Physical activity and stroke

– *Associations and patient experiences*

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Abstract

Background: Insufficient physical activity is a global problem and a risk factor for stroke. Furthermore, physical activity is often reduced after stroke, and many patients are physically inactive in stroke units.

Aim: To explore the association between pre-stroke physical activity and stroke severity, cognition, and health-related quality of life, as well as patient experiences of physical activity and inactivity in the stroke unit.

Methods: One qualitative interview and three register-based quantitative studies were conducted. The register-based studies included between 925─2,044 patients with first stroke treated at three stroke units in one Swedish hospital between the years 2014 and 2018. In this qualitative study, 16 patients from eight Västra Götaland Region hospitals were interviewed. Statistics were mostly regression analyses, while interviews were analysed using thematic analysis.

Results and conclusions: Higher levels of pre-stroke physical activity were associated with less acute stroke severity, a higher odds ratio for intact cognition during hospital stay, and better health-related quality of life 3 months after stroke than pre-stroke inactivity. Light physical activities, including walking for at least 4 h/week and moderate physical activities for at least 2–3 h/week were associated with positive stroke outcomes. In the in-depth interviews, patients with stroke said that physical activity in the stroke unit help them regain independence, be seen, and choose between solitude and social connection. The interviewees wanted to explore familiar activities in new ways and for the stroke unit staff to focus on patients with stroke rather than their daily routines.

Keywords: Stroke, physical activity, exercise, sedentary behaviour, stroke unit care

Sammanfattning på svenska

Bakgrund: Denna sammanläggningsavhandling omfattar tre registerstudier och en intervjustudie om fysisk aktivitet och stroke.

Syfte: Att undersöka samband mellan fysisk aktivitet före stroke och olika konsekvenser efter stroke, nämligen akut svårighetsgrad av stroke, kognition under sjukhusvistelsen och hälsorelaterad livskvalitet efter tre månader samt att beskriva erfarenheter av fysisk aktivitet och inaktivitet för personer som nyligen vårdats på en strokeenhet.

Metod: De tre registerstudierna inkluderade personer som vårdats på någon av Sahlgrenska Universitetssjukhusets tre strokeenheter med förstgångsinsjuknande i stroke. Data mellan åren 2014 och 2018 analyserades där antalet patienter varierade mellan 925 och 2044 personer. Statistiskt användes främst regressionsanalyser i de tre kvantitativa registerstudierna. Intervjustudien omfattade 16 djupintervjuer. Personer från åtta strokeenheter i Västra Götalandsregionens intervjuades en till två veckor efter utskrivning. Deltagare med en variation i ålder, kön och svårighetsgrad av stroke inkluderades. Intervjuerna analyserades med tematisk analys.

Resultat och konklusion: Fysisk aktivitet före stroke har samband med mindre neurologiskt bortfall vid akut stroke, högre odds för bevarad kognition bedömd under sjukhusvistelsen samt bättre hälsorelaterad livskvalitet tre månader efter stroke. Sambandet gällde för både lätt fysisk aktivitet såsom promenader minst fyra timmar/vecka och måttlig fysisk aktivitet såsom träning minst två till tre timmar/vecka. Intervjustudien visar att rörelse på strokeenheten betyder mer än bara fysisk aktivitet för personer efter stroke. Det beskrivs också att man får en känsla av att bli sedd och respekterad när man är uppe på benen. De berättar om den starka drivkraften att återfå självständighet och att man vill nyttja de resurser man har vid rörelse och vardagliga aktiviteter. Deltagare beskriver vikten av att vara delaktig, att ses som en individ med egna behov och önskemål. Det sägs att det är träning som gäller för att bli bättre. Personer efter stroke efterfrågar en strokeenhet där patienten är i centrum och där man får individualiserad vård och rehabilitering.

List of Papers

This thesis is based on the following papers, referred to in the text by their Roman numerals.

I. Reinholdsson, M, Palstam, A, Sunnerhagen, KS.

   Prestroke physical activity could influence acute stroke severity (part of PAPSIGOT)

   Neurology 2018; 91: e1461–e1467.

II. Reinholdsson, M, Abzhandadze, T, Palstam, A, Sunnerhagen, KS.

   A register-based study on associations between pre-stroke physical activity and cognition early after stroke (part of PAPSIGOT)

   Scientific Reports 2022; 12: 5779

III. Reinholdsson M, Palstam A, Jood K, Sunnerhagen KS.

   Associations between pre-stroke physical activity levels and health-related quality of life 3 months after stroke: A registry-based study (part of PAPSIGOT).

   International Journal of Stroke. 2023 Jun 12:17474930231184367.

IV. Reinholdsson, M, Herranen, G, Sunnerhagen, KS, Palstam, A.

   There is more to movement than physical activity. Patients´ experiences on physical activity and inactivity at the stroke unit: A qualitative interview study.

   Submitted manuscript 2023.

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Abbreviations

BMI	Body Mass Index
CI	Confidence Interval
GDPR	General Data Protection Regulation
HRQOL	Health-related quality of life
NIHSS	National Institute of Health Stroke Scale
MoCA	Montreal Cognitive Assessment
OR	Odds Ratio
SGPALS	Saltin-Grimby Physical Activity Level Scale
SFS	Swedish Code of Statues
SU	Sahlgrenska University Hospital
TIA	Transient Ischemic Attck
VGR	Region Västra Götaland
WHO	World Health Organization

Definitions in short

Cognitive function:	Mental action or acquiring knowledge and understanding through thought, experience, and the senses.
Exercise	A subset of physical activity that is planned, structured, and repetitive, to improve or maintain physical fitness.
Health	A state of physical, mental, and social well-being not merely the absence of disease.
Health-related quality of life	Perceived physical and mental health over time in individuals and groups.
Ischaemic stroke	Neurological dysfunction caused by focal cerebral, spinal, or retinal infarctions.
Intracerebral haemorrhage	Neurological dysfunction caused by focal blood collection within the brain not caused by trauma.
Physical activity	Any bodily movement produced by skeletal muscles that results in energy expenditure.
Physical inactivity	Insufficient physical activity levels to meet international recommendations (1).
Rehabilitation	A process of active change by which a person who has become disabled acquires the knowledge and skills needed for optimal physical, psychological, and social functioning.
Sedentary behaviour:	Any awake behaviour characterised by low energy expenditure, such as sitting, reclining, or lying.
Stroke	Sudden focal symptoms lasting > 24 h.

Preface

As a physiotherapist at Mölndals hospital my profession has taken me along a circular path. I began working in a medical ward in combination with cardiac rehabilitation in 1992. At the cardiac rehabilitation clinic outpatients attended lectures and exercises where we actively promoted healthy lifestyles. There was a close collaboration with the patient organisation. In the medical ward, I encountered patients with minor strokes and transient ischaemic attack (TIA). Then, patients with TIA went home or were sent home after visiting the emergency room. The patients with stroke went to the stroke unit (opened in 1994), where I only worked occasionally. In 1997 four Gothenburg hospitals were merged into one hospital across four sites. Thereafter I worked in the geriatric ward, with patients with moderate-to-severe stroke who required care for ≥1 month. After moderate-to-severe stroke, rehabilitation could take 3–6 months. Now, the Gothenburg stroke units have a median stay of 7 days. When I started, we knew patients, their spouses, children, and, sometimes, friends. We made home visits even if it required a ferry ride to an archipelago island. In 2006, geriatric rehabilitation and the geriatric ward were integrated into the stroke unit. Later, the hospital refocused on health enhancement and disease prevention, and work with lifestyle behaviours returned to my clinical repertoire. Patients with minor stroke and TIA were prioritised and investigated in the hospital, and secondary prevention was back on my table. My circle was closed.

My story is also personal. Several of my family members have experienced stroke. My grandfather had repeated stroke, and several aunts and uncles currently live with the consequences of stroke. My grandfather started to smoke at 6 years (!), a status symbol between the two world wars. He used his car, avoided physical activity, and did not take antihypertensive medications. He has taught me how to draw, write, and sing. We were very close. When I was 17 years old, he had his first stroke and ended up in a wheelchair with left hemiparesis and aphasia. Therefore, if anyone in the family, my town, or anywhere else adopts a healthier lifestyle and decreases the risk of having stroke or a less severe stroke because of this thesis, I will be most grateful.

1. Introduction

Physical inactivity is a global pandemic. Physical inactivity is associated with non-communicable diseases including stroke (2). Insufficient physical activity affects one in four adults and three in four adolescents globally (3). The World Health Organization (WHO) has a global action plan to reduce physical inactivity by 15% by 2030 (2).

Healthcare resources should prioritise primary prevention to address the high burden of stroke (4). Global and national efforts are underway to reduce non-communicable diseases and stroke (4). Many middle-, low-, and high-income countries have increasing age-standardised rates of cardiovascular disease, the leading cause of disease worldwide (5). Development Goal 3, ‘Good Health’ of the WHO, promotes health for all ages. The goal is to reduce premature mortality from non-communicable diseases by 30% by 2030. Implement cost-effective policies and interventions, increase awareness of good health and healthy lifestyle, and provide healthcare to everyone (5). The World Stroke Organization developed guidelines for a continuum of stroke care (6).

Stroke unit care with early rehabilitation, including physical activity, is highly recommended (7). However, international studies reported that hospitalised patients spend most of their days in bed and rooms (8, 9, 10, 11, 12). Inadequate physical inactivity in stroke units can be referred to older age, more severe strokes (13), and insufficient staff. The stroke unit design can also promote or hinder movement (14). One reason for physical inactivity later after stroke can be slow walking speed, but can only explain parts of the story, and other factors remain uninvestigated (15).

1.1 Stroke

The global burden of stroke remains high in a growing and aging population. Stroke was the second and third leading cause of death and disability worldwide in 2019 (4, 16). One in four patients are estimated to have stroke during their lifetime (17). Mortality rates have decreased more than incidence rates, indicating that treatment has been more successful than prevention (4). Globally, the incidence of ischaemic stroke has increased, and the incidence increases with age, especially in women aged 50-69 years (18).

1.1.1 Definition and stroke types

According to the World Health Organization, stroke is the rapid development of clinical signs of focal (or global) impairment of brain function, lasting >24 h or leading to death, with no apparent cause other than vascular origin (19). An updated definition includes cell death attributable to ischaemia in the brain, spinal cord, or retinal cell death, which can be a radiological finding or clinical symptom (20).

The three stroke subtypes are ischaemic, haemorrhagic, and subarachnoid. According to the updated definition, ischemic stroke is 'an episode of neurological dysfunction caused by focal cerebral, spinal, or retinal infarction'; intracerebral haemorrhage is 'a focal collection of blood within the brain parenchyma or ventricular system but is not caused by trauma', and subarachnoidal haemorrhage is 'rapidly developing signs of neurological dysfunction and headache because of bleeding into the subarachnoid space, which is unrelated to trauma' (20). Globally, 62% of strokes are ischemic, 28% haemorrhagic, and 10% subarachnoid (4). In Sweden, the corresponding rates were 72%, 18 %, and 11% for ischaemic stroke, haemorrhagic stroke, and subarachnoid haemorrhage, respectively (4). The National Swedish Stroke Registry, Riksstroke reports that 88% of patients with stroke have ischaemic stroke, and 12% have cerebral haemorrhage, while subarachnoid haemorrhage is registered optionally and excluded in the overall registry's statistics (21, 22). Subarachnoidal haemorrhage is not covered in this thesis.

1.1.2 Burden of stroke

In 2019, the global incidence of stroke was 12.2 million cases, and stroke prevalence was 101.5 million, resulting in 6.6 million stroke-related deaths (4). The global stroke incidence increased by 70%, its prevalence by 85%, and deaths by 43% between 1990 and 2019, while age-standardised incidence rates decreased (4). National differences show that lower- and middle-income countries have a higher stroke burden than high-income countries (4). Over the past 20 years, the incidence and prevalence rates of stroke have decreased in people aged > 70 years; however, over the last decade, these rates have increased in people aged < 70 years (4).

Worldwide, stroke prevalence is higher in men aged < 85 years, although women aged > 85 years have a higher incidence (23). In a global study, 5–10% of patients with stroke were < 45 years (24). In Sweden, stroke risk increases with age, and > 80% of incident strokes occur in individuals aged ≥ 80 years (25). An international study in 2019 reported that Sweden had 15,700 cases of stroke, with a prevalence of 176,300 cases and 8,400 deaths, with lower age-standardised rates from 2009 to 2019 (4). The National Swedish Stroke Registry (Riksstroke) recorded 20,200 incidents in 2021, 20% of which were recurrent strokes (22). In Sweden, the incidence of stroke and recurrent stroke has decreased over the past decade. The mean age at which stroke occurs in Sweden is 75 years, with women being 4 years older than men at the time of occurrence (22).

1.1.3 Stroke registers

Swedish healthcare is tax-funded and available to all citizens. Quality registers are common in Sweden and used as data sources for the quality of care and research. Swedish identification numbers are unique to every citizen; therefore, data from different registers can be merged into larger datasets containing the requested information. Data from the registers comprise most people with a diagnosis, and a consecutively collected cohort lowers the risk of selection bias. Quality registers aim to improve stroke care quality. (26). Furthermore, they provide an opportunity to conduct research studies on large cohorts with the possibility of generalising the results within similar healthcare contexts.

There is a national stroke register, Riksstroke (26) which contains data on all patients with stroke, regardless of the hospital or ward in Sweden. The register included acute and follow-up forms after 3 and 12 months. Riksstroke has good coverage, estimated to be 87% in the acute form and 78% in a 3-month follow-up survey (25). The variables in Riksstroke were validated (27).

Väststroke (https://www.gu.se/strokecentrumvast/vaststroke) comprises patients who receive care at three stroke units at SU: Mölndal, Sahlgrenska, and Östra Hospital. The register has an acute form and forms for 3 months. These variables are complementary to the Riksstroke variables. There have been no reports on the coverage. However, more than 95% of patients with stroke are cared for in stroke units (25) where dedicated nurses register data. In addition, occupational, physiotherapists, and speech and language therapists registered variables related to function and rehabilitation in Väststroke.

1.1.4 Risk factors and causes for stroke

Population growth, aging, and risk factors exposure contribute to the global stroke burden (4). Risk factors for stroke are metabolic risk factors, including hypertension, obesity, hyperglycaemia, and hypercholesterolaemia; behavioural factors, including smoking, unhealthy diet, and physical inactivity; and environmental risks, including air pollution and lead exposure (28). Obesity is the fastest- growing stroke risk factor, and hypertension is the most important risk factor (4). High blood pressure (BP), obesity, hyperglycaemia, pollution, and smoking were the five most important stroke risk factors in 2019 (4). Ten modifiable risk factors account for 90% of all strokes worldwide, including hypertension, physical inactivity, high blood lipids, unhealthy eating habits, increased waist-to-hip-ratio, psychosocial factors, smoking, cardiac causes, alcohol consumption, and diabetes in order of importance (29). However, risk factors relevance varies by study timeline, geography, and risk factors selection(29).

1.1.5 Stroke prevention

Effective primary prevention must be implemented as the global stroke burden increases (4). Primary stroke prevention should involve patients, healthcare, populations, and governments (30). Stroke can be prevented by reducing modifiable risk factors, as supported by several large international studies (4, 28, 31). This aligns with the call for stroke prevention by the WHO (32) and the European Stroke Organization, with an action plan that includes stroke prevention as a prioritised area (33). With better prevention measures, healthcare resources can focus on stroke patients who need it the most (33). Secondary prevention is internationally recommended and can reduce the burden of stroke by a fourth (34). Secondary prevention includes the promotion of healthy lifestyle behaviours, in which risk factors can be targeted with both medication and lifestyle behaviour changes (35, 36, 37). Moderate and high levels of physical activity can reduce the risk of ischaemic and haemorrhagic stroke, with 25% reported in a meta-analysis when highly active individuals were compared with inactive individuals (38). Physical activity can also reduce several negative consequences of stroke (39). Interventions to promote healthy lifestyle behaviours include counselling, patient education, and risk factor management, which can be provided by health professionals in the stroke team (40). Lifestyle behaviours and health promotion are important in primary care, hospital care, and follow-up on a continuum of care (41).

Physiotherapy and prevention

Physical activity is essential for maintaining good health, and regular physical activity reduces the risk of several non-communicable diseases (42). Healthcare counselling and support for healthy lifestyle behaviours, including increased physical activity, should be provided to individuals at risk (41). All healthcare staff can promote physical activity; however, physiotherapists have more advanced knowledge, particularly when physical activity needs to be adjusted for different conditions and diseases (43). Integrating health protection in clinical practice for physiotherapists is a line of work that needs to be developed and applied in all physiotherapy practices, not only for patients with cardiovascular disease and stroke (43, 44). Physiotherapists have specialised functions in specific physical activity recommendations, supervised exercise, and motivation to increase or sustain a physically active lifestyle (44).

1.1.6 Consequences of stroke

Stroke is a leading cause of disability worldwide. Stroke severity varies between symptoms that disappear quickly and the life-long consequences of stroke or death from stroke. Over the last few decades, thrombolysis and thrombectomy stroke severity have decreased and reduced functional disability (45). Social awareness of stroke has also contributed to a faster care chain from stroke onset to treatment in stroke units, including reperfusion therapies (46).

Stroke symptoms include motor and sensory impairments, altered speech, ataxia, vertigo, (47) and impaired postural control (48). Hidden symptoms may include cognitive impairment, fatigue, depression, anxiety, and behavioural changes (49). Cognition is a system with varied cognitive functions from visual perception to social cognition. It encompasses all thought processes related to social and environmental interactions (50). Cognitive impairment occurs in 20%–70% of patients with stroke, depending on diagnostic criteria and assessments (51). After stroke, 25% of patients report reduced health-related quality of life (52). Health-related quality of life refers to how well a person functions and perceived well-being in the physical, mental, and social domains of health (53).

1.1.7 Stroke care

Treatments

In Sweden, stroke care is permeated by the concept of *Time is brain*, where a fast pre-hospital and acute procedure is important for the use of available reperfusion therapies for ischaemic stroke (54, 55). For haemorrhagic stroke blood pressure control and reduction are prioritised. Acute monitoring and early mobilisation were initiated upon hospital admission. In Swedish stroke units, mobilisation increases gradually and a multi-disciplinary team is involved within the first 1-2 days after admission (21).

Secondary prevention is addressed at Swedish hospital with smoke cessation, hypertensive treatment, statin use, and treatment for atrial fibrillation (Riksstroke 2021) (22), however lifestyle behaviour like smoking, physical activity, alcohol use, and diet are not targeted to the same extent as modifiable risk factors which can be treated with medication (41).

Stroke Units

Stroke unit care improves outcomes after stroke regardless of age, sex, stroke type, stroke severity, or follow-up duration (7, 56). One year after stroke unit care patients are more independent and live at home, and have better survival (56). For every 100 people receiving stroke unit care, two survived, six lived at home, and six lived independently (7). Furthermore, stroke unit care does not increase hospital stay (7, 56).

Comprehensive stroke units, where multi-disciplinary teams monitor and rehabilitate patients with stroke are the top priority, according to the Swedish National Guidelines for Stroke Care (21). The multi-disciplinary team includes physicians, nurses, assistant nurses, occupational therapists, physiotherapists, speech, and language therapists, and often dietitians, social workers, and psychologists. Team members should coordinate treatment, care, and rehabilitation based on current evidence and best practices corresponding to the needs of patients with stroke (7). According to Swedish Stroke Register, 92% of patients with stroke were treated at comprehensive stroke units, and the median hospital stay was 7 days (25). The multi-disciplinary team assessed most patients; approximately 86% were assessed by physiotherapists and occupational therapists, with half of the assessments made within 24 h, while 40% were assessed by speech and language therapists (25).

Stroke rehabilitation and recovery after stroke

Care at stroke unit with rehabilitation from a multi-disciplinary team is prioritised in Swedish stroke care (21). Early mobilisation often commences within the first 24 h after stroke onset. However, early mobilisation at higher intensity has shown less favourable outcomes, whereas frequent shorter sessions are more favourable (57). The Swedish National Stroke Guidelines recommend multi-disciplinary rehabilitation that includes fall prevention, task-specific walking and motor training, aerobic and strength training, training in daily activities, compensatory strategies for cognitive impairment, communication training, and early supported discharge (21). Modified constraint induced movement therapy for the upper extremity and mirror therapy may be beneficial after stroke while robot assisted rehabilitation can be used in exceptional cases in stroke rehabilitation (21) (57).

Recovery is described as how body structure and function, as well as activities, return to the functional status before stroke (58). Improvements in behavioural recovery can occur spontaneously without intervention, especially early after stroke (58). Recovery can be a change (improvement or worsening) between two or more time points due to behavioural restitution or compensatory strategies (58). The timeline of recovery after stroke are separated in several phases: hyperacute (0–24 h), acute (1–7 days), early subacute (7 days–3 months), late subacute (3–6 months), and chronic (≥ 6 months) (58). Recovery depends on the time after stroke, with most behavioural recovery occurring in the first weeks or months, although changes can be accomplished several years after stroke (58).

Physiotherapy in stroke rehabilitation

Due to successful reperfusion treatments, most patients with stroke have mild stroke and a short hospital stay. The median length of stay in Sweden is 7 days (22) demanding physiotherapy interventions to focus on assessment and planning. Assessments include motor and sensory functions, transfer, walking ability, and postural balance, whereas planning involves setting goals and referrals for further physiotherapy when needed. This is done with a person-centred approach, where the patient's narrative, collaboration, and rehabilitation plan are included (59). Despite decreased stroke severity, many stroke survivors require extensive rehabilitation. Motor rehabilitation should include assessments of motor function, followed by progressed training with the right dosage. Additionally, it should be repetitive, goal-oriented, task-specific, and applied in different contexts (60). According to Swedish guidelines patients with moderate to severe stroke require fall prevention, task-specific walking and motor training, aerobic and strength training, daily activities training, cognitive impairment compensation, and communication training. A gait intervention study found that a higher intensity in physiotherapy sessions was more beneficial than standard care (61). One review reported that physiotherapy interventions were more effective when intensive, repetitive task-oriented, and task-specific training was performed in all phases after stroke (62).

1.2 Physical activity and inactivity

Physical activity is defined as any bodily movement produced by the skeletal muscles that results in energy expenditure. Physical activities in daily life can be categorised into occupational, sports, conditioning, household, and other (63). Exercise and physical fitness are subsets of physical activity. Exercise is planned and structured to improve or maintain health and skills, including physical fitness (63). The different components of physical activity are intensity, duration and frequency (63). There are also different skills targeted in exercise and physical fitness, such as cardiovascular fitness, strength, postural control, and range of motion (63). Physical inactivity is defined as a level of physical activity that does not meet the current WHO recommendations and is therefore considered insufficient (1).

International recommendations for physical activity and exercise developed by the WHO exist. The recommendations are that all adults should undertake 150–300 minutes of moderate-intensity physical activity, 75–150 minutes of vigorous-intensity physical activity, or an equivalent combination of moderate-intensity and vigorous-intensity aerobic physical activity weekly. These guidelines recommend regular muscle strengthening activities and reduced sedentary behaviours (1). These guidelines apply to all age groups and abilities and are therefore applicable to individuals after stroke (1). Physical activity is recommended for people with disability since the health benefits outweigh the risks (64). The Swedish interpretation is that the recommendations refer to all people, regardless of sex, age, culture, socioeconomic status, or functional disability. For those who cannot reach the recommended physical activity level, the goal is to be as physically active as their condition allows (65, 66). Physical activity can benefit health and reduces a lower risk of ischemic heart disease, ischemic stroke, diabetes, breast- and colon cancer (67). Furthermore, increased mental health and later onset of dementia are positive effects of physical activity as well as keeping a healthy weight (68). Physical activity varies with age (69), sex, and physical activity decrease with older age and sex (female) (3, 68). A Swedish survey found that younger (30-44 years) men are more physically active than women, middle-aged (45-64 years) women being more active than men, and for older (65-84 years) people, no sex difference exists (70).

Sedentary behaviour is characterised by very low energy expenditure in positions such as sitting, reclining, or lying while awake and is not entirely synonymous with physical inactivity (1). Sedentary behaviour can involve office work, driving a car, watching television, being unable to walk, or needing a wheelchair (1). Physical inactivity is a global problem that causes disease (71) and is the fourth leading cause of death (72). Therefore, the WHO has provided an action plan to decrease physical inactivity by 15% by 2030 (2). However, the process of reducing physical inactivity is slow and needs to be accelerated to achieve the 2030 Sustainable Development Goals (68). High levels of insufficient physical activity have been reported to increase, especially in high-income countries and in women worldwide. Increased physical activity is beneficial for individuals and communities as well as for health, economic, and environmental sustainability (68).

1.2.1 Assessments on physical activity

Physical activity can be assessed objectively using wearable devices, by observation measuring activity behaviour, and self-reported questionnaires (73). Due to inconsistencies in the outcomes and tools used to assess physical activity after stroke, an international consensus recommendation was presented (73). To assess different aspects of physical activity such as type, duration, intensity, and frequency, more comprehensive assessments are needed (73) with either a combination of more than one wearable device or a combination of a wearable device and questionnaire (73). The choice of wearable device depends on which aspect of physical activity is the focus of measuring physical activity intensity, duration, and frequency, while more extensive questionnaires can provide information on the physical activity setting and type of activity (73). Selecting the right assessment tool is complex and should consider the research question and feasibility of the assessment with regards to researchers, clinicians, and participants with stroke (73).

1.2.2 Pre-stroke and post-stroke physical activity

Pre-stroke physical activity can reduce stroke occurrence (38) and its negative consequences (39). Pre-stroke physical activity is associated with decreased infarct volume, whereas evidence of its association with milder stroke severity is conflicting (74). Furthermore, higher pre-stroke physical activity is associated with lower odds of depression and fatigue (39), but not cardiorespiratory fitness after stroke (74). Pre-stroke physical activity can predict independence in ADL and walking (39) and is associated with post-stroke physical activity and increased walking volume (39). There is conflicting evidence regarding the association among pre-stroke physical activity, cognition, and poststroke disability (39).

Physical activity levels are low after stroke and recommendations are often not fulfilled (75). After stroke, the aerobic capacity and muscle function decreased (74). Low levels of physical activity one year after stroke have been reported and associated with older age, pre-stroke physical inactivity, and functional dependence at discharge (76). Physical activity and exercise can contribute to functional independence, reduce the risk of recurrent stroke, and improve the quality of life after stroke (77). One study reported that one-third of patients returned to their previous physical activities after stroke, but one-third had to modify the type of activity performed (78). Exercise interventions and improvement of cardiorespiratory fitness and mobility can be beneficial after stroke and are often included in stroke guidelines (74).

1.2.3 Dose dependency

Dose-dependency for pre-stroke physical activity on stroke outcomes is not fully investigated. Weekly exercise was associated with less severe stroke in pre-stroke patients. However, protection is applied to light- and moderate-intensity physical activity and not to high-intensity physical activity (79). A study by Ricciardi et al. showed that pre-stroke physical activity was dose-dependently associated with smaller infarct volume and good functional outcomes after 3 months

(80). A dose-response relationship occurs between higher levels of pre-stroke physical activity and decreased insulin-like growth factor I levels at 3 months (39). Dose dependence requires further investigation on pre-stroke physical activity and stroke outcomes (74).

1.2.4 Physical activity and inactivity at the stroke unit

International and national studies reported that patients with stroke in Sweden (12), Europe (9, 10, 11, 81), and Australia (8, 9) are often inactive or alone in stroke units. Patients in a Swedish stroke unit spent 49 % of their day in bed, 73 % in their room, and 7% standing or walking, or were alone 56% of their day (12). National differences exist, yet physical inactivity in stroke units is a problem in all studies. Physical activity increases somewhat in the stroke unit (12, 13). Patients are more physically active when they are with physiotherapists, who train patients to stand or walk (12, 81). The average daily therapy time for patients is approximately 60 minutes, including occupational therapy, and physiotherapy (12, 82); however, hospitals and countries vary. After stroke, elderly persons are less physically active compared to healthy people of similar age (83).

Known reasons can only partly explain physical inactivity after stroke (15). Reasons for physical inactivity at the stroke unit can be aging and severe stroke (9, 12, 13). Independence, higher physical function (walking, balance, and leg strength) (13), more time spent with a physiotherapist, and group meals increase hospital physical activity (81). More time spent in early bed rest after stroke is associated with poor functional outcomes 3 months later (84). The environment in stroke units can promote or hinder physical activity. Single rooms can increase loneliness and safety risks due to less nursing care contact (85). The physical environment of the stroke unit can influence the patients' movements, activities, and participation (86, 87, 88). Stroke unit need to be both private and communal (87). Sedentary behaviour in people with chronic stroke is associated with decreased physical functioning and walking capacity, not cognition or emotion (15). However, one study reported that patients increased or decreased their physical activity levels 6 months after stroke, where males with normal cognition were more likely to increase their physical activity (83).

1.3 Theoretical frameworks

1.3.1 Rehabilitation

According to the WHO, Rehabilitation is 'A set of interventions designed to optimise functioning and reduce disability in individuals with health conditions in interaction with their environment.' Multi-disciplinary teams provide rehabilitation (89). Rehabilitation promotes good health and disease prevention, treatment, and palliative care. Rehabilitation can support people of all ages participate in education, work, recreation, and family as independently as possible (90). Aging and growing population worldwide require more rehabilitation. One-third of the global population needs health-related rehabilitation and the WHO supports the implementation of the Rehabilitation 2030 initiative (90). This initiative emphasises leadership and governance, multi-disciplinary and financial rehabilitation, data collection and rehabilitation research (90).

Rehabilitation has expanded the focus of health beyond preventive and curative care. A biopsychosocial perspective on health is fundamental in rehabilitation. In the holistic bio-psychosocial model, biological, psychological, and social contexts are equally included in an interaction that results in illness and health (91).

1.3.2 International Classification of Functioning

In 2001, the WHO established the International Classification of Functioning, Disability, and Health (ICF) to describe and classify health and disability. (91, 92). The ICF uses a holistic bio-psychosocial model (91) that stroke teams should utilise to alleviate patient symptoms and promote functional independence and participation (social integration). The ICF classifies health and health-related domains for individuals and populations. (93). The model is useful for structuring guidelines, clinical setting, and person-centred care (91, 94). **Figure 1** shows that the ICF includes health conditions, body functions and structures, activities, and participation. The model includes environmental and personal factors to comprehend a person's situation (92). The health condition referred to in this thesis is stroke, and the ICF describes stroke symptoms as body functions and structures. However, these impairments might affect everyday activities and participation which stroke survivors value most. Activities can include functional disabilities, including walking and activities of daily living (ADL) (95), while problems participating in usual activities can include socialising, familyoriented activities (96), and returning to work (97). Survivors often deal with the consequences of stroke for months and years, sometimes their entire life.

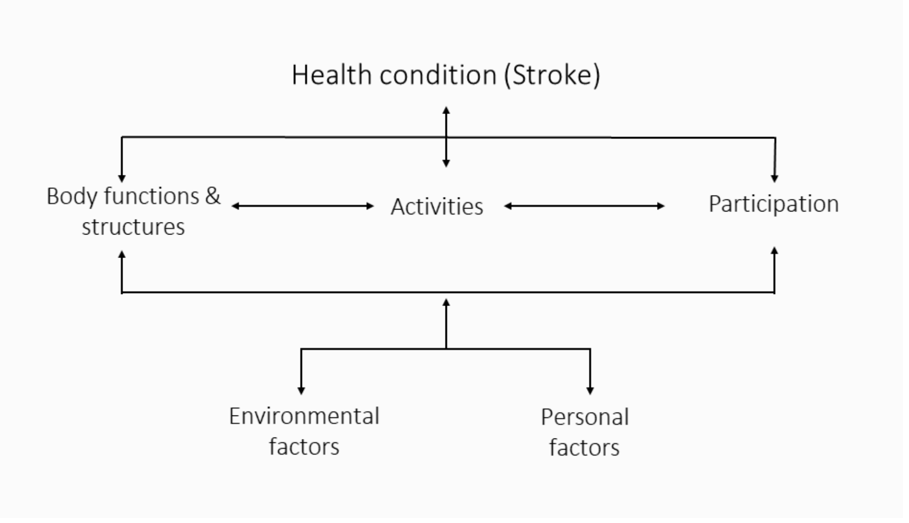

Figure 1 *The International Classification of Functioning, Disability and Health (ICF)*

1.3.3. Patient involvement

A person-centred approach emphasises a person's narrative with unique preferences, resources, and life circumstances (59, 98). This approach treats patient as people with will, feelings, needs, and capacity to participate in their care and treatment. Hence, the patients are partners with healthcare staff who share knowledge and decision-making. Documenting the patient's narrative as valid protects the collaboration. A care and rehabilitation plan should be documented as a fusion of the patient's perspective and clinical decision making (98).

Patient and public involvement in research has increased; however, quality and transparency must be improved (99). Collaboration with patient research partners should involve all stages of the research to confirm stroke-relevant research questions. Respect, openness, flexibility, and collaboration are essential while working with patient research partners. (100).

1.3.4 Social constructivism

When performing qualitative studies, it is important to disclose the underlying assumptions and theories or lack of theory to increase trustworthiness (101). Social constructivism is the sociological theory of knowledge. Social constructivism explains the perspective of producing knowledge and how we examine the world, epistemology and ontology (101). This theory originated from cognitive constructivism, in which it was believed that all knowledge could come from within a human and that learning could be separated from its social context. Social constructivism has challenged and rejected these assumptions, claiming that learning originates from cognitive functions and social interactions. In social constructivism, the assumption is that experiences are subjective in a specific context involving interactions with others. Individual and social phenomena should be studied by understanding the subjective experiences of individuals and not only by observing people's behaviours (102). Ontology is relativism, where there is no objective reality, and the view of the world is subjective. How one perceives reality depends on one's experiences and context. The relativistic view of truth in social constructivism is criticised for its lack of objective reality, as everything is socially constructed (102).

1.3.5 Trustworthiness in qualitative research

The trustworthiness of qualitative studies can be evaluated and discussed based on their credibility, dependability, confirmability, and transferability (101). Credibility depends on clear descriptions of concepts, theories, models, methods, data quality, depth, researcher's preconceptions, analytical experience, results interpretation, and conclusions. Quantitative research credibility is internal validity. Asking participants if the results make sense or asking people with similar experiences as the study sample might also evaluate credibility. This credibility matches quantitative research face validity (101). Transferability evaluates how well results can be transferred elsewhere. In quantitative research, transferability means internal validity and generalisability. This depends on participants selection, setting and context description, and theory transferability (101). Transferability should be carefully considered in the discussion of methods (101). All analytical stages were consistent with assumptions, proving dependability. Data stability can be demonstrated by collecting data over time. Comparing study results with those of previous studies can also demonstrate dependability. In quantitative research, dependability means reliability (101). Confirmability measures researchers' influence on study results. Researchers must reveal their characteristics and preconceptions to show transparency of their own perspectives at risk t while analysing results to acquire confirmability. Confirmability corresponds to objectivity in quantitative research (101).

1.4 Knowledge gap

The journey for this thesis began almost a decade ago, and the knowledge gap in pre-stroke physical activity has decreased since. Over the past decade, popular science in Sweden has focused on the benefits of exercise, sometimes with insufficient evidence. Studies on pre-stroke physical activity was formerly focused on stroke occurrence. At first, the association between pre-stroke physical activity and stroke outcomes focused on functional disability and animal studies. Several studies have examined pre-stroke physical activity and stroke outcomes in recent years. However, there are many more outcomes to explore, and their long-term consequences are unknown.

Several observational studies reported that patients with stroke are physically inactive in stroke units. The patient's functional ability, stroke severity, and stroke unit prerequisites can partly explain physical inactivity. No qualitative studies have explored patients' physical inactivity experiences in stroke units. Only qualitative analysis can explore this knowledge gap by describing patients' experiences. Interviews can reveal patients' physical activity and inactivity experience in stroke units. This can transform stroke units, increasing the patients' activity and improving care.

2. Aims

This thesis aimed to investigate the association between pre-stroke physical activity and different consequences after stroke and to understand people's experiences of physical activity and inactivity at the stroke unit. The specific aims of each study were as follows:

I. To investigate the influence of pre-stroke physical activity, age, sex, smoking, diabetes, and protective treatments, such as statins and hypertension, on acute stroke severity.

II. To investigate whether pre-stroke physical activity is associated with intact cognition early after stroke.

III. To identify the associations between pre-stroke physical activity and health-related quality of life 3 months after stroke.

IV. To describe the patient's perceptions of physical activity and inactivity at the stroke unit.

3. Patients and Methods

The thesis includes four studies: three quantitative and one qualitative study were included in this thesis. The quantitative studies were based on data from registers, and the qualitative study was based on data from in-depth interviews. paper I–III have been published, and paper IV is a submitted manuscript.

3.1 Study designs and study samples

Studies I–III were cross-sectional studies based on retrospective data, where Studies I–II involved the acute and subacute phases after stroke, while Study III involved 3 months of register data. Study IV involved qualitative interviews with a recruitment and data collection in 2022. Table 1 shows the study design and sample size.

Studies I–III contained consecutively collected data from patients with first-ever stroke, while Study IV strategically collected data from participants with various characteristics regarding age, sex, and stroke severity. The characteristics of the participants are presented in Table 1, along with the inclusion and exclusion criteria. Studies I–III were register-based and involved patients in stroke units at SU. The SU has three comprehensive stroke units at Mölndal, Sahlgrenska, and Östra Hospitals and has a catchment area of 750,000 inhabitants for acute care. Study IV involved the strategically selecting 16 participants to retrieve a heterogeneous sample. The participants were recruited from eight of the nine identified stroke units in the Region Västra Götaland (VGR), involving SU (Sahlgrenska, Mölndal, and Östra), Hospitals in the West (Alingsås and Kungälv), Skaraborg Hospital (Skövde and Lidköping), and Södra Älvsborg's Hospital (Borås), whereas North Älvsborg's Hospital (Trollhättan) declined to participate.

Table 1. Study design and samples
Presentation of the study designs, inclusion periods, and study samples in the included Studies.

	Study I	Study II	Study III	Study IV
Size of study sample (n)	925	1,111	2,044	16
Study design	Quantitative Cross-sectional	Quantitative Cross-sectional	Quantitative Cross-sectional	Qualitative interviews
Data source	Väststroke register Riksstroke register	Väststroke register Riksstroke register	Väststroke register Riksstroke register	In-depth single interviews
Time for data collection	2014–2016	2014–2018	2014–2018	2022
Register form	Acute form	Acute form	Acute form, and 3 months questionnaire	NA
Time after stroke	Admission, in-hospital discharge	Admission, in-hospital discharge	Admission, in-hospital discharge 3 months	Subacute ≤ 2 weeks after discharge
Stroke units involved (n)	Sahlgrenska University Hospital, (3)	Sahlgrenska University Hospital, (3)	Sahlgrenska University Hospital, (3)	Region Västra Götaland, (8)
Inclusion criteria	First-ever stroke (ICD-10 I61, I63), ≥ 18 years	First-ever mild to moderate stroke (ICD-10 I61, I63), ≥ 18 years, previous independent living, Swedish speaking	First-ever stroke (ICD-10 I61, I63), ≥ 18 years,	Stroke diagnosis, ≥ 18 years, Swedish speaking
Exclusion criteria	No data on physical activity or stroke severity (NIHSS)	Severe stroke (NIHSS ≥ 15), no data on physical activity or cognition,	No data on physical activity or health-related quality of life	Severe aphasia, severe cognitive impairment

ICD= International Classification of Diseases, NIHSS= National Institute of Health Stroke scale, n=numbers

There were 925 participants in Study I, 1,111 participants in Study II, and 2,044 participants in Study III, while 16 purposively sampled participants were included in Study IV. **Figure 2** shows a flow chart with an overall description of Studies I–IV.

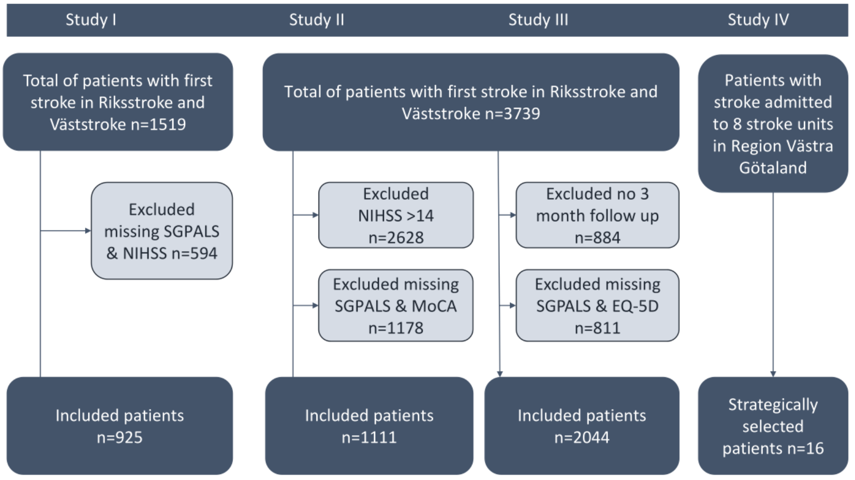

Figure 2. Flow chart
Flow chart for Studies I–IV including numbers of eligible, included, and excluded participants.

3.1.1 Patient involvement

In Study IV, collaboration with a patient research partner permeated all aspects of the research process. The main researcher and the patient research partner found a way to collaborate along the way, as the process was new. The patient partner made important contributions in editing the interview guide, validating the results, reviewing themes and subthemes, and selecting representative quotes from the interviews. The writing of the project plan, ethical application, and specific phases of the analysis were based more on providing information to the research partner as a base for discussion. Furthermore, the collaboration emphasised discussions between the researcher and patient partner on topics such as the feelings of being a patient with stroke, the purpose of the study, and the scientific process of conducting a qualitative study. Guidance for Reporting Involvement of Patients and the Public checklist (GRIPP) can guide how to report and engage patients and public involvement in research. The Short Form was used in Study IV (99).

3.2 Data collection in Study I-III

Data sources in Studies I–III were two stroke registers: the local register in Gothenburg Väststroke and the National Stroke Register in Riksstroke. The local quality register Väststroke defined the study samples using data on patients cared for in the three stroke units at the SU.

For Studies I–III, the acute form and the 3-month follow-up questionnaire from Väststroke and Riksstroke were used. Specially trained nurses at the stroke units entered the data in the acute forms of Riksstroke and Väststroke from the patients' charts. For variables related to rehabilitation, occupational therapists, physiotherapists, and speech and language therapists assessed and entered the patient register data in the acute form. For data collection about patient-reported outcomes after 3 months, questionnaires were sent out by the nurses to patients, with a reminder if they did not respond. During the data collection (2014–2018), trained nurses also collected 3-month data from non-respondents by telephone.

Participant data from Studies I–III data with first-ever stroke hospitalised between 2014–2018 were analysed. Two registers provided data, and two data withdrawals were made: one with data from 2014–2016 for Study I and one with data from 2014–2018 for Studies II and III, resulting in many patients participating in one, two, or all three studies. An overview can be seen in **Figure 3** of the study samples' participation in one or several studies. The included patients underwent registered assessments for pre-stroke physical activity and the main outcomes in Study I stroke severity, Study II cognition, and Study III health-related quality of life. The first data withdrawal consisted of 1,519 patients with first-ever stroke. The second data withdrawal consisted of 3,739 patients with first-ever stroke, and patients from the first data withdrawal were included.

Study I included patients with complete registration of pre-stroke physical activity and acute stroke severity. Study II included patients with complete registration of pre-stroke physical activity, acute stroke severity and screening for cognition, while Study III included patients with complete registration of pre-stroke physical activity and health-related quality of life data. There was an overlap because many patients participated in one (167–881), two (53–458), or three studies (368), as shown in **Figure 3**. There was a difference between the two data withdrawals, with 25 participants being less eligible for Study I in data withdrawal 1 than in data withdrawal 2.

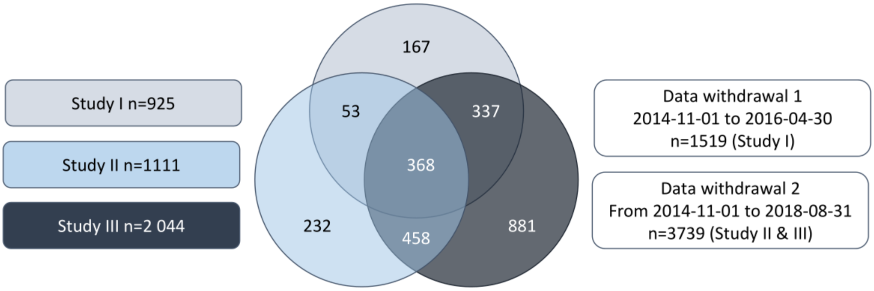

Figure 3 Venn diagram of number of participants
Presentation of the participants included in one, two, or three studies, illustrating the overlap in Studies I–III.

3.2.1 Data merging

Data merging for register data in Studies I-III was done by a statistician from the Swedish National Board of Health and Welfare (Study I) and a statistician from the Riksstroke register (Study II-III) who also kept the code key. Thereby data was pseudonymized when analyses were performed at the Sahlgrenska Academy, University of Gothenburg.

3.3 Data collection in Study IV

Study IV required preparatory work by contacting all hospitals in the VGR and producing an interview guide. The next step was the recruitment process, starting with informational meetings presenting a test kit for recruiting physiotherapists, followed by close contact with the recruiters to include a heterogeneous study sample. The interview phase demanded logistics and planning to recruit and interview 16 participants in the VGR for a short period and within two weeks of discharge from the stroke units. The same interviewer (MR) conducted all the interviews. The data collection is shown in **Figure 4.**

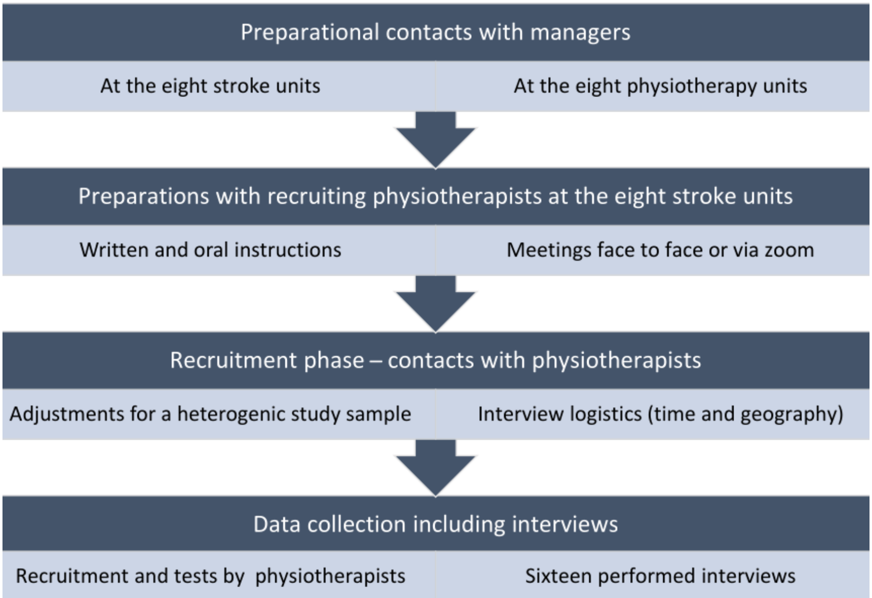

Figure 4. Preparations and data collection in Study IV

Table 2. Details on the interviews in Study IV
Participants' choice of time and place for the interviews and others present.

Interview details		*Median [IQR]*	*Min-max*
Time from discharge to interview (days)		*10.5 [7]*	*1–19*
Time for the interviews (min)		*40 [14]*	*25–60*
Location and surrounding people	*Alone*	*Spouse or Children*	*Others*
- *At home*	*3*	*7*	*1*
- *At hospital*	*1*		
- *At a short-term nursing home*	*1*	*1*	
- *At a café*			*1*
-			
- *By telephone*	*1*		

Participants could choose locations where most of the interviews were in their own homes. There was a striving to make the participants feel safe and comfortable to achieve the benefits of a deep interview, which can be therapeutic. Several participants had relatives present in the house but not in the interview room, although three relatives stayed in the room during the interview as support. Data sources were audio recordings and transcriptions of in-depth interviews collected one–two weeks after discharge. The mean interview time was 41 min, with a 25–60 min range. After the interviews, the interviewer (MR) answered questions and offered guidance if needed, as feelings and questions could be raised during the interviews. **Table 2** shows the details of the interviews.

3.3.1 Interview guide in Study IV

Before data collection, an interview guide was constructed. The interview questions came from the literature (103), previous interview studies, clinical experience (MR), and research partners' experience. A pilot interview was conducted but not included in the study. The interview guide was discussed and refined several times and is presented in **Table 3**.

Table 3. Interview guide
Presentation of the open-ended questions and techniques to deepen the dialogue,

Type of question	*Questions and Comments*
Introductory question	*- How do you think about movement, physical activity, and exercise in the stroke unit? Tell me about movement, physical activity, and exercise on an ordinary day.*
Open questions	*- How was it for you at the stroke unit with Rest? Getting out of bed? Getting out of your room? Going outside the stroke unit? Walking outdoors?* *-How was it for you at the stroke unit with: Physical activity and exercising?* *-What made you rest or move around during the day in the stroke unit? Were you alone or with someone? Was it your choice or someone else's?* *-How was the balance between physical activity and inactivity at the stroke unit, between movement and bed rest?* *-What do you think gets you up and going after stroke? Something you do. Something the staff does?*
Closing questions	*-How do you think about movement, physical activity, and training in the future?* *Did we forget something --is there anything else you want to add?*
Follow-up questions and comments to deepen the dialogue at the interviews	*-Can you tell me a little more about* *-Can you describe a situation, give an example* *-Can you elaborate your thoughts on.* *-If I summarise what you said. Have I understood correctly?* *Repeat a central concept that the interviewee said.* *Mirroring: -So, you mean that…* *Use the silence to let the interviewee talk at their own pace.*

3.4 Variables and assessment scales

Variables from the registers included a combination of patient characteristics, medical care and rehabilitation activities, functional abilities, and assessment scales. The acute forms were based on healthcare staff assessments and activities from admission, in-hospital care, and discharge, while the 3-month forms were based on patient-reported outcomes. Patient characteristics were variables covering the domains of demographic factors, risk factors for stroke, stroke characteristics, treatments for stroke, consequences of stroke, complications after stroke, and functional outcomes after stroke. The variables and assessment scores are listed in **Table 4**.

Table 4. Variables and Assessment scales
Presentation of the distribution of variables and assessments in the included studies (Studies I–III).

	Study I	*Study II*	*Study III*	*Study IV*
Demographic factors				
Age	*X*	*X*	*X*	*X*
Age groups			*X*	
Sex	*X*	*X*	*X*	*X*
Education		*X*		
Pre-stroke frailty				*X*
Comorbidity				*X*
Risk factors for stroke				
Pre-stroke physical activity (SGPALS)	*X*	*X*		*X*
Smoking	*X*	*X*		
Diabetes	*X*	*X*		
Atrial fibrillation		*X*		
Previous TIA		*X*		
Stroke characteristics				
Stroke type	*X*	*X*	*X*	*X*
Stroke severity (NIHSS)	*X*	*X*	*X*	*X*
Treatments for stroke				
Statin treatment	*X*	*X*		
Hypertension treatment	*X*	*X*		
Thrombolysis	*X*		*X*	
Thrombectomy	*X*		*X*	
Discharge information				
Length of hospital stay	*X*	*X*	*X*	*X*
Discharge destination		*X*	*X*	*X*
Complications after stroke				
New stroke	*X*	*X*		
Myocardial infarction	*X*	*X*		
Outcomes after stroke				
Cognition (MoCA)		*X*		
Walking ability (10 metre, 6MWT)				*X*
Balance (BBS, TUG)				*X*
Activities of Daily Living (Barthel Index)				*X*
Health-related quality of life (EQ-5D-5L)			*X*	

Assessments at the stroke unit: NIHSS=National Institutes of Health Stroke Scale, MoCA=Montreal Cognitive Assessment Scale, SGPALS=Saltin-Grimby Physical Activity Level Scale, Education > 12 years, TIA=Transient Ischaemic Attack, 10 m =optional and maximum speed, 6MWT=6 minute walk test, BBS=Berg's Balance Scale, TUG=Timed Up and Go; Assessment at 3 months: EQ-5D-5L=Euroqol in 5 dimensions and 5 answering levels for health-related quality of life. Education > 12 years.

Physical activity was assessed using the Saltin-Grimby Physical Activity Level Scale (SGPALS) (104) and the levels are presented in **Figure 5** (105). The scale is generic and has good concurrent and predictive validity (105). However, its reliability has not yet been investigated. In Study I, SGPALS was dichotomised into SGPALS 1 and SGPALS 2-4. In Studies II–III the SGPALS was divided in 3 levels as SGPALS 1, 2 and 3–4 due to few participants in level 4.

Figure 5. Tthe Saltin-Grimby Physical Activity Level Scale

Frailty was assessed with the Clinical Frailty Scale (CFS) (106). The scale is used as a screening tool to assess frailty and is administered by healthcare staff. The scale ranges from 1 to 9, where 1 indicates very fit, and 9 indicates terminal illness. It is a generic screening tool validated for people ≥ 65 years (106).

Stroke severity on admission was assessed with the National Institutes of Health Stroke Scale (NIHSS) (107). The NIHSS contains 15 items in the fields of consciousness, eye movements, visual fields, facial muscle function, extremity strength, sensory function, coordination (ataxia), language (aphasia), speech (dysarthria), and neglect. Each item is scored from zero (no symptoms) to 2, 3, or 4, with a total score of 42 indicating very severe severity. This scale was proven valid and reliable in clinical stroke trials (107). In Studies I–III, the NIHSS had the following cut off scores: 0–5, 6–14, 15–24, ≥ 25 points (108).

Activities in Daily living (ADL) were assessed with the Barthel Index for personal care in everyday activities (109). The Barthel Index assesses basic ADL in eight activities, with high scores indicating independence. The scale ranged from 0 to 100 points. The assessment is based on current ADL by summarising answers from patients or caregivers and does not rely on objective testing.

Cognition was screened using the Montreal Cognitive Assessment Scale (MoCA) during their stay in the stroke unit (110). The MoCA is a generic, reliable, and valid screening test for cognitive function and has good sensitivity for identifying mild cognitive impairment. The MoCA comprises several cognitive subdomains, including visuospatial abilities, executive function, attention, concentration, working memory, language, short-term memory, and orientation toward time and place. The score ranges from 0–30 points; the higher the better (110). Impaired cognition is often defined as a MoCA score ≤25 points (110). However, the cut-off score is discussed (111). The MoCA has good discriminative ability between mild cognitive impairment and normal cognition and mild cognitive impairment vs. dementia (110). Swedish reference values for the MoCA exist for people aged 65–85 years (112).

Health-related quality of life was assessed using EuroQol's EQ-5D version with five dimensions and five answer levels (EQ-5D-5L) (113, 114, 115). The EQ-5D-5L is a generic and patient-reported outcome comprising five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The five answering levels were 1) no, 2) slight, 3) moderate, 4) severe, and 5) extreme problems, where a 5-digit number combination describing a patient's overall health status can be calculated as an index value. Additionally, Euroqol has a Visual Analogue Scale (EQ-VAS) for self-reported general health. The EQ-VAS score ranged from 0 to 100, with a higher score indicating better self-perceived health (115). The EQ-5D has been validated in patients with stroke (116). There are reference values for the EQ-5D-5L for the general Swedish population (117).

A set of timed **walking tests** was administered. The 10-metre walk test was used to assess walking speed and determine functional mobility, gait, and vestibular function. The test is generic, reliable, valid, and can be used in patients with stroke (118). Normative values for different age groups were calculated as meter/second (m/s). Normal comfortable speeds and maximum speeds were assessed. In Study IV, a modified version of the 6-minute walk test (6 MWT) (119, 120, 121, 122) was used with registered pulses, Borg's scales for overall fatigue (RPE) and dyspnoea (CR10), walking length in meters, and registered interruptions. The 6 MWT is a generic, reliable (123) and valid (124) assessment tool after stroke, and normative values can also be found in patients with stroke (125).

Two **balance tests** were administered: the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test. The BBS (126, 127) has excellent reliability and validity for assessing balance and functional mobility in patients with stroke, although it is not a strong predictor of fall risk (128). The cut-off scores on the BBS vary between studies, as a score of 12 on admission could predict regaining unassisted ambulation, and a score of 29 can predict community ambulation (129). Furthermore, a score of ≤ 44 points in patients with chronic stroke indicates a risk of falling (130), and ≤ 47.5 points indicates slower walking status (131). The Timed Up and Go (TUG) is a generic, reliable, and valid test of basic functional mobility for older people (132). A risk of falling is detected if an older adult has a time of ≥ 12 seconds completing the TUG, while a time of ≥ 14 seconds is an indicator for older patients with stroke (124).

3.5 Statistical analyses

In Studies I–III, descriptive, dropout, and binary logistic regression analyses were performed. Differences between the study sample and excluded patients were assessed for age, sex, stroke type, and stroke severity using the NIHSS. Binary logistic regression analyses were performed to determine the association between independent variables and stroke outcomes. The main independent (explanatory) variable was pre-stroke physical activity, and the dependent variables were acute stroke severity (study I), cognition during the hospital stay (Study II), and health-related quality of life after 3 months (Study III). **Table 5** provides an overview of analyses. Since most variables were ordinal or categorical, and the continuous data were not normally distributed, non-parametric analyses were used. The alpha value for significance was set at < 0.05, and the Bonferroni correction was used in Studies I and II. Data analyses were performed with the IBM SPSS Statistics for Windows.

Table 5. Quantitative and qualitative analyses
Presentation of analyses performed in the individual studies.

	Study I	*Study II*	*Study III*	*Study VI*
Statistical analyses				
Descriptive analyses				
Mean and standard deviation	*X*	*X*	*X*	*X*
Median and interquartile range	*X*	*X*	*X*	*X*
Numbers and percentages	*X*	*X*	*X*	*X*
Group comparisons				
Mann Whitney U test	*X*	*X*	*X*	
Chi-square test	*X*	*X*	*X*	
Kruskal-Wallis's test			*X*	
Independent Jonckheere-Terpsta for ordered alternatives			*X*	
Correlations				
Spearman's rank-order correlation test	*X*	*X*	*X*	
Chi-2	*X*	*X*	*X*	
Regression analyses				
Negative binomial regression	*X*			
Binary Logistic regression	*X*	*X*	*X*	
Regression model validation methods				
Five-fold cross-validation		*X*		
Bootstrap validation			*X*	
Goodness of fit tests				
Nagelkerke's r square	*X*	*X*	*X*	
Cox and Snell's square		*X*	*X*	
Hosmer and Lemeshow test	*X*	*X*	*X*	
Area under curve (AUC)	*X*	*X*	*X*	
Interaction analysis				
2-way analysis of variance (ANOVA)	*X*			
Qualitative analysis				
Thematic analysis				*X*

3.5.1 Building the regression models

Binary logistic regression was used in Studies I–III to explore the association between a set of predictors and the dependent variable, which was dichotomised (**Table 6**). The dependent variables were mild stroke severity, defined as NIHSS 0–5 in Study I; intact cognition, defined as MoCA > 25 in Study II; and better health-related quality of life defined as a value above the median (Md > 0.736) of the EQ-5D-5L index value. We followed several steps to construct the regression model (133). Firstly, a cross-tabulation was performed between each categorical independent variable and the dependent variable to detect small or redundant groups where the events per variable rate should be ≥ 10. This was followed by the dichotomization of independent variables when needed. Second, multicollinearity was explored through a correlation analysis between all the variables. Nominal variables were compared using the phi value and Spearman's rho for ordinal and continuous variables. When a high correlation (defined as a value > 0.7) was observed, the choice between the two variables was based on their clinical importance. Third, univariate binary logistic regression analyses were performed separately for each independent and dependent variable. The threshold to put variables forward for multivariate analysis was $p < 0.25$ (133). Fourth, multivariate binary logistic regression analysis, including independent variables ($p < 0.25$ from the univariate analysis) was performed. The final model with the fewest independent variables was chosen and presented as odds ratios (OR), 95% confidence intervals (CI), and p values. Additionally, a negative binomial regression was performed in Study I due to the Poisson distribution of the NIHSS, with many patients scoring low, to explore whether different levels of pre-stroke physical activity were associated with the outcome.

3.5.2 Assessment of goodness of fit and validation

Several analyses were conducted to test the fit of the regression models in Studies I–III (see **Table 5**). The tests used were The Omnibus test where $p < 0.05$ indicated good fit, The Hosmer–Lemeshow test where $p > 0.05$ indicated good fit, and the Nagelkerke R-squared test with an expected value close to 1. The area under the receiver operating characteristic curve (AUC) was used to evaluate the ability of the model with an expected value close to 1. To validate the regression models, a five-fold validation was performed in Study II, where 80% of the sample had the same results regarding the included variables as the final model, and the procedure was repeated five times. In Study III, the regression model is validated using bootstrapping (n=2000). The bootstrap result should have the same estimate, B-value (slope), as in the binary logistic regression analysis but not the same p-value and 95% CI values. In the bootstrap analysis results, the same variables should be significant ($p < 0.05$), as in the final regression model, and the bias-corrected and accelerated 95% CI should not intersect with zero for the significant variables.

3.5.3 Missing data

Internal missing data are present in several variables, common to register-based datasets. In the inclusion and exclusion criteria, data on the main independent variable, pre-stroke physical activity, and the investigated outcome were necessary for inclusion in the study sample. For transparency, missing data are presented in the flow charts and tables. Imputation was discussed in Study II, with cognition screened using the MoCA as the dependent variable. The decision not to use imputation was based on the MoCA, and variables with many internal missing data were not missing at random.

Table 6. Variables and assessments in the Regression analyses
Presentation of dependent and independent variables and assessment scales in Studies I–III.

	Study I	*Study II*	*Study III*
Outcome – dependent variable			
Stroke severity (NIHSS)	X		
Cognition (MoCA)		X	
Health-related quality of life (EQ-5D-5L)			X
Explanatory – primary independent variable			
Pre-stroke physical activity (SGPALS)	X	X	X
Exploratory - secondary independent variables			
Age	X	X	X
Sex	X	X	X
Education		X	
Smoking	X	X	
Diabetes	X	X	
Statin treatment	X	X	
Hypertension treatment	X	X	
Atrial fibrillation		X	
Previous TIA		X	
Reperfusion therapies		X	X
Stroke severity (NIHSS)		X	X
Length of hospital stay			X
Discharge destination			X

NIHSS=National Institutes of Health Stroke Scale, MoCA=Montreal Cognitive Assessment Scale, SGPALS=Saltin-Grimby Physical Activity Level Scale, Education > 12 years, TIA=Transient Ischaemic Attack, EQ-5D-5L=Euroqol 5 dimensions and 5 answering levels.

3.6 Qualitative analysis

3.6.1 Reflexive thematic analysis

In Study IV, in-depth interviews were analysed using reflexive thematic analysis (134, 135) to explore and describe the meaning of physical activity and inactivity in the stroke unit. The meaning of the phenomenon was expressed as themes referring to the research question. An inductive approach was used in which the data directed the process of coding and generating themes and subthemes. Reflexive thematic analysis consists of six phases, as described in Table 7, where the phases have a specific order. However, by returning to the previous steps and going back and forth through the process, it is possible to ensure that the results (themes) remain close to the data (in-depth interviews) (134).

Table 7. Reflexive thematic analysis
Presentation of the six phases in the Reflexive Thematic Analysis according to Braun and Clarke.

The Reflexive Thematic Analysis process	
Phase	
1	***Familiarising yourself with the dataset:*** *Listening, reading, and re-reading the data and making brief notes on data items and the whole dataset.*
2	***Codes:*** *Identify data segments meaningful to the research question and code them into analytically meaningful descriptions.*
3	***Generating initial themes:*** *Compile clusters of codes to develop themes and collate all coded data relevant to each candidate theme.*
4	***Developing and reviewing themes:*** *Assess the fit of the themes in relation to codes and the full dataset, to the core focus (the central organising concept), and relationships between themes.*
5	***Refining, defining, and naming themes:*** *Fine-tune the analysis, ensure the themes are demarcated and built around a core concept, write a brief synopsis of each theme, and decide informative names for the themes.*
6	***Writing up:*** *Finesse and finish the writing process for the reflexive thematic analysis, where formal analytic writing begins in phase 3. Final writing also includes producing the introduction, method, and conclusion.*

In Study IV, social constructivism is applied as a theoretical framework. The assumption was that the participants had subjective experiences of physical activity and inactivity after stroke in the specific context of the stroke unit. There is no objective reality, and all knowledge is produced through interaction with others. Furthermore, the researchers have preconceptions, previous knowledge, and experiences that can influence the analytical process. However, this can be handled through awareness within the research group and transparency when reporting the results (101).

3.7 Ethical considerations

The Swedish Ethical Review Authority examines the applications for ethical reviews of research involving humans. Ethical approval 346-16 for Studies I–III was obtained on 4 May 2016 with an amendment (T807-17 approved on 14 September 2018) for Studies II–III. Ethical approval 2021-06716-01 for Study IV was obtained on 26 January 2022. The Law regulating applications for ethical review of research is The Swedish Code of Statutes, although register-based research is exempt from informed consent according to the SFS 2003:460, 19§. The General Data Protection Regulation (GDPR) protects personal data in the European Union, and the Swedish Authority for Privacy Protection is responsible for the protection of personal data, monitoring, correct handling and possession of personal data. The ethical codes for research were the World Medical Association Declaration of Helsinki, Vancouver Convention, and Guidelines for Research Conducted by the Swedish Research Council.

The ethical dilemma in registry-based studies is the lack of informed consent from patients. There is written information at the stroke units with posters on the walls or brochures presenting the opt-out option. However, patients are seldom aware of their participation in quality registers, especially after stroke when cognitive or communicative impairments are common. However, the benefits of registry-based research include improving the quality of care. Register-based research can be applied to the four ethical principles of care: beneficence, non-maleficence, autonomy, and justice (136). The data are pseudonymised using a key saved by a third party; thus, autonomy is not threatened. The benefits include both people suffering stroke and those with a future risk of stroke, with the possibility of generalising the results to support priorities in healthcare in accordance with the justice principle. Hence, the benefits exceed the disadvantages of register-based studies I–III.

There are other ethical considerations for qualitative research. First, recruitment was performed without force, with oral and written informed consent (137). When reporting the results of qualitative research, it is important to avoid conveying individual participants by revealing quotes. In the data collection in Study IV, there was an effort to make the participants feel seen, respected, and listened to with the possibility of asking questions or being guided to future care, if needed. Considering the participants' needs, the benefits exceeded the drawbacks of Study IV.

4. Results

4.1 Patient characteristics

There were 925 participants in Study I, 1,111 participants in Study II, and 2,044 participants in Study III, while 16 purposively sampled participants were included in Study IV. Patient characteristics in Studies I–IV are described in **Table 8**, presenting the study sample demographics, risk factors, stroke characteristics, treatments for stroke, length of stay, complications after stroke, functional outcomes, discharge destination, and patient-related outcome measures (PROM). There was an overlap of participants in Studies I–III.

Table 8. Presentation of the participant's characteristics in the included studies (Studies I–IV).
Participants in Studies I–III are drawn from the same cohort with the overlap presented in Figure 3.

n (%) *Median [IQR]*	*Study I* *n=925*	*Study II* *n=1111*	*Study III* *n=2044*	*Study IV* *n=16*
Demographic factors				
Age, years	*75 [19]*	*72 [17]*	*74 [18]*	*75 [10]*
Sex (female)	*418 (45.2)*	*442 (39.8)*	*935 (45.7)*	*9*
Education (≤ 12 years)	*-*	*526 (47.3)*	*-*	*-*
Frailty Index	*-*	*-*	*-*	*2.5 [3]*
Comorbidity	*-*	*-*	*-*	*1.5 [3]*
Risk factors for stroke				
SGPALS 1	*481 (52.0)*	*428 (38.5)*	*978 (47.8)*	*5*
SGPALS 2	*384 (41.5)*	*573 (51.6)*	*914 (44.7)*	*9*
SGPALS 3	*59 (6.4)*	*106 (9.5)*	*149 (7.3)*	*2*
SGPALS 4	*1 (0.1)*	*4 (0.4)*	*3 (<0.01)*	*0*
Smoking	*125 (14.9) [a]*	*165 (14.9) [f]*	*-*	*-*
Diabetes	*163 (17.7) [b]*	*170 (15.3) [g]*	*-*	*-*
Atrial fibrillation	*-*	*199 (17.9)*	*-*	*-*
Previous TIA	*-*	*62 (5.6) [e]*	*-*	
Stroke characteristics				
Ischemic stroke	*87(94.2)*	*1,038 (93.4)*	*1,862 (91.1)*	*14*
Cerebral haemorrhage	*54 (5.8)*	*73 (6.6)*	*182 (8.9)*	
Stroke severity (NIHSS 0-42):	*1 [4]*	*1 [3]*	*2 [5] [b]*	*4 [7]*
Treatments for stroke				
Statin treatment	*179 [c]*	*226 (20.4) [b]*	*-*	*-*
Hypertension treatment	*535 [b]*	*595 (53.6) [g]*	*-*	*-*
Thrombolysis	*-*	*127 (11.4)*	*231 (11.3) [j]*	*-*
Thrombectomy	*-*	*44 (4.0)*	*115 (6.0) [k]*	*-*
Length of stay				
Length of hospital stay (days)	*8 [10]*	*-*	*8 [12]*	*-*
Length of stroke unit stay (days)	*8 [12]*	*9.1 (7.7)*	*-*	*10 [7]*
Functional outcomes after stroke	*-*	*25 [5]*	*25 [5] [d]*	*-*
Cognition MoCA score (0-30)	*-*	*472 (44.0) [i]*	*-*	*16*
Cognition in daily activities				
Discharge destination [g]				
Own home	*-*	*1,004 (90.4)*	*1,607 (79.0)*	*13*
Nursing home	*-*	*30 (2.7)*	*272 (13.4)*	*2*
Hospital/Rehabilitation ward	*-*	*75 (6.8)*	*163 (8.0)*	*1*
Deceased	*-*	*1 (0.1)*	*2 (0.3)*	*0*
PROM				
Health-related quality of life (EQ-5D-5L)	*-*	*-*	*0.74 [0.33]*	*-*
General health (EQ-VAS) [h]	*-*	*-*	*70 [30]*	*-*

Abbreviations: IQR=Interquartile range, n=numbers, PROM=patient related outcome measures. Assessments at the stroke unit: NIHSS=National Institutes of Health Stroke Scale, MoCA=Montreal Cognitive Assessment Scale, SGPALS=Saltin-Grimby Physical Activity Level Scale for pre-stroke physical activity level, Education > 12 years, TIA=Transient Ischaemic Attack, Assessment at 3 months: EQ-5D-5L=Euroqol in 5 dimensions and 5 answering levels for health-related quality of life. Missing: [a]=87, [b]=2, [c]=3, [d]=1010, [e]=5, [f]=82, [g]=1, [h]=51, [i]=38, [j]=6, [k]=130.

4.2 Pre-stroke physical activity and outcomes

4.2.1 Drop out analyses in Studies I–III

Participants were excluded from the study if they had missing data on the primary explanatory variable, which in Studies I–III was pre-stroke physical activity assessed with the SGPALS, or the main outcome variable in Study I stroke severity assessed with the NIHSS, in Study II cognition screened with the MOCA, and in Study III health-related quality of life self-reported with the EQ-5D-5L.

The results of the dropout analysis are presented in **Table 9**. In Studies I–III, the excluded patients were more women, with more severe strokes and more haemorrhagic strokes compared with the study sample. Regarding age, the excluded patients were older in Studies I and III, but there was no significant difference between the excluded patients and the study sample in Study II.

Table 9. Difference between included vs excluded participants in Studies I–III. *Drop out analyses presenting significant p-values in bold text.*

n (%) *Median [IQR]*	*Study I*	*Study II*	*Study III*
Study sample size	*925*	*1,111*	*2,044*
Number of excluded participants	*594*	*1,178*	*1,695*
Age (years), in median			
- *n study sample*	*75 [19]*	*72 [17]*	*74 [18]*
- *excluded participants*	*78 [18]*	*72 [18]*	*77 [20]*
- *P-value*	***< 0.001***	*0.459*	***< 0.001***
Sex (females)			
- *Study sample*	*418 (45.2)*	*442 (39.8)*	*935 (45.7)*
- *Excluded participants*	*318 (53.5)*	*524 (44.5)*	*873 (51.5)*
- *P-value*	***0.001***	***0.026***	***< 0.001***
Stroke severity (NIHSS 0–42), in median			
- *Study sample*	*1 [4]*	*1 [3]*	*2 [5][b]*
- *Excluded participants*	*2 [7][a]*	*2 [6]*	*6 [12][c]*
- *P-value*	*0.001*	*< 0.001*	*< 0.001*
Stroke type (Ischemic stroke)			
- *Study sample*	*871 (94.2)*	*1,038 (93.4)*	*1,862 (91.1)*
- *Excluded participants*	*482 (81.1)*	*1,042 (88.5)*	*1,436 (84.7)*
- *P-value*	***< 0.001***	***< 0.001***	***< 0.001***

Missing: [a]=467, [b]=2, [c]=3.

4.2.2 Pre-stroke physical activity and stroke severity

Study I included 925 patients with a mean age of 73 (SD, 14) years; 45% were females. Pre-stroke physical activity was associated with mild stroke severity (NIHSS 0–5 OR (95% CI) 2.30 (1.64–3.22), **Figure 6**. In the multivariable analysis, when adjusting for other factors, the final model included pre-stroke physical activity OR (95% CI) 2.02 (1.43–2.86) and younger age 0.97 (0.96–0.99) to be associated with mild stroke severity. This result indicates that pre-stroke physically active patients have higher possibilities of having a mild stroke instead of a more severe stroke than inactive patients. In addition to pre-stroke physical activity, younger age contributed to higher odds of having a mild stroke than a severe stroke. There was no dose-dependency for pre-stroke physical activity (SGPALS level 2 vs. SGPALS level 3–4) on the dependent variable, mild stroke severity (NIHSS 0–5), p=0.140. There were significantly higher odds of better outcomes for both light physical activity (SGPALS 2) (p < 0.001) and moderate-to-vigorous physical activity (SGPALS 3–4) p < 0.001) than for physical inactivity (SGPALS 1).

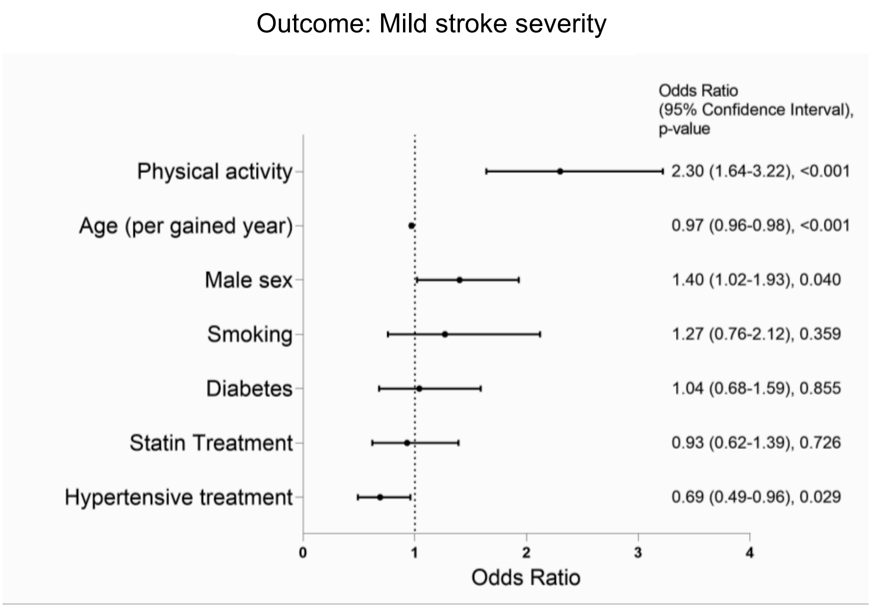

Figure 6. Association between independent variables and mild stroke severity (NIHSS 0-5).
Pre-stroke physical activity is assessed as 1–3 on SGPALS. National Institute of Health Stroke = NIHSS; Saltin Grimby Physical Activity Level Scale = SGPALS. The reference values were physical inactivity, sex (female), non-smoking, non-diabetic, and no treatments. Unadjusted values were presented.

4.2.3 Pre-stroke physical activity and cognition

Study II included 1,111 patients with a mean age of 70 years (SD, 13), and 40% were females. Pre-stroke physical activity was associated with intact cognition with a MoCA value of ≥ 26 points, see **Figure 7**. In the multivariable analysis, when adjusting for other factors, the final model included light pre-stroke physical activity OR (95% CI) 1.32 (0.97–1.80) and regular physical activity and training pre-stroke physical activity 2.04 (1.18–3.53) to be associated with intact cognition. In addition to pre-stroke physical activity, younger age, being non-diabetic, non-smoking, having a higher level of education, and less severe stroke (milder than moderate) were also associated with higher odds of intact cognition. There was a dose-dependency with better results for higher intensity physical activity, where the odds for intact cognition were higher for patients with regular pre-stroke physical activity and training than for the light pre-stroke physical activity group.

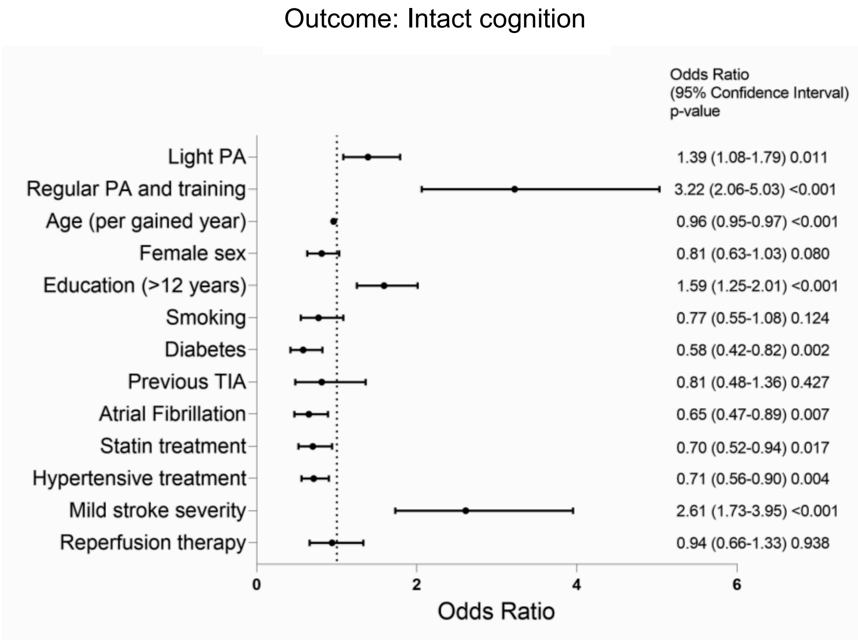

Figure 7. Association between independent variables and intact cognition (MoCA > 25).
Pre-stroke physical activity (PA) is assessed as light = SGPALS 2, regular PA and training = SGPALS 3–4; Stroke severity was assessed as mild NIHSS ≤ 0–5, moderate NIHSS 6–14; MoCA = Montreal Cognitive Assessment Scale; SGPALS = Saltin-Grimby Physical Activity Level Scale, TIA = Transient Ischemic Attack, NIHSS = National Institute of Health Stroke. The reference values were physical inactivity, male sex, education ≤ 12 years, non-smoking, non-diabetic, no atrial fibrillation, no TIA, no treatments, NIHSS 6–14. Unadjusted values were presented.

4.2.4 Pre-stroke physical activity and health-related quality of life

Study III included 2, 044 patients with a mean age of 73 (SD, 13) years, and 46% were females. Pre-stroke physical activity was associated with a better health-related quality of life, defined as a value above the median. The unadjusted values were OR (95% CI) 2.56 (2.13–3.08) for light physical activity and 4.18 (2.87–6.07) for moderate to vigorous physical activity, see **Figure 8**. In the multivariable analysis, when adjusting for other factors, the final model included pre-stroke light physical activity with OR (95% CI) 1.86 (1.52–2.29) and for moderate to vigorous physical activity 2.25 (1.51–3.36). The final model also included discharge to one's own home and shorter length of hospital stay to be associated with better health-related quality of life, while sex (female), older age (> 85 years), and moderate to severe stroke (NIHSS > 5) were associated with decreased health-related quality of life 3 months after stroke. Additionally, there was a dose-dependency for pre-stroke physical activity, where the odds for better health-related quality of life were higher for patients with moderate to vigorous pre-stroke physical activity than for those with light pre-stroke physical activity.

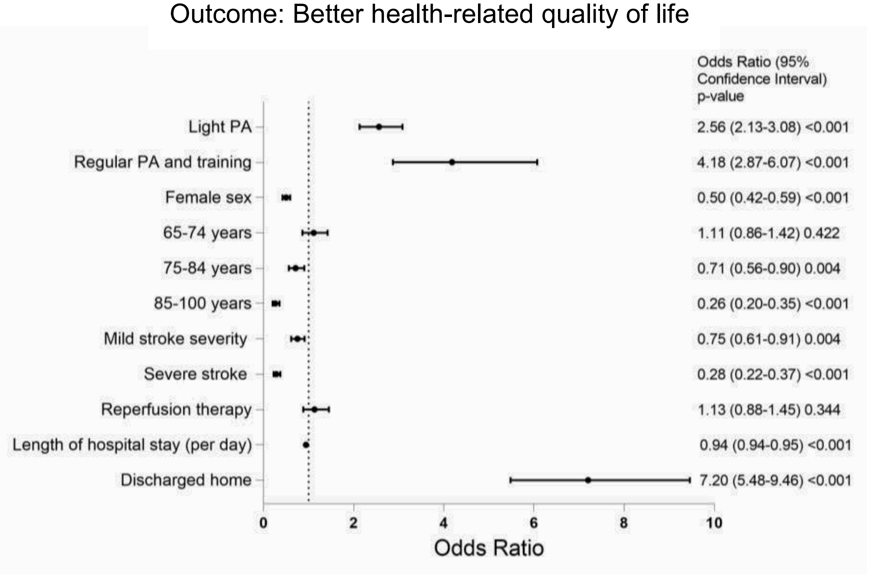

Figure 8. Association between independent variables and better health-related quality of life. Pre-stroke physical activity (PA) is assessed with SGPALS. Stroke severity was assessed as mild NIHSS 1–5, severe stroke NIHSS > 5; SGPALS = Saltin-Grimby Physical Activity Level Scale, NIHSS = National Institute of Health Stroke. The reference values were physical inactivity, male sex, age < 65 years, NIHSS zero, no reperfusion, and discharge to the nursing home/other ward. Unadjusted values were presented.

Study III showed better results for the five domains of EQ-5D mobility, self-care, usual activities, pain/discomfort, and anxiety/depression of the EQ-5D-5L assessment, as well as for overall health, EQ-5D VAS and EQ-5D index values in patients with light physical activity and moderate to vigorous physical activity compared with physically inactive patients. For the EQ-5D domains mobility, self-care, and usual activities, there was a dose-response relationship, for the pain/discomfort and anxiety/depression domains, all physical activities were equally beneficial, see **Figure** 9.

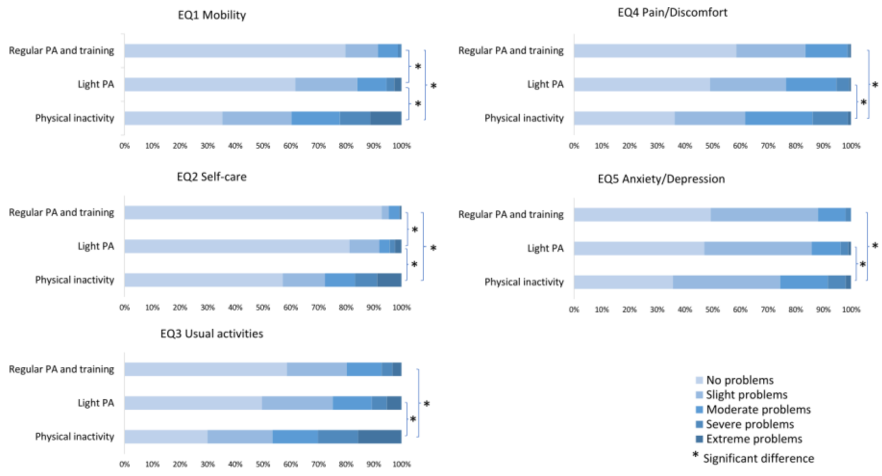

Figure 9. Health-related quality of life in groups with different pre-stroke physical activity levels. *The five health-related quality of life domains were presented with group differences. Pre-stroke physical activity (PA) assessed with the SGPALS = Saltin-Grimby Physical Activity Level Scale. *Indicates significant differences between groups.*

4.3 Experiences of physical activity and inactivity in the stroke unit

This qualitative interview study explored patients' experiences of physical activity and inactivity in the stroke unit. In the heterogeneous study sample, the 16 participants varied in age (49–84 years), sex, and stroke severity (**Table 8**). Various functions and discharge destinations for characteristics exist. The in-depth interviews were conducted after discharge from the stroke unit, after a median of 10.5 days (range 1–19 days). **Table 2** shows details about the interviews.

The patients' experiences of physical activity and inactivity in the stroke unit were analysed using reflexive thematic analysis, and three themes were generated from the interview data, see **Figure 10**. For each theme, four subthemes were identified in the texts and codes. The three themes and their subthemes are described in **Figure 11–13** and sections 4.3.1–4.3.3.

Dealing with the challenges of a changed body while striving to become independent	The stroke unit is crucial for physical activity	Physical activity is important for interaction with others, autonomy and feeling seen
• Doing everyday activities in new ways requires focus and energy	• Care and rehabilitation are pivotal to physical activity	• Becoming mobile gives the opportunity to choose to interact with others or being on your own
• Exercise is necessary for recovery after a stroke	• Receiving the rehabilitation, you need promotes recovery	• Being out of bed transforms the patient to a person who is seen and respected
• The opportunity to explore how to move is essential to move towards independence	• Attitudes and communication can influence physical activity and inactivity	• Physical activity could create contact with the outside world
• Fear can hinder physical activity, but sometimes it is worth taking the risk	• Rehabilitation staff challenge while instilling confidence to gain independency	• Encouragement and support give strength and confidence to continue exercising

Figure 10. Themes and subthemes *from patients' experiences of physical activity and inactivity at the stroke unit.*

4.3.1 Theme 1: Dealing with the challenges of a changed body while striving to become independent

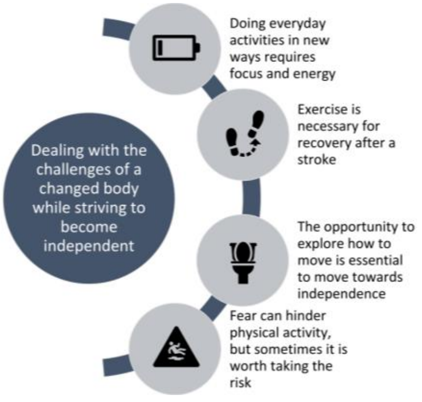

Figure 11. *Theme 1 with subthemes*

Theme 1 and its subthemes are illustrated in **Figure 11**. After their stroke, the participants strived to regain independence and experienced doing daily activities in new ways, which required more energy. To walk safely required a significant amount of concentration, according to several respondents. Many said that exercise was necessary to improve and make progress. Being motivated and never giving up was expressed as a personal responsibility after stroke. This also resulted in anxiety about insufficiency. Furthermore, the strive to manage everyday activities was expressed, often with a desire to do as much as possible and then get help with more difficult tasks. It was also described as valuable and meaningful to try and practice activities required at home. It was said that fear can hinder physical activity. Fears of falling, having a new stroke, and being infected (COVID-19) were told to create fear and anxiety. Participants expressed awareness that falling with a subsequent injury could worsen their situation and prognosis. However, many were prepared to take risks if they could achieve independence. One participant who addressed fear said the following:

> *'I was afraid to move because I feared that my blood pressure would rise, that I would feel nauseous and vomit, and that vomiting would not be good for me because it is exhausting and taxing. Thus, I did not move and spent the entire day in bed. I asked them if there was a risk for a new haemmorhage if I strain myself or vomit again. Yes, there is a risk, they said. Then I think I will not move!' Monica 75 years old*

4.3.2 Theme 2: The stroke unit is crucial for physical activity

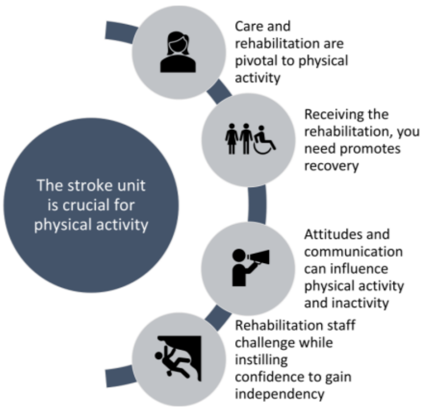

Figure 12. *Theme 2 with subthemes*

Theme 2 and its subthemes are illustrated in **Figure 12**. The participants expressed that the stroke unit needed to promote physical activity and to achieve this, the staff needed to be supportive, communicative, and place the patients in the centre of attention. Participants described a strong drive to improve after their stroke and wanted individualised rehabilitation and care that met their needs. A holistic approach among the staff and rehabilitation in everyday activities, was requested as a natural part of the stroke unit. The physical design and organisation of the stroke unit also influence the level of physical activity achieved. One quote addressing the physical design and organisation of the stroke unit:

> *'I was able to manage myself pretty well because it was spacious. [...] There were a lot of different treatments and different people, and I wanted to pull a blanket over my head to avoid seeing everything. There was no view either, and I looked straight out onto a wall from the window, but I had a window which was a good thing because the others did not Later, when I came to the hospital nearer to home, it was a newly built ward. Outside there were green spaces with the forest nearby, and deer ran there in the morning and came back in the evening, and that was a completely different experience.' Sophia, 83 years old*

4.3.3 Theme 3: Physical activity is important for interaction with others, autonomy and feeling seen

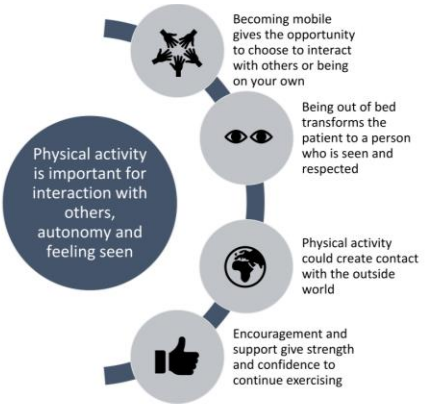

Figure 13 *Theme 3 with subthemes*

Theme 3 and its subthemes are illustrated in **Figure 13**. The participants described how the movement influenced their thoughts about themselves and how they related to others. With this ability to move, choosing between a community and privacy is possible, which can create a sense of normalcy and reduce loneliness. Being physically active contributed to get in touch with the outside world, could be nature, other people, or news feed on TV in the daytime. The world becomes tiny when you are in a hospital with your bed, cupboard, your purse, and nothing more. There was also a feeling of autonomy choosing between community and privacy and to get outside the room or outdoors, which created a sense of normalcy or reduced loneliness. When up on their feet, participants felt seen while in bed; they were passive and invisible. Physical activity was described as a way of being seen. This also entailed encouragement, which created confidence in one's abilities. One quote addressing how staying in bed made you passive and invisible is:

> *'I think that they [the staff] saw that I could manage on my own. There he lies, and he is quiet; thus, that is a good thing (laughter). I think that they prioritised the noisy and messy patients, that is how it is. I can go inside my own bubble. therefore, I do not mind lying or sleeping the whole day. it did not matter to me. It is because this downtime should not be so long. I am in my dreams and thoughts, but that is not for everyone. Others get worried and want to get up, walk, and do crazy stuff.'* Björn, 74 years old

5. Discussion

The studies in this thesis comprised physical activity both before and after stroke, explored with quantitative and qualitative designs. The main findings were that pre-stroke physical activity was associated with less acute stroke severity, intact cognition during the hospital stay, and better health-related quality of life 3 months after stroke. Additionally, after adjusting for other risk factors for stroke, pre-stroke physical activity remained associated with stroke outcomes in the final models of Studies I–III. In Study I, pre-stroke physical activity combined with younger age was associated with less severe acute stroke. In Study II, pre-stroke physical activity in combination with younger age, being non-diabetic, non-smoking, having a higher level of education, and having a less severe stroke were associated with a higher odds ratio for intact cognition after stroke. In Study III, pre-stroke physical activity in combination with discharge to one's own home and a shorter length of hospital stay were associated with better health-related quality of life. However, sex (female), older age, and more severe stroke were associated with decreased health-related quality of life. In Study IV, the interviewed participants described that physical activity is important in the stroke unit and that there is much more to movement than just physical activity. After stroke, patients at the stroke unit strive towards independence, and the way to achieve this is through exercise. The stroke unit should provide individualised care and rehabilitation and promote physical activity. Being up on your feet relates to autonomy, the feeling of being seen, and respect.

The time points explored in Studies I–IV included the acute and subacute phases after stroke (58) with acute stroke severity on admission, cognition during hospital stay, patients' experiences when staying in the stroke unit, and health-related quality of life after 3 months. The studied outcomes included body functions and structures, and activities according to the ICF (91). In this thesis, all components of the ICF have been considered in the studies in which the focus on register-based studies has focused more on body functions and activities, while the interview study was more focused on activities and participation. In this thesis, the outcomes of stroke severity and cognition are linked to body functions. Health-related quality of life is more complex and cannot be incorporated into the ICF, whereas physical activity experiences are primarily characterised as activities, but sometimes include participation. (39). It is important to consider ICF in rehabilitation studies, and a scoping review by Viktorisson et al. investigated pre-stroke physical activity regarding stroke outcomes according to the ICF (39).

Patient involvement was considered in Studies I–III but was more pronounced in Study IV. The researchers' experience determined the clinical relevance of the research questions in Studies I–III, while this was discussed between the researchers and a patient research partner in Study IV. Throughout the research process for this thesis, there have been initiatives to spread the results among clinicians, the media, older citizens, and patient organisations. Collaborations with patient research partners will continue in the future.

5.1 Discussion of the results in Studies I–III

5.1.1 Pre-stroke physical activity

In Study I, pre-stroke physical activity was associated with mild stroke severity. This finding has been confirmed in other studies (80, 138, 139). However, one review reported conflicting evidence (74, 140). Another review explored pre-stroke physical activity and its association with stroke outcomes by referring to the ICF (39). In Study II, pre-stroke physical activity was associated with normal cognition as assessed at the stroke unit. These results are partly in line with those of Damsbo et al. (141) and Levine et al. (142), although the former had different pivotal cognitive outcomes (141). In Study III, pre-stroke physical activity was associated with better overall health-related quality of life (the index value) and all five domains of mobility, self-care, everyday activities, pain/discomfort, and anxiety/depression, with similar results reported by Zirnsak et al. (143).

Dose dependence for physical activity

In Studies I–III, light physical activities of at least 4 h/week and moderate to vigorous exercise of 2–3 h/week were beneficial for stroke outcomes. However, in Studies II and III, moderate-to-vigorous exercise was even more beneficial for cognition and health-related quality of life than light physical activity. Other studies have not verified this dose-dependency of cognition and health-related quality of life. However, two previous studies reported a dose dependency of physical activity on stroke severity, where a longer duration was more positive (80, 138), while a higher frequency made no difference in stroke severity (144). The dose-dependent physical activity on stroke outcomes requires further exploration (74). A problem when exploring dose dependency and comparing it with other studies is the differences in the definitions of physical activity, assessment scales, and timing of assessments.

The mechanisms of pre-stroke physical activity

The mechanisms underlying the effects of pre-stroke physical activity on brain protection is unknown. This can be explained by a reduction in inflammation and an increase in the levels of growth factors that stimulate neurogenesis and angiogenesis (145, 146). Many studies exploring the underlying mechanisms of neuroprotection have been conducted in animal models or have small sample sizes with a risk of bias (147). Additionally, questions can be raised about how physical activity influences other risk factors and whether the role of physical activity is strong enough to stand alone, whether it is a mediator, or if physical activity is a proxy for something else, such as healthy lifestyle behaviours or the absence of comorbidities. In a study by Viktorisson et al., physically active pre-stroke participants had decreased stroke severity and mortality independent of other risk factors, including comorbidities (148).

5.1.2 Stroke outcomes

In Study I, pre-stroke physical activity combined with younger age was partially associated with milder stroke severity. This is consistent with the results of previous studies (80, 138). The association between pre-stroke physical activity and reduced stroke severity has been reported in several studies with methodological differences in the assessment of physical activity, stroke severity, and time of assessment (139, 149, 150). However, one study reported no association between pre-stroke physical activity and stroke severity (144).

In Study II, patients with pre-stroke physical activity, younger age, non-diabetes, non-smoking status, higher level of education, and less severe stroke had higher odds for intact cognition when screened during the hospital stay. The association of pre-stroke physical activity with cognitive performance was confirmed by a study in which faster processing speed was reported (after 1 and 6 months) but without an association with global cognition (141). Another study reported that participation in intellectual, recreational, social, and physical activities before stroke was associated with a reduced risk of dementia after stroke. However, physical exercise with higher intensity did not influence this risk (151).

Differences in outcomes, physical activity, and cognition assessment, and timing limit comparisons between Study II and other studies.

In Study III, pre-stroke physical activity was associated with better health-related quality of life 3 months after stroke onset. Another study reported similar results, in which pre-stroke physical activity was associated with better health-related quality of life, consistent with the results of Study III (143). Furthermore, previous studies have reported that physical inactivity after stroke is associated with a reduced health-related quality of life (152, 153, 154, 155). In the Swedish general population, physical inactivity is associated with decreased health-related quality of life (117). Furthermore, physically active patients had better health-related quality of life on the overall EQ-5D-5L index value, and on the EQ-VAS and all five domains (health-related quality of life mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) than the physically inactive group.

5.2 Discussion of the methods in Studies I–III

5.2.1 Register-based studies

Register-based studies provide data collected consecutively in clinical settings. This approach has advantages and disadvantages. The strength is the possibility of generalising the results to similar contexts with comprehensive stroke units and predominantly in patients with mild stroke severity. Furthermore, the data were consecutively collected with large study samples in the context of tax-financed public healthcare accessible to all in Sweden. Additionally, the coverage in the Riksstroke Register was high. Variables already collected from a register can be used in research with the possibility of merging additional variables from other registers.

A limitation of Studies I–III was missing internal data in the registered variables when staff who collected the data in the registers could not find the information in the patients' record or simply assessments were not conducted. This is a disadvantage of clinically collected registry data compared to research data. Data from the acute forms of Riksstroke and Väststroke were collected from patients' records, and 3 months follow-up data from questionnaires sent to the patients. Study III, used data from the 3 months follow-up period from Väststroke. From the 3 months follow-up, more internal data were missing, even though specially trained nurses sent reminders and, when needed, collected information by telephone. Another limitation is that some of the desired variables for the research question were not included in the registers. In the studies performed, we wanted more information on lifestyle habits, comorbidities, and post-stroke physical activity. Whether pre-stroke physical inactivity is a proxy for comorbidity was discussed with co-authors and reviewers before publishing the studies. However, Viktorisson et al. reported that pre-stroke physical activity was associated with better survival despite the comorbidities (148).

5.2.2 Study sample

The large study sample is a strength of this study. However, Studies I–III overlapped, in which some participants were included in all three studies and some in one or two studies (**Figure 3**). These results would have been more generalisable if the cohorts had been fully separated. There was a risk of selection bias owing to older patients with more severe stroke in the excluded groups in Studies I–III. This may be due to the difficulty in assessing patients with more severe stroke and palliative patients, resulting in more internal missing data. However, the necessary variable in Studies I–III, pre-stroke physical activity, may be unethical in assessing and prioritising patients who are very disabled or at risk of death. Moreover, all patients admitted to the stroke units were included in the registers regardless of stroke severity, communication skills, or cognitive impairments. Another limitation is that the excluded patients without 3-month follow-up data and with more severe stroke were probably discharged to nursing homes more often.

5.2.3 Data collection

There is a risk of interpretation bias when collecting data from stroke unit staff. As trained nurses collected more information, this risk decreased. Pre-stroke physical activity data were collected by physiotherapists and cognition data were collected by occupational therapists at the stroke units; thus, many assessors were involved, implying a risk of assessment bias. In Study III, a 3-month follow-up questionnaire from Väststroke was used. To collect the information, a postal questionnaire was sent out first, followed by a reminder if needed, a telephone call from a nurse with an increased risk of interpretation bias for non-responders. Carers or relatives can answer the questionnaires in Riksstroke and Väststroke with the risk of less valid register data. Furthermore, using data collected early after stroke, as in this thesis in the acute and subacute phase, is a strength as more research is needed early after stroke (156).

5.2.4 Variables and assessment scales

All variables were selected based on previous research and clinical experience, and Digital Acyclic Graphs were used for the selection. However, there is always a risk of variables being overlooked, especially thosenot included in the registers. Furthermore, Studies I and II were more exploratory and included more variables besides physical activity, whereas Study III was more explanatory and adjusted only for the most essential confounders. Methodological inconsistencies exist in stroke studies, with variations in defining the variables, assessment scales, and timing of assessments, making it difficult to compare results between different studies. There are articles with research guidelines to reduce these inconsistencies, (58).

Pre-stroke physical activity was the explanatory variable in Studies I, II, and III. Physical activity was assessed using the SGPALS, a generic and self-reported four-level scale. A limitation is the use of retrospective self-reported assessment scales that entail the risk of recall bias (157, 158), especially after stroke, with risks of post-stroke cognitive impairments. However, self-reported scales are reproducible and reliable when assessing physical activity (73, 159, 160). Objective assessments, including accelerometers, provide more accurate measurements of performed physical activity but are less feasible in large cohorts. Furthermore, self-reported assessments are more feasible in large study samples and registers (39, 161). A prospective study design would provide more reliable data on physical activity. Additionally, more extensive assessments of physical activity, such as the IPAQ or PASE, would provide more detailed information on the frequency, duration, intensity, and type. Using accelerometers and other objective measurements is more reliable when measuring physical activity but is difficult in large populations (73). However, the SGPALS, which is easy to use, has been validated to detect cardiovascular risk and the risk of physical inactivity (105) and is feasible in large clinical settings. In Studies I–III, recall bias was decreased by assessment of pre-stroke physical activity by physiotherapists providing more detailed questions about previous physical activity and, when needed, confirming previous lifestyle and habits with next of kin. Another limitation of the SGPALS is that it is inconsistent with international recommendations on physical activity and has limited information about the type, duration, frequency, and intensity of physical activity (1).

Cognition in Study II was assessed using the MoCA, a clinically feasible, generic assessment with validity to detect mild cognitive impairment after stroke (110, 162). In general, barriers to cognitive screening are problems with mobility and communication (163). Hence, the MoCA is less suited for patients with aphasia, impaired function of the dominant hand, or visual impairment; therefore, patients with severe stroke were excluded from this study. This induced a selection bias in Study II as severe stroke was an exclusion criterion; therefore, the results only applied to patients with mild or moderate stroke. Furthermore, information on pre-stroke dementia is lacking, and previous ADL independence was used as a proxy because independence in ADL is associated with intact cognition (164). Thus, previous dependence was an exclusion criterion in Study II as a proxy for pre-stroke dementia.

One limitation is that all assessments used are generic and that stroke-specific scales could have better covered physical activity, cognitive function, and health-related quality of life after stroke. However, the availability of variables in the registers guided the decisions. Patient-reported outcomes provide useful information and complement other healthcare assessments (165).

5.2.5 Other stroke-related factors

In Studies I–III, in addition to pre-stroke physical activity, several other factors associated with stroke outcomes were included in the analyses. These studies aimed to explore the best multifactorial models and adjust for confounding factors other than pre-stroke physical activity. Stroke severity is expected to influence other stroke outcomes and was included as an important factor in the final model in Studies II and III, where mild stroke severity (NIHSS 0–5) was associated with normal cognition and moderate to severe stroke NIHSS 6–42) was associated with decreased health-related quality of life. The association between stroke severity and decreased quality of life was reported in two studies (166, 167). Reperfusion was adjusted for in Studies II and III. However, it was excluded in the final model for either cognition or health-related quality of life, possibly because reperfusion was performed mostly for severe strokes. This contradicts previous studies in which thrombectomy was positively associated with cognition (168) and health-related quality of life (169). Furthermore, a longer hospital stay was associated with decreased health-related quality of life in Study III, as shown in a previous study (166).

Demographic variables, including younger age positively influenced outcomes in Studies I–III. In Study I, younger age, but not sex, was partly associated with less stroke severity, which is in line with studies in which older age and sex (female) were associated with more severe strokes (170). Furthermore, Study II showed that younger age and longer education were associated with normal cognition, in accordance with previous studies in which older age and lower levels of education were associated with cognitive impairment (51, 142). Furthermore, in Study III, health-related quality of life decreased in the oldest age group (> 85 years), which has been reported in previous stroke studies on decreased health-related quality of life in older individuals (152, 166, 171, 172). Female sex was associated with decreased health-related quality of life in Study III, as previously shown in several studies (153, 172, 173).

Risk factors and comorbidities can influence the outcomes of Studies I–III. Study II, being non-diabetic was associated with normal cognition at the hospital, while in Study III, it was only adjusted for the most important factors, although more variables could have been interesting. Other factors that would have been interesting to include in the analyses were functional ability, socioeconomic status, and comorbidities.

5.2.6 Statistics

In Studies I–III, pre-stroke physical activity was associated with stroke outcomes in univariate analyses, the so-called unadjusted or crude analyses. The results were validated after adjusting for other factors. A limitation of this thesis is that the same analysis, binary logistic regression analyses were used in Studies I–III. However, an ordinal outcome would have been more interesting but did not fulfil the assumptions for the analyses, or the results were difficult to interpret. With a dichotomised outcome, the difference between good and bad outcomes can be small, and the variation is less explored.

5.3 Discussion of the results in Study IV

The participants wanted to focus on their physical abilities and what works to find new ways to move and function. This reflects a salutogenic perspective in which health factors and capabilities are considered resources for recovery and health (174). The participants described a strong drive towards independence after stroke. They call for active everyday life in the stroke unit, where sufficient exercise adjusted for their needs is provided. Exercise is necessary for this improvement. This is consistent with a study by Kannisto et al. in which patients' physical functioning, independence, and self-confidence were supported by a rehabilitative approach in acute hospital wards (175).

Patients stated that stroke unit care and rehabilitation are pivotal to physical activity, where their experiences varied from almost complete physical inactivity to high levels of physical activity and exercise. A review report confirms physical inactivity in stroke units where patients spend 48% of their day inactive, 57% in their bedroom, and 54% staying alone, while 1 h is spent in physiotherapy (82). However, a Norwegian study reported that physical activity increased when stroke units focused on early rehabilitation, even in patients with severe stroke (176).

Additionally, there was a narrative in which the participants in Study IV described their struggle to cope with their changed bodies and take charge of their exercise and situation as capable persons. Furthermore, the participants desired a holistic view and to be seen as a person, not a diagnosis. Additionally, they requested to be listened to, be informed about, and be involved in care and rehabilitation. The positions mentioned by the participants in Study IV regarding themselves as capable of being involved in decision-making and planning of care and rehabilitation are in line with person-centred care (59, 98), supported by the Swedish National Stroke Guidelines (21).

Physical activity was perceived as vital for feeling seen and respected, as described by the participants in Study IV. Similar results were reported in a qualitative study of patients' experiences after hip surgery where the participants reported the need to be seen as a person, to have their needs met, and to strive for independence to recover in a geriatric ward (177). It can be assumed that some results of this study can be applied to other diagnoses and wards. However, this is a qualitative study, and the results can only be transferred to similar contexts to improve the quality of care and rehabilitation.

5.4 Discussion of the methods in Study IV

The research question regarding patients' experiences of physical activity and inactivity in the stroke unit is relevant and supported by clinical experience, the knowledge gap presented in previous research, and the research patient partner.

Trustworthiness in qualitative research depends on credibility, dependability, confirmability, and transferability (101). The participants were purposively sampled to ensure a heterogeneous study sample. Contact with the recruiting physiotherapists was continuous in recruiting heterogeneous samples based on differences in age, sex, and stroke severity. Heterogeneity was more excessive than planned with dialogue in the recruitment phase, in which participants with light aphasia, light cognitive impairment, wheelchair users, and participants discharged to short-term nursing homes were also included in the study. Prerequisites for generating rich data were that the participants could choose the location for the interview and that the moderator strived to create an open and comfortable atmosphere during the interviews. To ensure the credibility of the analysis process, the analysis was performed by two independent researchers and validated by a co-researcher and the patient's partner. Participants' quotes were carefully selected to support the analysis and represent the heterogeneity of the study sample to further strengthen the credibility of the study. A carefully constructed interview guide was used to support the dependability of the results, and the same moderator conducted all interviews. All interviews were conducted within 2 months to capture the phenomena during a specific period to analyse the phenomena and reduce the impact of potential organisational changes. In Study IV, the authors' preconceptions were reported, a transparency which increases the confirmability of the study (101, 134), and the authors tried to stay close to the data. However, the influence of researchers on the analytical processes is unavoidable. Furthermore, thematic analysis was reflexive, going back and forth to ensure consistency between data, subthemes, codes, and data (134). There is a need to increase the transferability of the results through detailed descriptions of the methods and analysis procedures (101).

This was analysed within a social constructivist framework with no objective truth, and experiences are subjective and dependent on the context. This framework suited the research question, although other interesting results could have been obtained using other theoretical frameworks. Other interesting frameworks could be critical theory, where power distribution could have been explored; person-centred care, exploring the partnership between patients and staff at the stroke unit; or the phenomenology of the body exploring the experiences of a changed body and how to cope with the changed situation.

This study had several limitations. First, there is a risk of researcher bias because researchers' preconceptions can influence the analysis. Second, the limitation of power inequalities is present, as researchers can have precedence over interpretation and more power in the research design and analysis process compared with patient research partners or participants in the interviews. There was also a risk of recall bias because the participants were interviewed after discharge and not in the stroke unit. Furthermore, collecting retrospective data from poststroke experiences can induce problems in remembering experiences, particularly if cognitive problems exist. However, interviews were conducted soon after discharge to reduce recall bias. The deliberate choice to interview after discharge and separate from the stroke unit was to reduce the risk of interviewees wanting to please the staff with their answers. Another limitation is that not all interviews were equally rich in data because of cognitive or communicative impairment or fatigue. Furthermore, it should be considered that the interviews took place in the autumn of 2022 when some stroke units had restrictions on being in communal areas at the stroke units or visiting restrictions, while other stroke units had no restrictions. The context of the post-pandemic Swedish situation should be considered when interpreting the results.

6. Conclusion

In conclusion, pre-stroke physical activity is positively associated with several stroke outcomes and can reduce some of the consequences. In this thesis, pre-stroke physical activity was associated with less acute stroke severity, intact cognition during hospital stays, and better health-related quality of life 3 months after stroke. Light physical activity, such as walking for at least 4 h/week and moderate physical activity for 2–3 h/week is beneficial for stroke outcomes. Additionally, a higher intensity of pre-stroke physical activity is more beneficial to cognition and health-related quality of life after stroke.

Participants claimed there was much more to movement than just physical activity when staying in the stroke unit. It is said that they have a strong drive to become independent, and the way to reach independence is often through exercise. The interviewees asked the stroke unit to provide individualised care and rehabilitation to promote physical activity. The participants also felt the need to be listen to and have their needs for care and rehabilitation met by the staff at the stroke unit. Moving and being up and around relates to autonomy; the participants felt seen and respected.

7. Clinical implications

This thesis provides information on the positive influence of pre-stroke physical activity on the consequences of stroke. The results of this thesis can be applied throughout the continuum of stroke care. Promoting physical activity is an important part of public health when writing guidelines and planning healthcare. Promoting physical activity in public health can reduce stroke occurrence and recurrence and is therefore of societal and economic interest. Prevention must be prioritised in healthcare. Lifestyle behaviours and health promotion are important in primary care, hospital care, rehabilitation programs, and at follow-up (41). Healthcare counselling and support for healthy lifestyle behaviours, including increased physical activity, should be provided to individuals at risk (41). There is much knowledge regarding the benefits of physical activity; however, existing guidelines need to be implemented.

In the interviews the participants stressed the importance of physical activity while staying in the stroke unit. Physical activity is both physically and emotionally important for participants. The interview study can contribute to improved stroke care and rehabilitation. This can be achieved through staff awareness and education, as well as organisational actions in the stroke unit, including changes in clinical practice, routines, and staffing. Some changes are easily achieved, whereas others require time, money, and effort. Physical activity levels often decrease after stroke (76); therefore, the motivation to be physically active or to continue a physically active lifestyle among physically active individuals with stroke is important.

The new knowledge from the present thesis can add to the evidence about physical activity before stroke and thus avoid more severe consequences of stroke. A deeper understanding of the experiences of physical activity and inactivity in patients with stroke can help develop stroke care and rehabilitation strategies. This thesis also provides information on how stroke unit care can promote physical activity.

8. Future Perspective

To be physically active can be difficult after stroke. Future studies should investigate the design and effects of targeted physical activity interventions in patients with stroke. Increasing physical activity levels after stroke are important, as is finding ways to sustain healthy lifestyle behaviours over time. Complementing quantitative studies with qualitative narratives of patients' experiences can provide a deeper understanding of the different perspectives on physical activity and inactivity. Therefore, there is a need to understand the underlying reasons for physical activity or inactivity after stroke.

Further studies are needed to investigate the association between pre-stroke physical activity and long-term outcomes after stroke. Furthermore, randomised control studies and prospective studies are needed to investigate causal connections to confirm the associations between pre-stroke physical activity and stroke outcomes within this thesis. Another problem is the diversity of methodological approaches to this topic. Studies on physical activity require both objective devices and subjective self-reported assessments. The use and development of wearable devices that provide metrics for surveillance in accordance with the guidelines for physical activity are desired. There is also a need to define and measure physical activity to compare different studies with current international guidelines. A more comprehensive approach to physical activity, including type, frequency, duration, intensity, and timing, is also of interest. Another urgent issue is stroke recurrence, which occurs in 25% of patients. No evidence exists for the association between physical activity and stroke recurrence. If more aggressive secondary prevention after TIA and stroke could reduce new stroke cases, it would benefit individuals, society, and healthcare.

Future studies should explore how to promote healthy lifestyle behaviours, including physical activity and sedentary behaviour, in clinical settings. Integrating health protection into the clinical practice of physiotherapists is a line of work that needs to be developed, evaluated, and applied to all physiotherapy practices. Research on the active implementation of healthy lifestyle behaviours, including physical activity, is needed.

Physical activity is of general interest to people of all ages, is cheap, readily available, and is associated with health and disease prevention. Therefore, it is worth exploring this topic from various perspectives to support global public health. To engage society, healthcare, schools, media, and politics, we need evidence and action to promote physical activity regardless of age, sex, and socioeconomic status.

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