofte
- ☐ 1 Ikke så veldig ofte
- ☐ 0 Ikke i det hele tatt

14. Jeg kan glede meg over gode bøker, radio og TV

- ☐ 0 Ofte
- ☐ 1 Fra tid til annen
- ☐ 2 Ikke så ofte
- ☐ 3 Svært sjelden