UNIVERSITY OF COPENHAGEN
FACULTY OF HEALTH AND MEDICAL SCIENCES

PhD Thesis

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Cross-sectoral rehabilitation after stroke

In hospital and municipalities of North Zealand

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Preface

Prior to undertaking this thesis, I developed a strong interest in the long-term physical rehabilitation of patients with severe illnesses. My professional background as a physiotherapist, including several years of experience in an acute hospital setting, has provided me with valuable insights into the initial phase of patient care, which typically involves a brief period of treatment prior to discharge. This clinical experience has informed my understanding of the challenges and opportunities in early rehabilitation. My research interest in physical activity led to the publication of my master's thesis, which examined the effects of aerobic exercise in individuals with type 1 diabetes mellitus. Additionally, I contributed to research projects focused on physical activity in patients with chronic kidney disease.

As therapists, we have the opportunity to assist a wide variety of patients and collaborate with numerous healthcare professionals. However, we rarely receive follow-up information about our patients' progress after they leave the hospital. This lack of continuity sparked my curiosity about the longer-term recovery trajectory and the potential benefits of extended rehabilitation support.

Motivated by a desire to understand the rehabilitation journey beyond the acute phase, I chose to explore the course of recovery across healthcare sectors. A key objective of this thesis is to produce clinically relevant findings that can ultimately benefit both healthcare practitioners and patients.

Stroke, in particular, is a life-altering condition often accompanied by a wide range of sequelae. It is therefore crucial to deepen our understanding of how to best support stroke survivors within the current healthcare system and to identify ways to improve transitions between care sectors.

This research aims to contribute to the existing body of knowledge on physical activity, long-term follow-up of stroke patients, and the use of repeated physical function assessments. Furthermore, it addresses the role of patient-centered rehabilitation goals and planning in facilitating optimal recovery outcomes. Artificial Intelligence (Copilot) was utilized exclusively for tasks such as paraphrasing and refining the author's original text.

Gabriel T. Notkin 24th September 2025.

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Abbreviations

PA = physical activity

MVPA = moderate-vigorous physical activity

BBS = berg balance scale

30sCST = 30-seconds chair stand test

HRQoL = health-related quality of life

DM = diabetes mellitus

SSS = scandinavian stroke scale

mRS = modified rankin scale

ICF = international classification of function, disability and health

ADL = activities of daily living

WHO = world health organization

TIA = transcient ischemic attack

LMM = linear mixed model

VAS = visual analog scale

BMI = body mass index

CVD = cardiovascular disease

OR = odds ratio

TUG = timed up and go test

MoCA = montreal cognitive assessment

FIM = functional independence measure

GDPR = general data protection regulation

Studies in thesis (I-IV)

Study I

Gabriel Tafdrup Notkin, Dorthe Gaby Bové, Kai Jensen, Lisbet Lind, Julie Lyng Forman, Michael Broksgaard Jensen, Stig Molsted.

Title: Low levels of physical activity and high amount of sedentary behavior in the acute phase after stroke. Submitted to Topics in Stroke Rehabilitation – Taylor & Francis. Under review.

Study II

Gabriel Tafdrup Notkin, Dorthe Gaby Bové, Lisbet Lind, Michael Broksgaard Jensen, Stig Molsted.

Title: Rehabilitation after stroke in a transition from hospital to municipality – impact of amount of rehabilitation. Manuscript in preparation.

Study III

Gabriel Tafdrup Notkin, Dorthe Gaby Bové, Lisbet Lind, Michael Broksgaard Jensen, Stig Molsted.

Title: Goal achievement in stroke outpatient rehabilitation. Manuscript in preparation.

Study IV

Gabriel Tafdrup Notkin, Stig Molsted, Michael Broksgaard Jensen, Lisbet Lind, Dorthe Gaby Bové.

Title: How do stroke survivors experience rehabilitation goal setting and plans to support their rehabilitation? A qualitative study. Disability and rehabilitation, 1–9. 2025 May 6:1-9.

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Dansk resumé

Stroke rammer i Danmark over 12000 personer årligt. Konsekvenserne kan være særdeles alvorlige på det personlige plan (lammelser, talebesvær, balancemæssige udfordringer og depression), såvel som samfundsmæssigt i form af høje udgifter til akutbehandling særligt til hospitalsbehandlinger eller specialklinikker, tabt arbejdsevne og øget behov for hjælp og støtte i dagligdagen grundet følgevirkninger fra stroke. Tidlig genoptræningsindsats og rehabilitering skal sikre, at personer ramt af stroke genvinder mest muligt af deres tabte eller svækkede funktioner og fremadrettet kan indgå i sociale og fysiske kontekster, hvor de kan tage del i en fysisk aktiv hverdag og indgå i arbejdslivet og familielivet.

Igennem denne afhandling har jeg fokuseret på at undersøge forskellige aspekter af den fysiske genoptræning efter stroke på tværs af sektorer via tre studier på en kohorte bestående af 122 deltagere og et kvalitativt arbejde med udvalgte deltagere fra Nordsjælland.

Studie I vedrørte fysisk aktivitet i tiden med akut stroke under hospitalsindlæggelsen og i den første uge efter udskrivelse fra hospitalet. Med SENS-sensorer målte vi fysisk aktivitet med antal skridt, moderat-højintens fysisk aktivitet, total fysisk aktivitet og stillesiddende tid. Vi fandt lave niveauer af fysisk aktivitet under indlæggelse og efter udskrivelse ved mange daglige timers stillesiddende tid og få minutters moderat-højintens aktivitet. Trods forbedringer i fysisk aktivitet fandt vi begrænsede ændringer imellem perioderne. Antallet af skridt efter udskrivelsen var omkring 5400 skridt i gennemsnit. Vi konkluderede, at der er behov for bedre indsatser for at højne fysisk aktivitet hos patienter med akut stroke.

I studie II blev deltagerne i kohorten fulgt fra indlæggelse til afslutningen på det kommunale genoptræningsforløb. Deltagerne blev fulgt med målinger af fysisk funktion med 30 sekunders rejse/sætte-sig test, Berg balance skala og helbredsrelateret livskvalitet EQ-5D-5L målt ved indlæggelse og afslutning. Der blev fundet fremgang i hele perioden for fysisk funktion og balance samt helbredsrelateret livskvalitet. De største fremgange blev fundet under indlæggelsesperioden. Samlet set sluttede deltagerne dog forløbet med lavere scorer end baggrundsbefolkningen for fysisk funktion og helbredsrelateret livskvalitet. Trods forbedringerne er der derfor behov for yderligere genoptræning, hvis deltagerne skal opnå sammenlignelige niveauer med baggrundsbefolkningen.

Studie III undersøgte målopfyldelsen af deltagernes træningsmål efter træning i kommunerne. Genoptræningsmålene blev vurderet af terapeuterne i kommunerne. I 30,8 % af tilfældene blev det vurderet, at målet var helt opnået. I 45 % var det vurderet, at målet var delvist opnået og i ca. 14 %, blev målet ikke opnået. Der blev ikke fundet uligheder, der skyldtes alder, køn, kommune, uddannelsesniveau, genoptræningsniveau eller type af stroke. Yderligere analyser viste dog, at baselinescore og afslutningsscore i 30-sekunders rejse/sætte-sig test eller Berg balance skala kunne have betydning for graden af målopfyldelse. Vi konkluderede derfor, at der er behov for fokus på deltagere med lave scorer i nævnte funktionstest og øget fokus på målsætning og evaluering i klinisk praksis.

Studie IV undersøgte deltagerperspektivet i tværsektoriel genoptræning ved at undersøge, hvordan deltagerne opfattede det at have en genoptræningsplan, og hvordan de følte sig hørt eller inddraget i målene for deres træning. I dette kvalitative arbejde blev 17 udvalgte deltagere interviewet og spurgt ind til deres oplevelser/erfaringer med genoptræningen på tværs af sektorer. Oplevelserne pegede på manglende inddragelse i mål og i evaluering af genoptræningen og genoptræningsplanen. Endvidere blev aktuelle træningstilbud opfattet som standardiserede og rigide samtidig med at flere deltagere påpegede, at de ikke blev tilgodeset i genoptræningen, og at de oplevede at leve med senfølger knyttet til stroke, som der ikke blev gjort nok for at løse i tilbuddene. Vi konkluderede, at der er behov for bedre og mere inddragende løsninger i den nuværende kliniske praksis med genoptræning efter stroke, og at genoptræningsplanerne ikke altid følger patienternes behov, hvorfor der ønskes øget fokus på patientcentrerede tilgange.

Samlet set viste studierne positive resultater og en række udfordringer ved tværsektoriel genoptræning efter stroke, som vi skal arbejde hen imod at forbedre. Øget fokus på patientinddragelse og strukturelle ændringer er nødvendige for at kunne tilgodese bedre forløb for patienter med stroke i fremtiden.

English summary

Stroke affects over 12,000 individuals annually in Denmark. The consequences can be profound, both personally and societally. At the individual level, stroke may result in paralysis, aphasia, balance impairments, and depression. At the societal level, the burden includes substantial costs associated with acute medical care—particularly hospitalization and treatment in specialized clinics—as well as loss of work capacity and increased demand for long-term care and support due to stroke-related sequelae. Early rehabilitation is essential for restoring lost or impaired functions, enabling individuals to re-engage in social and physical activities, participate in family and work life, and maintain a physically active daily routine.

In the present thesis, I have examined various aspects of physical rehabilitation following stroke across healthcare sectors. This was done through three studies involving a cohort of 122 participants, as well as a qualitative study with participants from North Zealand.

Study I focused on physical activity from the time of acute stroke hospital admission through the first week after discharge. Physical activity was measured using the SENS system, which provided data on step counts, moderate-to-vigorous physical activity, total physical activity, and sedentary time. Our findings revealed consistently low levels of physical activity both during hospitalization and in the immediate post-discharge period. Sedentary time was high, and participants engaged in only a few minutes of moderate-to-vigorous physical activity daily. Although slight improvements were observed between the two periods, overall changes were minimal. Post-discharge, participants averaged approximately 5,400 steps per day. We conclude that more effective strategies are needed to promote physical activity in patients recovering from acute stroke.

Study II followed participants from the cohort throughout their rehabilitation journey—from hospital admission until the completion of municipal rehabilitation services. Physical function was assessed using the 30-Seconds Chair Stand Test and the Berg Balance Scale, while health-related quality of life was measured with the EQ-5D-5L at both admission and rehabilitation completion. Improvements were observed across the entire period in physical function, balance, and health-related quality of life. The most significant gains occurred during the initial phase following admission. However, despite these improvements, participants' final scores remained below those of the

general population in both physical function and quality of life. These findings suggest that while rehabilitation yields positive outcomes, additional efforts may be necessary to help stroke survivors reach levels comparable to the general population.

Study III investigated goal achievement in relation to participants' rehabilitation objectives within municipal services. These goals were evaluated by municipal therapists. In 30.8% of cases, the rehabilitation goals were fully achieved, while 45% were assessed as partially achieved. In 14% of cases, the goals were not achieved. No significant differences were found in goal achievement based on age, sex, municipality, education level, rehabilitation intensity, or stroke type. However, further analysis revealed that baseline and completion scores on the 30-Seconds Chair Stand Test and the Berg Balance Scale were associated with the degree of goal achievement. These findings suggest a need for increased attention to participants with lower functional scores and a stronger focus on goal setting and evaluation practices in clinical rehabilitation.

Study IV explored participants' perspectives on cross-sectoral rehabilitation, focusing on their experiences with rehabilitation plans and involvement in goal setting. Seventeen participants from North Zealand were interviewed about their rehabilitation journeys across sectors. The findings revealed a perceived lack of involvement in both goal setting and evaluation processes, as well as in the development and implementation of rehabilitation plans. Participants described the rehabilitation services as rigid and standardized, often failing to address their individual needs—particularly when living with stroke-related sequelae that were not fully understood or accommodated within the existing rehabilitation framework. We conclude that there is a need for greater patient involvement in clinical rehabilitation practice post-stroke. Rehabilitation plans should be more responsive to individual needs, highlighting the importance of a patient-centered approach.

Overall, the studies demonstrated both positive outcomes and significant challenges in cross-sectoral stroke rehabilitation. To improve future rehabilitation pathways, increased emphasis on patient involvement and structural changes are essential to ensure more personalized and effective care for stroke survivors.

Brief introduction

The annual incidence of stroke in Denmark is approximately 12,500 cases, positioning it as the second leading cause of mortality and the third leading cause of disability globally. Stroke can have devastating impact on the individual due to an estimated 50–85% frequency of stroke survivors experiencing persistent sequelae, including impaired balance and gait, reduced upper extremity function, and communicative and cognitive deficits. These impairments significantly affect individuals' daily lives, particularly in relation to family involvement, social participation, and occupational engagement. With increasing numbers of elderly and chronically ill people in the future stroke can be expected to pose a considerable threat to many people worldwide. Stroke also imposes a considerable economic burden on the Danish healthcare system, with annual costs estimated at 2 billion DKK. These expenses stem from both direct medical treatment and care, as well as indirect costs such as loss of income among affected individuals.

Early initiation of rehabilitation during hospitalization, followed by continued rehabilitation post-discharge, is therefore essential and widely recommended to optimize recovery outcomes. Rehabilitation plans should be developed collaboratively with patients, emphasizing individualized and meaningful goal setting. Hospitals further advocate for maintaining physical activity between exercise sessions to mitigate the risk of recurrent stroke.

1. Background

1.1 Stroke

Ischemic stroke is defined as “an episode of neurological dysfunction caused by focal cerebral, spinal, or retinal infarction” (1). In contrast, stroke resulting from intracerebral hemorrhage is defined as “rapidly developing clinical signs of neurological dysfunction attributable to a focal collection of blood within the brain parenchyma or ventricular system that is not caused by trauma” (1). Thus, these stroke subtypes are typically caused either by an obstruction of blood flow to the brain or central nervous system—such as from a thrombus or embolus—or by bleeding from a ruptured intracerebral vessel, both of which result in neurological symptoms or dysfunction.
Globally, stroke remains the second leading cause of death and the third leading cause of death and disability combined (2). In 2021, approximately 7 million deaths worldwide were attributed to stroke (2). In 2017, the total estimated cost of stroke across 32 European countries was €60 billion, with €27 billion attributed to direct healthcare expenditures (3). Stroke-related costs vary significantly depending on the phase of care (acute, subacute, and chronic) and the structure of national healthcare systems (4). Among these, inpatient hospital care represents the largest economic burden, accounting for estimated 49.4% of total stroke-related costs globally (4). Behind these figures are highly diverse patient experiences, ranging from full recovery to profound long-term disability, underscoring the need for individualized rehabilitation approaches.

Stroke can result in a wide range of impairments and deficits, depending on the specific regions of the brain and neural pathways affected by ischemia or hemorrhage. Some impairments may be evident immediately, while others may emerge over time.
Motor dysfunction is among the most common consequences of stroke, affecting movement, balance, gait, and the functional use of the extremities (5,6). Post-stroke motor impairments are estimated to affect 50–85% of patients, frequently co-occurring with other deficits and manifesting in diverse combinations (6). Such impairments, particularly when combined with cognitive or emotional changes, may influence the extent to which patients can actively engage in rehabilitation.
Visual deficits are reported in up to 30% of stroke patients while hearing impairments occur in approximately 21% of individuals with posterior circulation ischemia (5). Aphasia, a language disorder frequently associated with stroke, has a globally reported prevalence ranging from 7% to 77%, with estimates in Denmark ranging from 28% to 55% (7).

Around half of patients with stroke (6) experience cognitive issues, and up to one-third suffer from post-stroke depression (5), although the exact prevalence remains uncertain (5,8). Other symptoms after stroke like pain and fatigue, and together with depression are linked to lower quality of life (9). In addition, depression also significantly impacts mortality (10). Qualitative studies describe these 'invisible symptoms', such as fatigue (11) and depression (12), as among the most debilitating aspects of stroke, despite being less visible to healthcare providers.

Certain modifiable factors related to lifestyle are associated with 90% of the risk of ischemic and intracerebral hemorrhagic stroke worldwide (13). These factors among others were found to be related to all stroke risk: hypertension (odds ratio (OR) 2.64), smoking (OR 2.09), unhealthy diet (OR 1.35), psychological stress (OR 1.30), excessive alcohol intake consisting of 30 drinks or more per month (OR 1.51), whereas physical activity (PA) were associated with a reduced stroke risk (OR 0.69) (13). Those factors affect medical conditions that are associated with stroke risk, and atrial fibrillation have been found to be one of the most common cardiac sources of thromboembolism in ischemic stroke cases with a prevalence of 23% in high-income countries (13). Diabetes mellitus (DM (OR 1.35)), dyslipidemia, and high waist-to-hip circumference ratio (OR 1.65) are associated with increased ischemic stroke risk (13).
Addressing these modifiable risk factors requires not only medical management but also active patient engagement in lifestyle changes, such as increasing PA (14). Although the optimal amount and intensity of PA required for stroke prevention remains a topic of debate, regular PA is generally associated with a 25–30% reduction in stroke risk (14). General exercise has demonstrated beneficial effects on several modifiable risk factors relevant to secondary stroke prevention, including hypertension, dyslipidemia, DM, and obesity (15). However, little is known about how patients with stroke maintain or change their activity levels during the critical transition from hospital to community care.

During the acute phase of stroke treatment, patients are assessed and managed by a multidisciplinary team of healthcare professionals at various stages. While this multidisciplinary approach offers a wide range of expertise, patients may experience it as fragmented if communication and coordination between professionals are insufficient.

In the early management of stroke, patients undergo thorough clinical evaluations conducted by physicians, nurses, and laboratory or radiological staff (16). In addition, other staffs including speech language pathologists, occupational therapists, and physiotherapists are involved. At this

stage, critical decisions are made regarding the administration of intravenous thrombolytic therapy to dissolve blood clots, as well as the use of neuroimaging techniques—such as magnetic resonance imaging or computed tomography—to determine the location and extent of the cerebral infarction (16). Thrombolysis and thrombectomy are key components of acute ischemic stroke management and have been shown to significantly reduce long-term neurological sequelae when administered promptly (17). The timing of these interventions is critical, as their effectiveness diminishes rapidly with delayed initiation. Therefore, evaluation for thrombolysis (pharmacological revascularization) and thrombectomy (mechanical removal of a thrombus) should begin immediately upon hospital admission (17). The proportion of ischemic stroke patients receiving thrombolysis exceeds 15% globally (18) with regional variation observed in Denmark, where rates range from 17% to 27% depending on the specific healthcare region (17).

In Denmark, stroke severity is commonly assessed using the Scandinavian Stroke Scale (SSS) (18). Internationally, the National Institutes of Health Stroke Scale (NIHSS) and the modified Rankin Scale (mRS) are recommended to register clinical impairments and monitor changes in the patient's condition over time (16). Other essential assessments during the acute phase of stroke include measurements of blood pressure, blood glucose levels, electrocardiography, and evaluations of oxygenation and respiratory function (16).

1.2 Rehabilitation

Rehabilitation is central to post-stroke recovery, aiming to restore function, promote independence, and improve quality of life through multidisciplinary interventions. Effective rehabilitation requires coordination across clinical settings and alignment with patients' personal goals and capacities.

During the acute hospital stay, the rehabilitation team—typically comprising a physiotherapist, occupational therapist, and speech-language pathologist—plays a crucial role in initiating early rehabilitation interventions (5). These professionals assess motor impairments, implement targeted exercises to address functional deficits, and evaluate physical capabilities, pain levels, and potential cognitive impairments following the stroke (5). The rehabilitation team may be involved both during the acute hospital stay and after discharge in an outpatient setting, reflecting evidence supporting the benefits of intensive and continuous therapy (19). In the subacute phase following hospital discharge, patients may also be referred to a brain injury coordinator or vision and hearing specialists if sensory impairments persist.

During the acute-subacute phase of stroke the patient will be subjected to transitions between of hospital setting in the acute phase to outpatient settings in the subacute phase, that usually is provided in municipalities in Denmark. In Denmark, the regional authorities (hospitals) are responsible for assessing patients' rehabilitation needs and for informing the municipalities of the results. This includes preparing a rehabilitation plan with recommendations for further rehabilitation (20,21).

Rehabilitation in the municipalities is organized in the local rehabilitation centers and provided in the centers, within the homes of the citizens or the nursing homes in the municipalities. The municipalities are responsible for planning, initiating and coordinating a thorough rehabilitation course for the patient post-discharge (20). No later than four days after discharge, the municipality must inform the patient about the details of their rehabilitation, including when and where it will begin (20). Furthermore, the municipal rehabilitation should begin no later than seven days post-discharge otherwise the person can choose freely where the rehabilitation should take place.

The rehabilitation is a fundamental component of stroke management in the post-acute phase to support recovery and functional improvement (19). It involves a comprehensive assessment of the patient's physical, cognitive, and psychosocial needs, followed by the formulation of individualized, attainable, and clinically relevant rehabilitation goals. The rehabilitation process includes targeted interventions aimed at achieving these goals, with regular evaluations to monitor progress and adjust the treatment plan accordingly (19).
The guidelines from American Stroke Association 2016 (5) have stated the need for exercise as part of the rehabilitation post-stroke, and the European Stroke Organization (22) underscores the need for high intensity training, among them the modalities gait training and sit-to-stand training, as part of the motor rehabilitation post-stroke. The recommendations also include a focus on increasing the intensity of the exercises and adding more transfer between rehabilitation and daily activities. The Danish national guideline for rehabilitation across sectors for patients with acquired brain damage recommends rehabilitation to begin as early as possible with the use of International Classification of Function, Disability and Health (ICF) for determining functional abilities and impairments (20). The patient and their next of kin should be involved in the plan for the rehabilitation course and goal setting (20). A thorough coordination between hospitals and municipalities (20) with sharing of results and plans across sectors and between the multidisciplinary teams should provide evidence-based treatment, rehabilitation and ongoing evaluation of the patient with respect to progress.

The rehabilitation plan used in Denmark (23) aligns with hospital discharge planning tools implemented in other healthcare systems (24–26) sharing the common objective of ensuring continuity of care by documenting treatment plans, patient and caregiver preferences, and rehabilitation needs for the subsequent community-based rehabilitation phase (20). The plan should be developed collaboratively with the patient, their next of kin, and relevant healthcare professionals, and must be provided at the time of hospital discharge (20,21). Timely initiation of rehabilitation in municipality following discharge is critical to maintaining momentum in the patient's recovery process. The rehabilitation plan is intended to accompany the patient and their family throughout the rehabilitation course, serving as a vital link between hospital-based and community-based care.

A critical component of post-stroke rehabilitation is the assessment of the patient's physical function prior to initiating therapeutic interventions. Various standardized scales and tests are available to evaluate motor and cognitive function following stroke (27). Commonly used assessments include the Timed Up and Go (TUG) test, 30-seconds Chair Stand Test, 6-Minute Walk Test, 10-Meter Walk Test, Barthel Index, Berg Balance Scale, Montreal Cognitive Assessment (MoCA), and the Functional Independence Measure (FIM) (27). The primary objective of these assessments is to provide healthcare professionals with detailed insights into the patient's functional capacity and impairments and to monitor progress throughout the rehabilitation process. These evaluations also serve as motivational tools by highlighting improvements over time. In Denmark, the national guidelines for assessing functional levels in adults with acquired brain injury have streamlined the number of recommended tests (28) with the expectation that these tools be applied consistently across healthcare sectors (28). Although evidence-based guidelines outline best practices for rehabilitation, there is limited knowledge about how rehabilitation plans are implemented and adapted to individual patients in real-world settings, and how continuity of care is maintained across the hospital-to-community transition.

1.3 Physical exercise

Physical exercise is a key component of stroke rehabilitation and has been shown to improve functional health and recovery outcomes (29). A systematic review by Todhunter-Brown et al reported improvements in activities of daily living (ADL), walking ability, and balance among stroke patients, with greater rehabilitation intensity associated with more substantial benefits (29). However, the review also noted that the optimal dosage and modality of exercise remain unclear due to heterogeneity across the included studies (29).

Although the precise intensity, duration, and frequency of the most effective exercise interventions post-stroke are not yet fully established, evidence suggests that higher doses and more frequent sessions are beneficial for motor recovery (30). High-Intensity Interval Training has been shown to enhance aerobic capacity efficiently, without requiring additional time compared to traditional exercise protocols (30). Repetitive Task Training has also demonstrated effectiveness in improving upper and lower limb function, with benefits persisting for up to six months post-intervention (31). Comparative studies of aerobic exercise programs for stroke patients in the United States—modeled after cardiac rehabilitation programs—have shown significant gains in aerobic capacity (32) further supporting the role of structured aerobic training in stroke recovery.

Muscle strength can be improved through resistance training targeting the upper and lower extremities, as well as trunk stability. According to the American Stroke Association guidelines (33) the recommended dosage for resistance training is 1–3 sets of 10–15 repetitions for major muscle groups, performed at 50–80% of one-repetition maximum. Saunders et al found that resistance training enhances physical function, muscle strength, and endurance in stroke patients (34). Furthermore, their systematic review indicated improvements in balance and mobility, including increased gait speed (34).

Balance training is defined as a combination of static and dynamic exercises aimed at improving an individual's ability to maintain postural stability and respond to destabilizing stimuli (35).

Delayed physical therapy interventions—initiated more than six months post-stroke—have demonstrated beneficial effects on balance in patients with ischemic stroke when resistance training is combined with balance exercises (36). In addition to specific exercise modalities, general exercise or Total PA are also important parts of the overall rehabilitation.

Patients with mild strokes are generally more likely to achieve favorable recovery outcomes compared to those with more severe impairments (37,38). Age is also a significant factor, with older adults (≥65 years) typically experiencing less favorable recovery trajectories than younger individuals (≤45 years) (38). The recovery process is most pronounced during the acute to subacute phase—within the first three months post-stroke—when the majority of neurological and functional improvements occur (19,39,40). Subsequent recovery is driven by a complex interplay of spontaneous neurobiological processes and rehabilitation strategies, including restitution, substitution, and compensation (39). Although the most rapid improvements are typically observed within the first six months, behavioral adaptations and spontaneous recovery may continue for years following the

stroke (41–43).

Whilst rehabilitation has the potential to improve physical function and other outcomes, the proportion of patients with stroke who return to work ranges from 20% to 66% (5). This wide variation is influenced by differences in healthcare systems, sample characteristics, definitions of employment status, and national standards across countries. Qualitative research indicates that while structured exercise programs improve physical outcomes, patients with stroke often struggle with integrating these routines into daily life, citing factors such as fatigue (44), lack of motivation (45), or poor alignment (46) with their personal recovery goals.

1.4 Physical activity and sedentary behavior

PA is part of an active daily lifestyle where PA can be used for transportation, leisure time as in sports and games, work, or occupational routines (47).

PA can be defined as "any bodily movements produced by skeletal muscles requiring energy expenditure" (35). PA can be stratified into the levels light, moderate, and vigorous. World Health Organization (WHO) recommends that "*Adults should do at least 150–300 minutes of moderate-intensity aerobic physical activity; or at least 75–150 minutes of vigorous-intensity aerobic physical activity; or an equivalent combination of moderate- and vigorous-intensity activity throughout the week, for substantial health benefits*" to gain benefits related to all-cause mortality and prevention of cardiovascular diseases, type 2 DM, and specific cancer types (47). In addition to this, adults are advised to engage in muscle-strengthening activities at least twice per week. For older adults, multicomponent PA that includes balance and strength training are recommended three times per week (48).

Steps can be part of the daily PA and different recommendations exist around the amount needed per day. Previously 10000 steps were recommended daily amount (49). In a randomized controlled trial by Handlery et al recommended number of steps per day >6000 steps was found to reduce subsequent risk of cardiovascular diseases and was recommended for patients suffering from stroke (50). However, Tudor-Locke et al described number of steps per day for healthy individuals could be within the range of 4000-18000 (49) and recommended minimum 7000 steps per day as a reasonable threshold of free-living PA associated with meeting minimal amounts of moderate-to-vigorous physical activity (MVPA) (49). As a rule of thumb, the general recommendation related to the health benefits from performing PA is that benefits are gained from performing any PA for people of all ages (35) and where increased amounts of PA would benefit even more (47).

To some degree the amount of Total PA is also part of the general recommendation of PA. Both total volume of PA and MVPA were found in a meta-analysis of prospective cohort studies to be associated with lower mortality risk in populations of middle-aged to older adults (51). In the meta-analysis by Tarp et al the results underscored a need for thorough studies regarding the health benefits from PA at MVPA-level as well as higher intensities. The authors however also emphasized benefits gained from PA of any intensity (51).

Engaging in regular PA is widely recognized as beneficial for maintaining a healthy lifestyle and preventing a range of chronic diseases. According to the *Global Status Report on Physical Activity 2022*, it is estimated that 7–8% of cases of cardiovascular disease, dementia, and depression, as well as 5% of type 2 DM cases, could be prevented by people worldwide being more physically active (48).

A 2023 Danish report (52) based on national survey and accelerometer data found that 58% of participants (52) met WHO's recommendation (35) of at least 150 minutes of MVPA per week. However, only 44% self-reported (52) meeting this target. Individuals with longer education levels, younger age, and female sex were more likely to meet the guidelines compared with men (52,53).

Globally, 27.5% of adults (48)—about 1.4 billion people—do not meet WHO's physical activity recommendations, with newer data suggesting this figure may be closer to one-third (54). Women and older adults are less likely to meet the guidelines (48). Physical inactivity increases the risk of chronic diseases, premature death, and places a financial burden on healthcare systems (48,55).

As physical inactivity may lead to several diseases, adhering to recommended levels of PA has been shown to prevent a range of non-communicable diseases, including cardiovascular diseases, certain types of cancer, and type 2 DM. The positive effects of PA on these conditions are attributed to a variety of physiological adaptations, including reductions in blood pressure, improved insulin sensitivity, favorable changes in lipid profiles, decreased body fat and low-grade inflammation, and enhanced cardiovascular function (56). Moreover, PA supports brain health and cognitive performance (48), strengthens bones and muscles, and reduces the risk of falls in older adults (48). Additionally, regular PA can alleviate symptoms of anxiety and depression (48). A recent study by Nyberg et al found that the greatest health benefits from leisure-time PA were observed among

high-risk populations, including individuals who smoke, those from lower socioeconomic backgrounds, and people experiencing depressive symptoms (57). These groups gained more disease-free years from increased PA compared to individuals from more advantaged backgrounds (57).

A meta-epidemiological study by Naci and Ioannidis demonstrated that exercise, either alone or in combination with pharmacological interventions, significantly reduced mortality in certain cardiovascular conditions, including stroke (58). Similarly, a recent prospective cohort study by Lee et al in the United States found that individuals who consistently adhered to the recommended 150–300 minutes of MVPA per week experienced a 19–25% reduction in all-cause, cardiovascular, and non-cardiovascular mortality (59).

Among older adults, regular PA plays a crucial role in maintaining and enhancing physical function, while also helping to mitigate age-related functional decline (47). In individuals with stroke, targeting physical function—alongside other modifiable factors—has been proposed as a strategy to increase PA levels (60,61). Specifically, cardiorespiratory training has demonstrated benefits in improving balance and gait endurance during rehabilitation (34,61). These findings support the inclusion of structured aerobic and balance-oriented exercises in rehabilitation programs to optimize functional outcomes.
Moreover, interventions that combine aerobic and resistance training post-stroke have been associated with moderate improvements in health-related quality of life (62). Such interventions also contribute to better sleep quality and reduced sleep latency, particularly among individuals experiencing insomnia (63). Overall, PA has consistently shown a positive impact on quality of life (64). However, the optimal target populations, exercise dosages, and specific outcome measures remain subjects of ongoing investigation and debate (61).

Whilst PA is important to improve and maintain health, sedentary behavior is strongly recommended to be minimized. Sedentary behavior is currently defined as time spent sitting/lying with low energy expenditure while being awake. This could be at home, during transportation or in community settings (47). Especially when focusing on sedentary behavior and cardiovascular disease increasing amounts of evidence shows that this unfavorable outcome is associated with prolonged time being sedentary (47). The general recommendation for adults (>18 years of age) is to limit the time spent in sedentary behavior, as increasing amounts of time in sedentary behavior is associated with all-cause mortality risk (47).

A variety of methods are available to measure PA and sedentary behavior, including both self-reported tools—such as surveys and exercise diaries—and objective instruments like accelerometers, pedometers, and activity trackers. Self-reported surveys rely on participants' ability to recall their PA levels (65) and may be either generic or tailored to specific populations. A meta-analysis by Prince et al found that self-reported questionnaires tend to underestimate sedentary behavior compared to accelerometer-based measurements (66). This finding was supported by Sagelv et al, who also observed discrepancies between self-reported, and accelerometer measured PA levels (51). Thus, self-reported PA is susceptible to recall bias and social desirability bias, which can lead to over- or underestimation of actual activity levels (67).

Accelerometers have been widely used to monitor PA and compared to questionnaires, accelerometers provide more consistent and objective estimates of PA (68). These devices use algorithms based on the time and frequency of body movements to classify PA into established categories or intensity levels (69). Triaxial accelerometers, such as ActiGraph and ActivPAL, measure body position across three axes (X, Y, Z) and track movement patterns, including step counts and frequency cycles, and these tools can also estimate sleep patterns (69). SENS trackers have been employed in research settings to study PA and sleep patterns and have been used in hospital environments with older medical and orthopedic patients (70–72). In addition, certain trackers combine their data with heart rate monitoring to provide a more accurate estimation of PA levels as a nature of the measured data. Those equipment are usually wrist worn to measure heart rate, however, the PA estimates may to some degree be affected by signal noise or inaccuracies due to heart rate variability (65,69). In summary PA is recommended and recognized as treatment and method for improving status for people to stay healthy or prevent chronic diseases. Several assessments exist to measure PA and estimate movement however all tools have pros and cons.

1.5 Cross-sectoral transition and patient involvement

When transferring between healthcare sectors there is a risk, that knowledge from communications, assessments and tests in the patient treatment that should be shared are reduced or even lost. The loss of knowledge in the transition may cover patient-wishes, clinical data, test results, and treatment plans, and the problem can lead to a reduced continuity in the treatment or rehabilitation. The problem may be worsened in patients with reduced resources including low educational status and reduced social support from family members or other. Given the central role that patient involvement plays in ensuring continuity and quality of care across sectors, it is important to clarify how

the term is used. In this dissertation, patient involvement refers to the active and meaningful participation of patients and, when relevant, their caregivers, in decisions about their care and rehabilitation. This includes shared decision-making, collaborative goal setting, and the co-creation of rehabilitation plans, as well as ensuring that information is accessible, timely, and tailored to individual needs and capabilities.

Transitions across healthcare sectors pose challenges, particularly in shifting patient roles. Hospitalized patients often take a passive role, but post-discharge, they are expected to actively manage their care. Van Grootel et al found that strong patient-provider relationships and coordinated discharge planning improved continuity of care (73). Clear, timely information is important, especially for stroke patients transitioning from rehabilitation to home (74). Studies by Krishnan et al (75) and Hodson et al (76) highlighted the need for shared decision-making, tailored support, and better information flow (77)—avoiding overload early on and gaps later in recovery. To address these issues, Eliassen et al (78) recommend using digital tools to enhance communication, support discharge planning, and reduce reliance on in-person consultations.

To improve the patient transition between sectors, standardized procedures with measurements could possibly heighten the transferability. However, the use of standardized outcome measures remains particularly challenging in clinical practice. A survey-based study by Maribo et al (27) revealed considerable variation in the use of measurement instruments and tests across Danish stroke rehabilitation units and clinics, with no clear consensus on preferred tools. Similarly, a comprehensive scoping review by Eliassen et al (78) highlighted a lack of organizational consensus and inconsistency in rehabilitation practices during the subacute phase. Furthermore, Zhao et al (79) found that while approximately half of best practice reports concerning hospital-to-home transitions involved patient input during development, patient engagement has been increasing over time. To facilitate smoother transitions between sectors in stroke rehabilitation and to enhance discharge planning, Miller et al (26) proposed five key recommendations: more effective communication processes; involve specialists with expertise in Transition of Care; implement comprehensive discharge checklists; standardized outcome measures to improve information continuity; and partnerships with community-based wellness programs coordinated by receiving providers. These five steps aim to reduce the complexity of care transitions and could improve the pathways.

A focus group study involving experienced rehabilitation nurses emphasized the importance of continuity within healthcare systems for ensuring smooth transitions between sectors. However, this continuity is often challenged by factors such as short hospital stays and insufficient follow-up after

discharge (80). Disagreements among healthcare professionals regarding the appropriate discharge destination or the patient's functional status can also function as barriers to seamless care transitions.

Whilst the healthcare system as an organization can improve the procedures and collaborations between sectors and their healthcare workers, it is important to involve the patients to improve the transitions during the rehabilitation. Patient involvement in individual rehabilitation plans has become a standard recommendation in stroke rehabilitation guidelines to meet the patient's wishes and preferences, and to strengthen the patients' motivation to the rehabilitation program. According to the WHO report on continuity of care (81) maintaining relational continuity and coordination across healthcare sectors enhances patient engagement in treatment and supports more effective management of health conditions.

The patient and next of kin is recommended to be informed and actively involved about the causes and consequences of stroke and goals, complications and the prognosis (5,82). Better involvement of patient in care planning post-discharge was found in studies involving healthcare professionals (83) and for patients and caregivers post-stroke (75,84). The studies emphasized a genuine involvement containing dialogue between the different persons, cooperation and planning of the course post-discharge and equality between the different persons.

Through use of the ICF system (85) multidisciplinary teams of healthcare professionals have a common language for describing the way a patient is functioning and participating in their own setting and context. This way an involvement process between the patient and his healthcare team could establish treatment, coherence and goal setting across healthcare systems (85). In addition to this a closer connection between hospital setting and the patient's home combined (86) with the recovery knowledge from healthcare professionals might help set a more realistic expectation of the prognosis post-stroke. Although frameworks for cross-sectoral collaboration and patient-centered care exist, there is a gap in understanding how these are operationalized in practice, and how patients and their next of kin experience and navigate the transition between healthcare sectors in the Danish context.

2. Overall purpose of the four studies

2.1 Objectives

The overall purpose of this thesis was to investigate PA levels and changes in physical function following rehabilitation during the acute and subacute phases with transitions between healthcare sectors after stroke, where the patient perspectives were included. Figure 1 illustrates the various timeframes examined across the included studies.

The aim for each study is depicted in the study section below with a brief description of the methods used in each study and the primary findings.

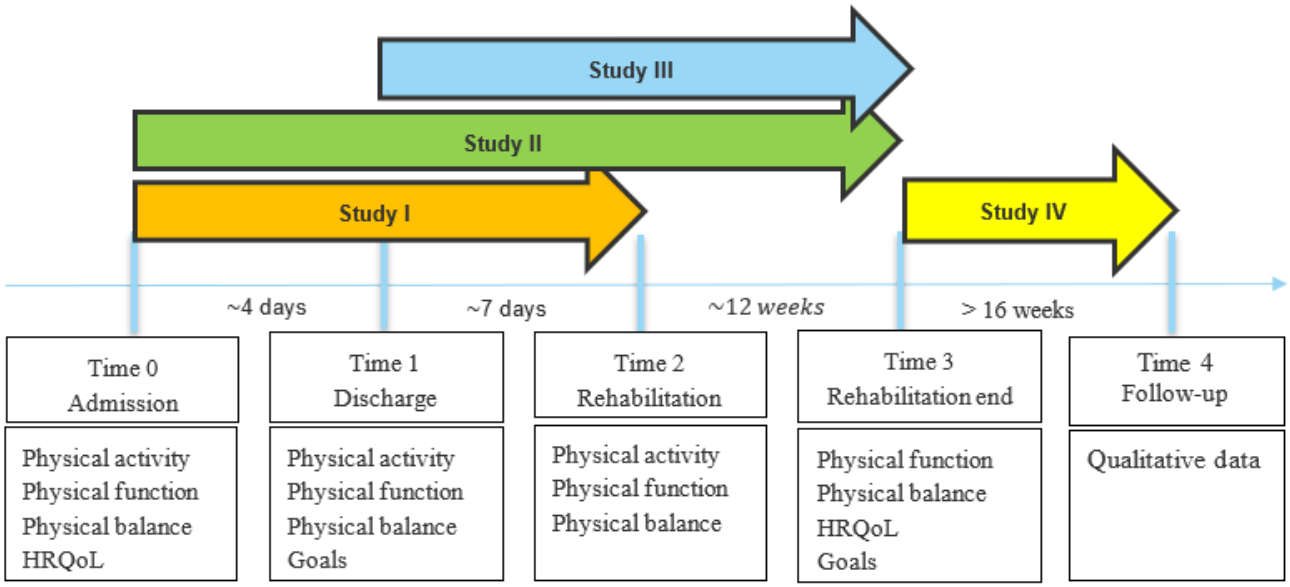

Figure 1: Research design and multiple methods approach for studies in thesis. HRQoL = health related quality of life.

3. Methodological considerations

3.1 Target population

This thesis focused on patients with stroke (ischemic or hemorrhagic) during their hospitalization till completion of rehabilitation in municipalities. Individuals with transient ischemic attacks (TIA) are less frequently reported to experience lasting sequelae and are less likely to receive a formal rehabilitation plan. All patients included in the thesis were provided with a rehabilitation plan, which served as a structured basis for continued rehabilitation. This was essential for enabling longitudinal follow-up across healthcare sectors.

An additional key population in the study was therapists working with rehabilitation in the municipalities. Their evaluations of goal achievement following rehabilitation were collected as part of the thesis. To ensure the therapists anonymity, no personal or demographic data (e.g., age, sex, education date) were recorded. Therapists were recognized as vital contributors to stroke rehabilitation in the municipal setting. Given the dynamic nature of municipal rehabilitation teams—due to staff turnover, reassignment, or shifting responsibilities—it was important to acknowledge the variability in therapist involvement throughout the study period.

3.2 Research designs

The thesis comprises four studies, designed to incorporate both quantitative and qualitative methodologies. Studies I–III employed quantitative approaches to explore longitudinal changes in patient outcomes and factors influencing rehabilitation progress. Study I followed the cohort from hospital admission to the initiation of municipal rehabilitation. Studies II and III extended this follow-up to the conclusion of municipal rehabilitation. Study IV was a nested qualitative study, aimed at capturing personal and individual experiences of stroke rehabilitation and transitions between sectors. Establishing and following a cohort of stroke patients provided a unique opportunity to gain valuable insights into the rehabilitation journey and the gaps that may occur between hospital and municipal care.

3.3 Outcomes in the thesis

I decided to focus on PA during the subacute phase and throughout the rehabilitation period, as PA is a core focus area for physiotherapists aiming to improve patient outcomes. In the Danish healthcare system, accelerated patient pathways often limit the time physiotherapists can follow patients during hospitalization. By collecting detailed data through observational studies across the rehabilitation cycle, we were able to capture outcomes that would otherwise remain undocumented.

To objectively measure PA and sedentary behavior, we used SENS motion sensors. These trackers have demonstrated reliability in previous studies, effectively capturing standard categories of PA and sedentary time in hospitalized patients (70). SENS sensors have shown good to high agreement with direct observation for postural classification (standing, sitting, lying, walking) and have performed comparably to ActivPAL3 (71). The sensors are particularly effective in detecting step counts and walking time in patients walking slower than 0.67 m/s (71), and consistently distinguish between activity, standing, and sedentary behavior (72).

For functional outcome measures in Study II, we selected the 30-seconds Chair Stand Test and the Berg Balance Scale due to their relevance to ADL and their widespread use in clinical practice to assess rehabilitation progress. Additionally, the EQ-5D-5L was used to evaluate health-related quality of life (HRQoL). This instrument is commonly applied in stroke research (9,87–89) and has proven sensitive to changes in more severely affected patients over a three-month period (90). It is also validated as a generic health outcome measure for individuals experiencing acute stroke (91).

Goal achievement was included as an outcome measure due to its significant role in the transition from hospital to municipal rehabilitation. Therapists in hospital settings use goal setting to communicate rehabilitation needs and potentials (92) to colleagues in the next sector. As goal setting is a daily and resource-intensive task for therapists, its inclusion was considered essential for understanding the longitudinal rehabilitation process.

General clinical outcomes such as stroke type, stroke severity (using the Scandinavian Stroke Scale), and functional status (using the modified Rankin Scale) were included to characterize the study population. These measures enhance comparability with similar studies and support a clearer understanding of the target population.

3.4 Ethical considerations

Prior to participant recruitment, formal approval was obtained from leadership in all eight participating municipalities, allowing for longitudinal follow-up throughout the rehabilitation process. Each participant received both written and verbal information detailing the study's purpose, voluntary nature, and confidentiality protocols. Informed consent was obtained from all participants before data collection commenced.

To ensure privacy and data protection, pseudonyms were used in the qualitative study results, and strict adherence to confidentiality and anonymity was maintained in accordance with the Danish Data Protection Agency and the EU General Data Protection Regulation (GDPR). The study was conducted in alignment with the ethical principles outlined in the Declaration of Helsinki (93).

The research plan was submitted to the Scientific Committee of Research Ethics (ID: H-22028744) and registered with the Danish Data Protection Agency (journal number: P-2022-623). A public description of the study was made available on ClinicalTrials.gov (ID: NCT05566782) to ensure transparency in research planning and execution (94).

Additionally, all municipal therapists were anonymized, and the names of the municipalities were withheld. This decision was made to avoid any interpretation of the data as a comparative assessment of rehabilitation quality across municipalities. The focus remained on understanding rehabilitation processes rather than evaluating institutional performance.

4. Individual studies

The studies are summarized in the following pages. Discussion and the methods chosen for the studies are discussed further down in the section Discussion. Figure 2 illustrates the distribution and movement of participants within each study phase.

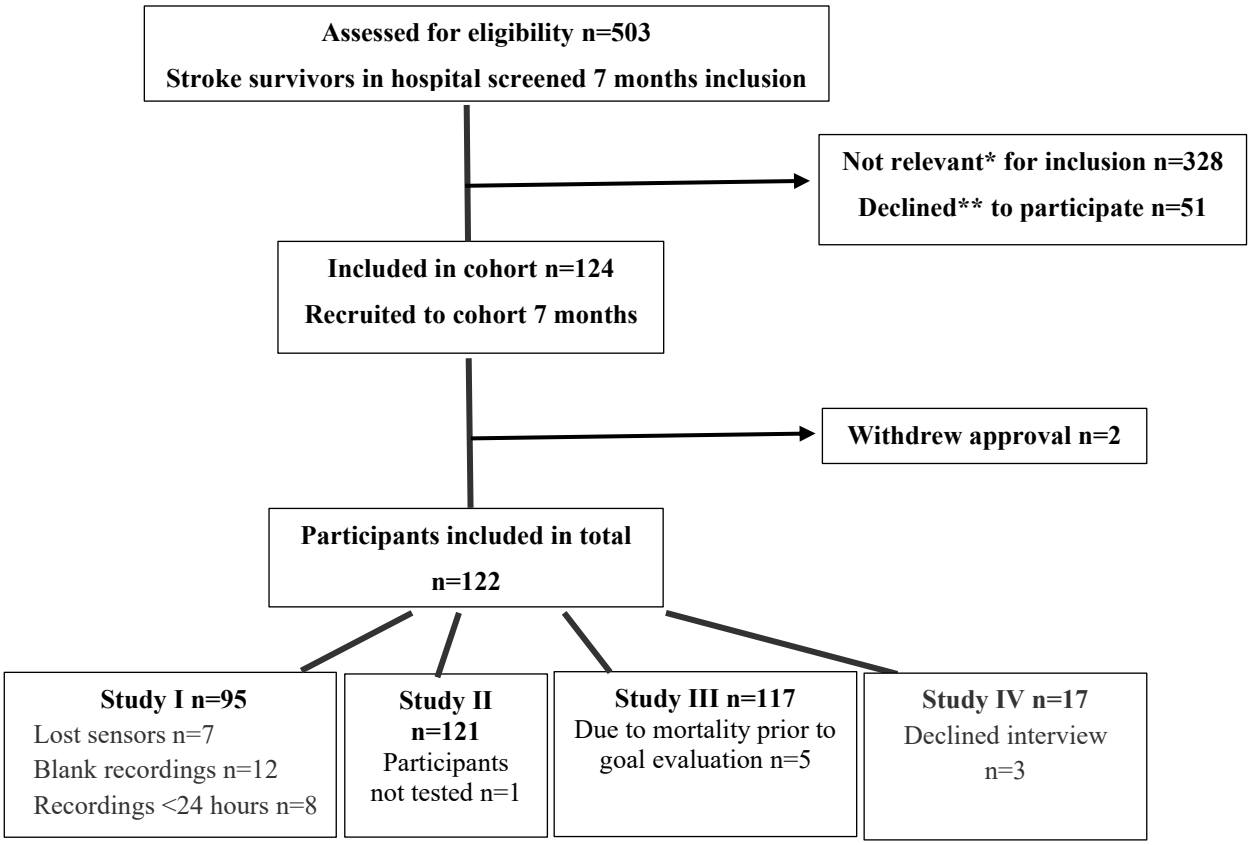

Figure 2. Flowchart with participants in the studies.

Study I

4.1.1 Aims Study I

The aim of study I was to measure the amount of PA during the period between hospital admission and post discharge to start of the rehabilitation taking place in municipalities. Secondary to this the aim was to identify factors associated with PA for the cohort.

4.1.2 Methods Study I

The participants were patients with acute stroke (ischemic or hemorrhagic) as the primary diagnosis and referred to further rehabilitation after their hospital stay. Inclusion criteria were age ≥18 years old, informed consent (or have consent provided by next of kin in writing), and discharge with a personalized rehabilitation plan for further rehabilitation in one of the eight municipalities in North Zealand. Exclusion criteria were unresponsiveness, poor or no Danish language proficiency, refusal

of rehabilitation, a medical prognosis indicating likely death within 12 weeks of stroke onset, death before discharge, spontaneous recovery and thus no rehabilitation needs at discharge, cognitive impairment or dementia which were deemed to make participation in the study unrealistic according to medical records, and residency outside North Zealand. Participants wore SENS trackers for measurement of PA. SENS trackers were placed mid-lateral (95) on the thigh with a band aid. SENS trackers calculate the performed PA using an algorithm for step counts and categorization of the intensity and type of PA (70). For study I we used summed step counts into steps and estimations of MVPA (consisting of moderate + run + cycling categories), Total PA (consisting of upright standing + sporadic walk + MVPA), Sedentary behavior (categories below standing) based on the preprogrammed categorization from SENS Innovation. Statistical analysis of the data involved linear mixed models (96) (LMM) and adjusted multiple linear regression. Adjusted linear regression models were used to analyze associations between the covariates (stroke severity, age, sex, BMI, educational level, and marital status) and the outcome variables (steps, MVPA, Total PA, and sedentary time) during the period after discharge.

Figure 3. An illustrative example of SENS monitor placement on a patient is shown in the image produced by SENS Innovation.

4.1.3 Results Study I

From the established cohort of 122 participants, PA data were available on 95 participants (Table 1) overlapping between in hospital and post discharge period with data available in 55 participants (in hospital) and 83 participants data from the post discharge period. We found no significant changes in the number of steps per day, MVPA and Total PA time, and sedentary behavior during admission (Table 2). From in hospital stay to the post discharge period, PA levels increased in those participants with data for both periods (steps per day from 2844 [2091; 3597] to 4970 [3790; 6150], $p<0.001$; MVPA from 1.7 [0.2; 3.2] to 3.8 [1.4; 6.2] minutes per day, $p=0.023$), and sedentary time decreased from 22.7 [22.2; 23.1] to 21.1 [20.4; 21.8] hours per day, $p<0.001$. Total PA was unchanged (from 108 [81; 136] to 84 [62; 106], $p=0.055$). During the seven days post discharge period, number of steps per day, and MVPA and Total PA times remained unchanged, whereas the sedentary time decreased from day one to day two, and again between day three and four (Table 3). In the adjusted analyses (Table 4) stroke severity was found to be inversely associated with number of steps per day. However, after false discovery rate analysis was used to account for multiple significance testing three tests remained significant: The sedentary behavior declines post discharge from day one to day two ($p=0.013$) and the change from admission to discharge for steps ($p=0.013$) and sedentary behavior ($p=0.013$).

Table 1. Demographic and clinical baseline characteristics of participants.

Variables	**Study Population (n=95)**
Age (years)	71.0 ± 10.2
BMI (kg/m^2)	26.2 ± 4.3
Sex (male)	64 (67.4%)
Stroke type	
Cerebral ischemic stroke	78 (82.1%)
Intracranial hemorrhage	17 (17.9%)
Scandinavian Stroke Scale (score 0-58)	54 (46.8-58)
Modified Rankin Scale (score 0-5)	
0 – No symptoms	0
1 – No significant disability	12 (12.6%)
2 – Slight disability	24 (25.3%)
3 – Moderate disability	30 (31.6%)
4 – Moderately severe disability	20 (21.1%)
5 – Severe disability	9 (9.4%)
Marital status	
Live with spouse/cohabitant	52 (54.7%)

Live alone	43 (45.3%)
Education	
Short	39 (41.1%)
Medium	39 (41.1%)
Long	15 (15.8%)
Other	2 (2.0%)
Time from stroke to admission (days)	0.6 ± 1.7
Time from admission to inclusion (days)	3 (2-5)
Length of stay in the hospital (days)	6 (4-9)
Length of stay in Dept. of Neurology (days)	5 (3-8)
Time from discharge to outpatient rehabilitation (days)	6 (4-10.5)
PA measured during admission (days)	1.8 ± 3.2
PA measured post discharge (days)	4.1 ± 4.4

Data are presented as mean ± SD, median (IQR), or number (%).
BMI=body mass index; Dept.=Department; PA=physical activity

Table 2. Linear mixed model of Steps, MVPA, Total PA, and Sedentary time during three days of hospital stay (n=55).

Variables	*Estimate*	*95% CI*	*p*
Steps (n)			
Intercept (β)	2770.1	[1999.0; 3541.1]	<0.001
Day 2	-213.6	[-633.2; 206.4]	0.310
Day 3	119.1	[-628.9; 866.9]	0.746
MVPA (min)			
Intercept (β)	1.4	[0.2; 2.5]	0.022
Day 2	0.4	[-0.9; 1.6]	0.569
Day 3	0.6	[-0.7; 1.9]	0.351
Total PA (min)			
Intercept (β)	99.9	[73.1; 126.8]	<0.001
Day 2	-3.7	[-17.1; 9.8]	0.586
Day 3	7.8	[-10.5; 26.1]	0.391
Sedentary (hours)			
Intercept (β)	22.4	[21.9; 22.8]	<0.001
Day 2	0.1	[-0.2; 0.3]	0.723
Day 3	-0.2	[-0.5; 0.2]	0.322

Data are presented as β, and [95% CI].

Table 3. Linear mixed model (fixed effect) for steps, MVPA, Total PA, and sedentary time seven days post discharge (n=83).

Variables	*Estimate*	*95% CI*	*p*
Steps (n)			
Intercept (β)	5410.38	[4371.56; 6449.21]	<0.001
Day 2	80.97	[-415.80; 577.74]	0.746
Day 3	290.06	[-514.31; 1094.44]	0.474
Day 4	546.58	[-321.91; 1415.07]	0.213
Day 5	310.25	[-552.09; 1172.59]	0.475
Day 6	745.17	[-154.04; 1644.27]	0.103
Day 7	680.07	[-270.72; 1630.86]	0.157
MVPA (min)			
Intercept (β)	2.63	[1.04; 4.22]	<0.001
Day 2	0.19	[-1.55; 1.93]	0.828
Day 3	1.72	[-1.29; 4.73]	0.259
Day 4	2.13	[-0.81; 5.08]	0.153
Day 5	1.19	[-1.53; 3.92]	0.385
Day 6	-0.04	[-1.91; 1.84]	0.971
Day 7	2.44	[-0.22; 5.11]	0.071
Total PA (min)			
Intercept (β)	173.33	[145.24; 201.42]	<0.001
Day 2	-4.95	[-18.10; 8.20]	0.456
Day 3	7.64	[-12.90; 28.18]	0.461
Day 4	5.08	[-15.56; 25.72]	0.625
Day 5	17.33	[-13.46; 48.12]	0.265
Day 6	15.42	[-10.62; 41.46]	0.241
Day 7	15.38	[-16.08; 46.85]	0.330
Sedentary (hours)			
Intercept (β)	20.60	[21.12; 21.09]	<0.001
Day 2	0.55	[0.29; 0.80]	<0.001
Day 3	0.26	[-0.11; 0.63]	0.160
Day 4	0.35	[0.01; 0.70]	0.043
Day 5	0.12	[-0.41; 0.65]	0.648
Day 6	0.17	[-0.27; 0.61]	0.440
Day 7	0.10	[-0.45; 0.66]	0.711

Data are presented as β and [95% CI].

Table 4. Adjusted multiple linear regressions analyses of associations between covariates and the four PA outcomes.

Covariates	***Steps***	***p***
Intercept (β)	-700.1 [-14607.5; 13207.4]	0.919
Age (years)	-40.9 [-164.1; 82.1]	0.506
Sex (male)	1392.5 [-1504.5; 4289.6]	0.338
BMI (kg/m^2)	22.1 [-295.9; 340.1]	0.889
Education		
Short	1	
Medium	1885.7 [-967.0; 4738.4]	0.189
Long	561.4 [-3098.9; 4221.7]	0.759
Other	477.5 [-6561.1; 7516.1]	0.892
Marital status (with partner)	-2165.6 [-4795.6; 464.3]	0.104
Stroke severity (SSS score)	155.0 [24.7; 285.4]	0.021
	MVPA	***p***
Intercept (β)	17.2 [-6.6; 40.9]	0.153
Age (years)	-0.1 [-0.3; 0.1]	0.206
Sex (male)	-4.5 [-9.5; 0.4]	0.072
BMI (kg/m^2)	-0.2 [-0.8; 0.3]	0.362
Education		
Short	1	
Medium	-2.0 [-6.9; 2.9]	0.412
Long	-3.6 [-9.9; 2.6]	0.248
Other	-7.1 [-19.1; 5.0]	0.244
Marital status (with partner)	2.8 [-1.7; 7.3]	0.218
Stroke severity (SSS score)	0.1 [-0.1; 0.3]	0.335
	Total Physical Activity	***p***
Intercept (β)	-51.8 [-473.5; 369.9]	0.806
Age (years)	1.0 [-2.7; 4.8]	0.574
Sex (male)	2.3 [-85.6; 90.1]	0.959
BMI (kg/m^2)	-0.2 [-9.9; 9.4]	0.865
Education		
Short	1	
Medium	17.4 [-69.1; 103.9]	0.687
Long	-8.4 [-119.4; 102.6]	0.879
Other	-3.4 [-216.8; 210.0]	0.974
Marital status (with partner)	-33.7 [-113.5; 46.0]	0.399
Stroke severity (SSS score)	3.4 [-0.6; 7.4]	0.089
	Sedentary	***p***
Intercept (β)	27.3 [18.1; 36.5]	<0.001
Age (years)	-0.0 [-0.1; 0.1]	0.417
Sex (male)	-0.5 [-2.4; 1.4]	0.598
BMI (kg/m^2)	-0.1 [-0.3; 0.2]	0.596
Education		
Short	1	
Medium	0.2 [-1.7; 2.1]	0.862
Long	0.2 [-2.3; 2.6]	0.897
Other	-0.1 [-4.7; 4.6]	0.994
Marital status (with partner)	1.2 [-0.5; 2.9]	0.167
Stroke severity (SSS score)	-0.1 [-0.1; 0.0]	0.227

Data are presented as β [95% CI].

4.1.4 Conclusions Study I

In conclusion, the levels of PA during hospitalization and in the first week after hospital discharge were low. Even though the level of PA was elevated after discharge, it remained low and unchanged for a week. Whilst sedentary time decreased during the post discharge period it remained high. Post discharge, less than three percent of the participants met the minimum amount of PA recommended by the WHO, and only 31% of participants exceeded 7000 steps per day. Whilst reduced stroke severity was suggested associated with elevated PA measured as steps, socioeconomic status assessed as educational level was not associated with PA levels.

Study II

4.2.1 Aims Study II

The aims of Study II were to investigate 1) the association between amount of structured rehabilitation after hospital discharge and changes of physical function and balance in patients with stroke, 2) the change of physical function, balance, and HRQoL from hospital admission to end of rehabilitation, and 3) to compare the patients' physical function and HRQoL after rehabilitation with data from the general population.

4.2.2 Methods Study II

In extension to first study I conducted an exploratory cohort study with the participants all admitted with acute stroke provided with a rehabilitation plan for further rehabilitation intervention in an outpatient setting in one of the eight municipalities around the hospital.

Physical function was evaluated using the 30-seconds Chair Stand Test (30sCST) (97), which is commonly employed in clinical settings to assess lower extremity strength. Balance was tested using the Berg Balance Scale (BBS) (98), a validated tool for detecting changes in post-stroke balance (99,100). HRQoL was assessed using the EQ-5D-5L questionnaire (101), which has been validated for use in patients with acute stroke (91) and in large-scale population studies with Danish cohorts (102). HRQoL evaluates five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each question was rated on a five-point scale, resulting in an index score, and a Visual Analog Scale (VAS) ranging from 0 to 100 used to rate overall HRQoL. Additional variables in the study were age, sex, body mass index (BMI), stroke severity assessed with Scandinavian Stroke Scale (SSS) (103), and assessment of disability and dependence according to modified Rankin Scale (mRS) (104). Educational level was assessed using the Danish National Health and Morbidity Studies (53) but reduced from seven self-reported levels and combined into the four levels: none/short, medium, long, or other.

Changes in performance on the 30sCST and the BBS throughout four timepoints (admission, discharge, start and end of rehabilitation) were analyzed using LMM implemented via the LMMStar package in R Studio (96). The change of the HRQoL from hospital admission to end of rehabilitation was assessed using Student's paired t-test. The associations between exercise dose (exposure) and the changes from start to end rehabilitation of 30sCST and BBS (outcomes) were evaluated using a multiple linear regression model. The model was adjusted for the covariates age, BMI, and stroke severity defined as the patient's score of the SSS. The patients' data for physical function

tested with the 30sCST (105) and HRQoL tested with the EQ-5D-5L (106) were evaluated after completing rehabilitation. These results were compared to data from the general population matched for age and sex, using the patients' age and sex distribution as weighting factors. Differences between the patient group and the general population were analyzed using Student's unpaired t-test.

Figure 4. Illustration of movement phases in the 30-seconds Chair Stand Test. Participants performed the tests with their arms positioned across the chest. Photo: Colourbox.

4.2.3 Results Study II

Data from 121 participants were available for inclusion in the analysis. The cohort was predominantly male (approximately two-thirds), with a mean age of 72 ± 10 years. Most participants had experienced an ischemic stroke (81%) and mean SSS score was 49 ± 11 points. As depicted in Table 5 positive changes were found in the LMM for testing repeated measurement data of 30sCST and BBS during the rehabilitation course across sectors.

Table 5. Linear mixed model (fixed effect) for changes of the 30-seconds Chair Stand Test and the Berg Balance Scale from hospital admission to end rehabilitation in the outpatient clinics in municipalities.

	Change of 30-seconds Chair Stand Test (repetitions)		
Variables	Estimate	Df	p
Admission, intercept	1.63 [0.96; 2.30]	117	<0.001
Discharge	6.16 [4.89; 7.43]	78	<0.001
Start rehabilitation	7.84 [6.88; 8.79]	100	<0.001
End rehabilitation	10.76 [9.47; 12.04]	83	<0.001
	Change of Berg Balance Scale (0-56)		
Variables	Estimate	Df	p
Admission, intercept	9.63 [6.34; 12.92]	116	<0.001
Discharge	24.20 [18.88; 29.53]	76	<0.001
Start rehabilitation	34.09 [30.34; 37.85]	113	<0.001
End rehabilitation	38.87 [35.18; 42.55]	113	<0.001

Data are presented as β [95% CI], Df = degrees of freedom.

The EQ-5D VAS scores (Table 6) increased between the two time points, whereas the EQ-5D index values remained unchanged.

In the adjusted linear regression models (Table 7) for 30sCST and BBS data we found number of possible exercise sessions to be associated with a change in the outcome scores. Furthermore, BBS baseline score from start of rehabilitation in municipality was additionally found to be associated with change in BBS scores.

Table 6. Change in HRQoL from hospital admission to ended rehabilitation in outpatient clinics in the municipalities.

Variable	Admission	End rehabilitation	p
EQ-5D-5L index (score), n=82	0.725 (0.617-0.810)	0.752 (0.625-0.859)	0.385
EQ-5D-5L VAS (0-100), n=80	57.2 [51.7; 62.8]	63.9 [58.8; 69.1]	0.010

Data are presented as median (IQR) or mean [95% CI]. VAS = Visual Analogue Scale.

Table 7. Rehabilitation doses and covariates' associations with changes of 30-seconds Chair Stand Test and Berg Balance Scale scores during rehabilitation after hospital discharge.

	Changes of 30-seconds Chair Stand Test (repetitions)	
Covariates	Estimate	p
Intercept (β)	4.52 [-8.51; 17.56]	0.489
Rehabilitation dose (adherence)	0.02 [-0.07; 0.11]	0.708
Age	-0.02 [-0.14; 0.09]	0.692
Sex (ref. male)	0.41 [-1.91; 2.72]	0.725
Scandinavian Stroke Scale	-0.07 [-0.17; 0.03]	0.176
Possible exercise times	0.04 [0.01; 0.08]	0.035
30sCST baseline score (Time2)	0.00 [-0.32;0.32]	0.997
	Changes of Berg Balance Scale (0-56)	
Covariates	Estimate	p
Intercept (β)	37.27 [20.87; 53.67]	<0.001
Rehabilitation dose (adherence)	-0.08 [-0.19; 0.04]	0.176
Age	-0.05 [-0.19; 0.09]	0.502
Sex (ref. male)	-1.18 [-4.37; 2.00]	0.458
Scandinavian Stroke Scale	-0.11 [-0.24; 0.01]	0.081
Possible exercise times	0.06 [0.01; 0.11]	0.040
BBS baseline score (Time2)	-0.40 [-0.52; -0.28]	<0.001

Data are presented as β [95% CI]. 30sCST = 30-seconds Chair Stand Test, BBS = Berg Balance Scale.

Finally weighted comparison analysis between participants and an age- and sex-matched norm population using 30sCST end score (Table 8) and HRQoL end scores showed participants performing worse at rehabilitation completion than the norm population.

Table 8. The patients' physical function assessed using the 30-seconds Chair Stand Test and balance assessed using the Berg Balance Scale test after the rehabilitation period compared with age- and sex-matched data from general populations.

Variable	Patients	General population	p
30-seconds Chair Stand Test (n reps), n=74	11.9 [10.7;13.2]	16.9 [16.1;17.7]	<0.001
EQ-5D-5L index (scale), n=84	0.75 (0.62-0.86)	0.90 (0.89-0.91)	<0.001
EQ-5D-5L VAS (0-100), n=84	63.9 [58.8; 69.1]	82.0 [81.7; 82.4]	<0.001

Data presented as mean [95% CI] or median (IQR). Reps = repetitions.

4.2.4 Conclusions Study II

In conclusion, the number of available exercise sessions was associated with changes in physical function and balance, as well as with baseline balance scores. Improvements in physical function, balance, and HRQoL were observed following the completion of the rehabilitation program, with the most substantial gains occurring during the initial admission period. However, post-rehabilitation levels of physical function and HRQoL remained significantly lower among participants compared to age- and gender-matched individuals from the general population.

Study III

4.3.1 Aim Study III

The aim of the study was to evaluate the achievement of patients' rehabilitation goals in stroke rehabilitation from discharge to end of rehabilitation.

4.3.2 Method Study III

In the third observational study nested within the existing cohort of patients with stroke the topic of interest was goal achievements in relation to the cross-sectoral rehabilitation. Recruitment and data collection were conducted between December 2022 and January 2024. The study included patients for whom data on goal achievement were available.

All participants had been admitted for treatment of acute stroke and were subsequently discharged to their respective municipalities with a rehabilitation plan outlining further rehabilitation needs. To systematically document rehabilitation goals, we recorded all identified needs and potentials as outlined in the rehabilitation plans submitted to the municipalities. These data were securely stored in the REDCap database (107,108) which is designed for safe and compliant research data management within the Capital Region of Denmark. Furthermore, goals established by therapists employed in the municipalities were registered as early as possible following the initiation of rehabilitation. Upon completion of the rehabilitation process, municipal therapists conducted evaluations of goal attainment. These evaluations were performed by therapists specializing in neurological rehabilitation; however, blinding was not feasible. Goal attainment was categorized as either *achieved*, *partially achieved*, *not achieved*, or *not reported*. Municipalities included in the study from North Zealand were: Allerød, Hillerød, Helsingør, Gribskov, Frederikssund, Fredensborg, Halsnæs, and Hørsholm. Later, the municipalities were anonymized. Similar to study II the covariates used in the statistical analysis were age, sex, BMI, mRS, marital status, stroke type, educational level, 30sCST, BBS, number of rehabilitation sessions and adherence. In addition to this the rehabilitation level in municipalities (basic, advanced, or not available) and discharge destination to either temporary municipal residential care or home were registered. Data distributions were assessed for normality using QQ-plots and scatterplots. Goal achievement was analyzed using one-way ANOVA or the Kruskal–Wallis test for continuous variables, depending on distribution, and the Chi-square test for categorical variables. P-values ≤ 0.05 were considered significant. All statistical analyses were conducted using R Studio and SPSS.

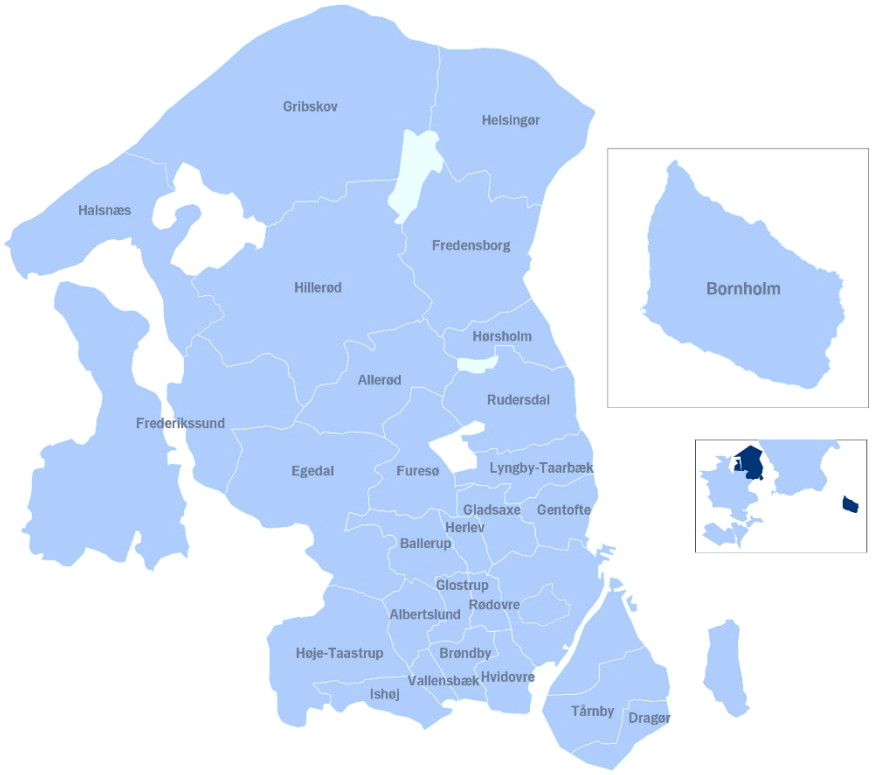

Figure 5. Map showing the municipalities located in North Zealand.

4.3.3 Results Study III

Data from 117 participants were included in the analysis. The majority of participants were male, comprising approximately two-thirds of the sample (see Table 9), with a mean age of 72 years. Ischemic stroke was the predominant type, affecting 82% of the cohort. Most participants had either no/short or medium-length education, and 53% were living with a partner at the time of hospital admission.

At the completion of rehabilitation (Table 10), 30% of participants were assessed by municipal therapists as having fully achieved their rehabilitation goals. Partial goal achievement was reported in 45.3% of cases, while 14.5% of participants did not achieve their goals. In 11 cases (9.4%), data on goal achievement were unavailable.

Analysis of goal achievement in relation to covariates did not reveal statistically significant differences (Table 10). Although the distribution of participants across the eight municipalities showed considerable variation in sample size, no significant differences were observed in goal achievement outcomes between municipalities. No differences were found in relation to rehabilitation level or when comparing participants discharged to home or temporary municipal residential care.

Comparative analysis of rehabilitation data and physical performance tests—including the 30sCST and the BBS—in relation to goal achievement (Table 11) indicated notable associations. Baseline scores (for partially achieved or achievement not reported) on both the 30sCST and BBS, as well as post-rehabilitation assessments, were found to be associated with goal achievement outcomes. Lower scores were found to be associated with goals not being fully achieved.

Table 9. Characteristics of the participants.

Variable	n=117
Age (years)	72 ± 10
Sex	
Female	41 (35%)
Male	76 (65%)
BMI (kg/m^2)	25.6 (23.1-29.0)
mRS (0-8)	3 (2-4)
Educational level	
Short	49 (41.9%)
Medium	49 (41.9%)
Long	17 (14.5%)
Other	2 (1.7%)
Stroke type	
Cerebral ischemic	96 (82.1%)
Intracranial hemorrhagic	21 (17.9%)
Marital status	
Live with spouse/cohabitant	62 (53%)
Live alone	55 (47%)
Municipalities	
No. 1	5 (4.3%)
No. 2	16 (13.7%)
No. 3	18 (15.4%)
No. 4	22 (18.8%)
No. 5	10 (8.5%)
No. 6	21 (17.9%)
No. 7	18 (15.4%)
No. 8	7 (6%)

Data are presented as mean ± SD, median (IQR), or n (%). BMI=body mass index; mRS=modified Rankin Scale.

Table 10. Characteristics of the participants stratified by goal achievement.

Variable	Achieved (n=36, (30.8%))	Partly achieved (n=53, (45.3%))	Not achieved (n=17, (14.5%))	Achievement not reported (n=11, (9.4%))	p
Age (years)	73 ± 9	72 ± 11	72 ± 7	69 ± 11	0.687
Sex					0.892
Female	13 (36.15%)	18 (34.0%)	7 (41.2%)	3 (27.3%)	
Male	23 (63.95%)	35 (66.0%)	10 (58.8%)	8 (72.7%)	
BMI (kg/m^2)	25.5 (23.4-29.2)	26.2 (23.9-30.4)	24.1 (22.3-25.2)	25.4 (22.9-27.3)	0.121
mRS (0-8)	3 (2-4)	3 (2-4)	4 (3-5)	3 (2.3-3.8)	0.192
Educational level					0.640
Short	13 (36.1%)	22 (41.5%)	8 (47.1%)	6 (54.5%)	
Medium	18 (50.0%)	21 (39.6%)	7 (41.2%)	3 (27.3%)	
Long	5 (13.9%)	9 (17.0%)	2 (11.8%)	1 (9.1%)	
Other	0 (0%)	1 (1.9%)	0 (0%)	1 (9.1%)	
Stroke type					0.586
Ischemic	32 (88.9%)	41 (77.4%)	14 (82.4%)	9 (81.8%)	
Hemorrhagic	4 (11.1%)	12 (22.6%)	3 (17.6%)	2 (18.2%)	
Marital status					0.879
Live with other	18 (50%)	29 (54.7%)	10 (58.8%)	5 (45.5%)	
Live alone	18 (50%)	24 (45.3%)	7 (41.2%)	6 (54.5%)	
Municipalities					0.434
No. 1	0 (0%)	4 (7.5%)	0 (0%)	1 (9.1%)	
No. 2	7 (19.4%)	6 (11.3%)	1 (5.9%)	2 (18.2%)	
No. 3	7 (19.4%)	10 (18.9%)	1 (5.9%)	0 (0%)	
No. 4	5 (13.9%)	13 (24.5%)	3 (17.6%)	1 (9.1%)	
No. 5	1 (2.8%)	4 (7.5%)	3 (17.6%)	2 (18.2%)	
No. 6	8 (22.2%)	6 (11.3%)	5 (29.4%)	2 (18.2%)	
No. 7	6 (16.7%)	6 (11.3%)	3 (17.6%)	3 (27.3%)	
No. 8	2 (5.6%)	4 (7.5%)	1 (5.9%)	0 (0%)	
Rehabilitation level					0.661
Basic	11 (30.6%)	12 (22.6%)	2 (11.8%)	2 (18.2%)	
Advanced	24 (66.7%)	40 (75.5%)	14 (82.4%)	8 (72.7%)	
Not available	1 (2.8%)	1 (1.9%)	1 (5.9%)	1 (9.1%)	
Temporary residential care	6 (16.7%)	16 (30.2%)	8 (47.1%)	3 (27.3%)	0.141
Yes	30 (83.3%)	37 (69.8%)	9 (52.9%)	8 (72.7%)	
No					

Data are presented as mean ± SD, median (IQR), or n (%). BMI=body mass index; mRS=modified Rankin Scale.

Table 11. Rehabilitation and outcome data stratified by goal achievement.

Variable	Achieved (n=36)	Partly achieved (n=53)	Not achieved (n=17)	Achievement not reported (n=11)	p
Rehabilitation sessions (n)	14 (6-28)	24 (10.5-41.5)	17 (4.5-50)	6 (2-12.75)	0.022
Rehabilitation adherence (%)	91 (75-100)	93 (85-100)	94 (80-100)	98 (77-100)	0.950
30sCST at baseline (repetitions)	10.4 ± 3.2	8.5 ± 4.2[a]	9.0 ± 4.6	13.2 ± 2.8 [a]	0.030
30sCST change	3.7 ± 3.3	3.1 ± 4.6	1.0 ± 1.6	3.5 ± 3.5	0.500
30sCST post tested					0.001
Yes	21 (58.3%)	42 (79.2%)	7 (41.2%)	3 (27.3%)	
No	15 (41.7%)	11 (20.8%)	10 (58.8%)	8 (72.7%)	
Berg Balance Scale at baseline	52.5 (46.25-55)	45.5 (27.75-53)	45 (30-47)	55 (52-56)	<0.001
Berg Balance Scale change	1 (0-3.75)	3.5 (0-10)	6 (3-9)	0 (0-2)	0.300
Berg Balance Scale post test					0.043
Yes	23 (63.9%)	35 (66%)	7 (41.2%)	3 (27.3%)	
No	13 (36.1%)	18 (34%)	10 (58.8%)	8 (72.7%)	

Data are presented as mean ± SD, median (IQR), or n (%). [a]Significant difference

4.3.4 Conclusion Study III

Only 30% of participants were assessed as having fully achieved their rehabilitation goals within the municipal rehabilitation programs. Furthermore, 23.9% either did not achieve their goals or were not evaluated for goal attainment. The rehabilitation level provided defined as either basic, advanced, or not reported did not appear to influence goal achievement outcomes. Among participants who partially achieved their goals, a higher number of rehabilitation sessions were observed. This may reflect an intensified therapeutic effort aimed at facilitating goal attainment but without a full achievement. Furthermore, higher baseline scores on the 30-seconds Chair Stand Test and the Berg Balance Scale were positively associated with full goal achievement, compared to partial or non-achievement. Thus, patients with lower baseline function may need more attention in rehabilitation to achieve goals.

Study IV

4.4.1 Aim Study IV

The aim of this study was to explore patients' experiences with rehabilitation plans in relation to their transition from hospital admission to the post discharge period, with or without municipal rehabilitation.

4.4.2 Method Study IV

In addition to the three quantitative studies the fourth study explored the rehabilitation course as perceived by selected participants in a qualitative design. The aim of this qualitative study was not only to explore patients with stroke' personal experiences with rehabilitation plans and goal setting, but also to complement the quantitative studies of this thesis by adding a patient perspective. In doing so, the study contributes to understanding how rehabilitation structures are perceived by those directly affected, thereby extending the scope of the thesis beyond the impact on quantifiable measures and estimates. Seventeen participants with varying functional levels and from all eight municipalities were recruited, ensuring diversity of experiences. Participants could choose to have a family member or other close relatives with them during the interviews which supported inclusion of those with cognitive or communicative challenges.

A semi-structured interview guide was developed drawing on both clinical knowledge and research experience. The focus was not on technical procedures but on eliciting patients' reflections on their rehabilitation plans, their sense of involvement, and the transition between hospital and municipal services. The PhD student conducted all the interviews, The interviews were analyzed using reflexive thematic analysis as described by Braun & Clarke (109), which allowed the PhD student and the research team to engage reflexively with the data and account for professional pre-understandings. This reflexive approach was particularly important, as it enabled critical awareness of how the PhD student's physiotherapy background shaped the interpretation of patient experiences (110,111).

4.4.3 Results Study IV

Out of 20 participants invited 17 were interviewed and three declined for the following reasons: Severe hearing loss that made the interview impossible; did not want to participate in an interview; and could not relate to the topic. Interviews lasted from 23 to 96 mins (mean 48 mins, SD ± 18 mins) and were recorded in the homes of the participants. In four cases, participants were accom-

panied by their spouses during the interviews. This presence contributed to a more nuanced reconstruction of the rehabilitation timeline and facilitated deeper reflections on how the stroke affected family dynamics. Additionally, it highlighted the need to adapt domestic environments and daily routines in response to the participants' impaired mobility.

Participants described their post-stroke situations and the varying degrees of impairment they experienced. While most participants were retired and therefore not working anymore, many were still actively working or participating in part-time work. Post-stroke many were impaired in their ability to participate in daily family activities or being physically impaired and therefore not able to move freely around without walking aids or people close by. Other barriers or disabilities mentioned by participants were invisible but severely limiting in terms of their daily life e.g., post-stroke insecurity about the future (financially and socially), lack of energy/motivation due to fatigue and experience of regular pain but not getting relief in the treatment.

Through analysis two main themes were identified (Table 12): *Misalignment of rehabilitation goals and plans with patient needs* and *Navigating Inequity in Rehabilitation: Unmet Needs and Personal Strategies.* **These themes captured participants' experiences of insufficient involvement in goal setting, lack of communication across sectors, and reliance on standardized rehabilitation offers.**

Table 12. Presentation of themes and subthemes**.**

Themes	Misalignment of rehabilitation goals and plans with patient needs.	Navigating inequity in rehabilitation: unmet needs and personal strategies
Subthemes	Challenges in Defining Goals	Seeking supplementary care to meet unmet needs
	Lack of Patient Involvement in Goal setting	Living within and beyond a standardized system

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Rather than reproducing detailed subthemes or quotations, the findings are here synthesized to emphasize their broader relevance for the thesis. First, the study showed that patients often struggled to define goals in the acute phase, leaving them vulnerable to be dependent on professionals to decide for them. Second, the timing and format of plans were perceived as poorly aligned with patients' readiness and evolving needs. Finally, participants reported seeking supplementary services or developing personal strategies when municipal rehabilitation did not meet expectations, thereby highlighting inequalities in access and outcomes. These insights provide an experiential layer that complements the quantitative findings: whereas registry data can demonstrate patterns of service delivery and outcomes, the qualitative study illustrates why and how patients may disengage or feel disempowered in the rehabilitation process.

4.4.4 Conclusion Study IV

This study demonstrated that patients with stroke face substantial challenges in understanding and engaging with rehabilitation plans. The lack of patient involvement and the standardized nature of municipal rehabilitation services illustrate systemic barriers to patient-centered care. Importantly, the study adds depth to the thesis by showing that quantitative measures of rehabilitation outcomes cannot be fully interpreted without considering patients' own perspectives. Together with the other studies, this qualitative work underscores the importance of aligning clinical, organizational, and experiential perspectives in order to strengthen cross-sectoral rehabilitation.

5. Discussion

This thesis found important results with relevance to the treatment of patients with stroke: Study I revealed only minor improvements of low levels of PA during the period from hospital admission to one-week post-discharge. Sedentary behavior was notably high, particularly during hospitalization, and was also associated with a minor reduction. Lower stroke severity was associated with step count. In Study II, improvements were observed in physical function, balance, and HRQoL following completion of the rehabilitation program. The most pronounced gains in physical function and balance occurred during the initial admission period. Despite these improvements, post-rehabilitation levels of physical function and HRQoL remained significantly lower compared to age- and gender-matched individuals from the general population. The number of possible exercise sessions was found to influence changes in outcomes for the 30sCST and the BBS. Study III identified that only 30% of patients with stroke fully achieved their rehabilitation goals upon completion of the cross-sectoral rehabilitation program. No disparities were found with respect to sex, municipality, educational level, rehabilitation intensity, or discharge to temporary municipal residential care between status for goal achievement. In Study IV, the first theme identified highlighted challenges in goal setting for patients with severe stroke and a lack of patient involvement in the goal-setting process. The second theme reflected participants' experiences of unmet needs within the existing rehabilitation system, characterized by standardized and inflexible rehabilitation programs. Participants illustrated various strategies employed to compensate for the lack of adaptability in these rehabilitation services. The interplay between severe post-stroke sequelae, difficulties in sustaining engagement in daily activities, and an uncertain prognosis contributed to pervasive feelings of fear and uncertainty.

5.1 *Physical activity and sedentary behavior in the acute and subacute phases*

Findings from this thesis revealed consistently low levels of PA across all PA categories during both the hospitalization period and the post-discharge phase. Concurrently, participants exhibited high levels of sedentary behavior throughout both timeframes. These behavioral patterns may impede the rehabilitation process by complicating the attainment of recovery goals and may contribute to an elevated risk of recurrent strokes and other CVDs. Furthermore, reduced PA levels during hospitalization among elderly patients have previously been associated with adverse outcomes such as pressure ulcers and an inability to return home upon discharge (113).

Previous studies (114,115) investigating PA during hospitalization has similarly reported minimal activity levels. However, it is important to consider the methodological limitations inherent in the present study. The SENS motion sensors employed are highly sensitive to step detection, particularly

in populations with impaired gait patterns (71). Consequently, step counts recorded during hospitalization may be overestimated relative to those reported in other studies. Similar to our findings, however, a comparable level of steps (5535 steps per day) was found during sub-acute phase of stroke in a systematic review by Fini et al (116).

Discrepancies between our estimates of MVPA and those found in existing literature (117,118) may also be attributed to measurement constraints. Specifically, MVPA was estimated without concurrent HR monitoring, which may have introduced inaccuracies. Additionally, the proprietary algorithm used by SENS Innovation (119) for PA classification lacks transparency, thereby limiting the ability to critically assess the validity of MVPA estimates.

The cohort included in this study was representative of the typical stroke patient population treated at the Section of Stroke, Department of Neurology. The study design incorporated minimal inclusion and exclusion criteria, which reduced the risk of selection bias and enhanced the generalizability of the findings. Although the dropout rate was low—with only two participants withdrawing—sensor data were incomplete. PA data were successfully retrieved from 95 sensors, representing 77% of the total cohort. Several sensors were lost, often mistaken for adhesive bandages by hospital staff or next of kin. Recovery efforts included direct contact with participants and caregivers, on-site visits to rehabilitation centers and homes, physical searches in reported locations (with and without the SENS app), distribution of return envelopes, and the return of non-functional sensors to SENS Innovation for potential data recovery. Retrieving the remaining sensors would be valuable, particularly for comparative analyses between admission and discharge periods. Incorporating additional PA data could enhance the analysis by enabling longer-term measurements using wrist-worn accelerometers. These devices may reduce the risk of data loss and provide more stable measurements over time, thereby facilitating trend detection and offering deeper insights into activity patterns. However, the use of such accelerometers may impose additional demands on participants, particularly those in vulnerable conditions, as the devices require frequent recharging and manual or wireless data uploads.

In this study we found no association between educational background for the participants or marital status in relation to levels of PA or sedentary behavior. This finding may be interpreted positively, as it suggests an absence of health disparities associated with socioeconomic status. In comparison to the present study, unpublished data from the Danish Health Profile 2021 (120) indicate that individuals with lower educational attainment are less likely to meet the WHO's minimum PA recommendations than those with higher education. This suggests a higher prevalence of PA adherence among

individuals with greater educational backgrounds. Shaw et al (121) similarly found that socioeconomic status, particularly education level, was associated with PA in older adults, with lower education predicting a steeper decline in PA over time.

During hospitalization, opportunities to promote PA within the hospital environment are often limited. Hospital wards are typically not designed to encourage movement, and patients frequently remain in bed for extended periods. This sedentary behavior can be partly due to logistical constraints, such as the need to stay near their beds for upcoming examinations or visits, and partly due to psychological factors, including fear of missing physician's round. Moreover, patients may perceive that healthcare staff are primarily focused on clinical tasks and lack the time or capacity to support general PA. This perception can further discourage patients from engaging in movement, contributing to physical deconditioning during their hospital stay. A Cochrane systematic review by Jones et al (122) reported inconclusive evidence regarding the effectiveness of interventions aimed at promoting PA among individuals with neuromuscular diseases which supports the findings by Shankaranarayana et al concluding that device-based feedback and physical environment alone are insufficient for enhancing PA levels for patients with stroke in hospital settings (123). A recent systematic review by Hartley et al (124) further added that complexity is part of the picture when evaluating factors influencing the amount of PA outside of staff-led sessions during the hospitalization post-stroke. The reviews also highlighted uncertainty surrounding the impact of such interventions on quality of life and potential harms, largely due to heterogeneity in intervention types and study designs. In contrast, a prospective cohort study conducted in the United States (125) found that higher levels of PA among patients with stroke were inversely associated with all-cause mortality, underscoring the potential health benefits of maintaining PA post-stroke.

In Study I, wearable sensors were used to assess sedentary behavior. Understanding the timing and context of sedentary behavior in stroke populations is essential for developing targeted strategies to reduce inactivity. A systematic review by Prince et al (66) demonstrated that self-reported measures tend to underestimate sedentary time when compared to device-based assessments. Although multi-item questionnaires and activity logs provide valuable contextual information, they lack the precision and reliability of objective measurement tools.
Notably, a recent systematic review found that engaging in more than 11 hours of sedentary behavior per day was associated with a 21% increased risk of stroke (126). Furthermore, an umbrella review by Lam et al (127) identified modifications to the physical environment as the most effective strategy for reducing sedentary time in adults. However, as this review did not focus specifically on popula-

tions with chronic conditions such as stroke, the applicability of these findings to stroke rehabilitation remains uncertain. In relation to our study findings, increasing the availability of structured activities during hospitalization—particularly during daytime hours—may help reduce sedentary behavior. For example, implementing general PA sessions for all patients or discouraging in-bed meals by encouraging consumption of meals in dining rooms could serve as practical strategies. These approaches may not only reduce sedentary time but also potentially lower the risk of complications such as aspiration.

A survey-based study aimed at establishing international consensus on PA measurement post-stroke recommended the concurrent use of objective devices and self-report questionnaires to obtain a comprehensive assessment of PA (128). Additionally, a recent experimental cross-sectional study with neurologically impaired patients including patients with stroke (129) found that waist-mounted accelerometers are more accurate in detecting steps and that the examined algorithms tend to underestimate steps in both healthy individuals and people with neurologic conditions. In our study, we adhered to the recommendations from the SENS Innovation framework and implemented our pilot tests within a comparable hospital setting. We employed SENS motion sensors to ensure consistency with previous studies. Additionally, we sought to align our PA categories and activity counts with those reported in the literature to enhance the validity and comparability of our findings.

Environmental factors also play a critical role in facilitating PA. Barnett et al (130) in their systematic review and meta-analysis, concluded that safe, aesthetically pleasing, and walkable environments positively influence PA participation among older adults in community settings. These findings underscore the importance of considering both individual and environmental determinants when designing interventions to promote PA in stroke rehabilitation.

5.2 *Physical function and rehabilitation and time of recovery*

We found improvement in the evaluated outcomes related to the rehabilitation course in terms of physical function and physical balance, and these positive changes were seen throughout all three time periods. We find it reasonable to assume that the participants were severely impacted by the acute stroke at the admission due to stress, confusion or sudden motor impairments and were more stable in the measurement at discharge. Furthermore, there could be a learning effect in the tests after multiple testing occurs timely close to each other between admission and discharge as part of the explanation for the greater improvement in the first period.

Given the observed variation in PA levels, some participants may experience faster recovery trajectories than others. A registry-based cohort study (131) found that patients with stroke with higher pre-

stroke PA levels tended to exhibit better physical functioning in the early post-stroke period. Additionally, we found that rehabilitation dose was not associated with the outcomes, whereas number of possible exercise sessions was associated with improvements of physical function and physical balance. There could be variation in the content of rehabilitation sessions, however this did not seem evident when visiting the different municipalities and when the therapists described how they provided the standardized rehabilitation. Time could also be a factor associated with recovery as time is known to play a role in post-stroke recovery (42,43), and improvements may occur in all rehabilitation periods with gradual increase in general PA. Consequently, it is challenging to determine whether the observed improvements were primarily due to rehabilitation efforts or the natural progression of recovery, as time alone appears to contribute to spontaneous healing (42,43). The study applied broad inclusion criteria, which resulted in a heterogeneous sample. Although all participants were referred to rehabilitation with individualized rehabilitation plans, they exhibited varying degrees of impairment, physical constitution, and educational backgrounds. While this approach enhances generalizability, it also introduces variability in functional status, with some participants potentially being too severely impaired to benefit fully from the intervention. Conversely, others may have been excluded due to selection bias.

The EQ-5D is a generic instrument for assessing HRQoL and is applicable across various populations. However, a disease-specific tool such as the Stroke-Specific Quality of Life Scale (132), which has been validated and translated (133), may offer greater sensitivity in detecting stroke-related changes in HRQoL. Our results pointed towards improvement in the VAS component of EQ-5D however no significant changes were found in the index values. Further analysis of the five EQ-5D dimensions from the beginning to the end of the rehabilitation period did not reveal statistically significant changes. To some extent, this may be attributable to challenges in assessing post-stroke impairments relative to pre-stroke functioning, potentially due to attrition bias. Comparable findings have been reported in a prospective cohort study by Kainz et al (134), which found a slight improvement in the VAS component of EQ-5D-5L among stroke patients within first year post-stroke.

The final assessments of the 30sCST and the EQ-5D-5L revealed significantly lower scores among stroke patients compared to age- and gender-matched reference populations. These findings suggest a continued need for rehabilitation beyond the formal program period. Although similar post-stroke deficits have been documented in previous studies, the duration for which patients remain in this impaired state remains unclear and warrants further investigation. Competing diagnoses e.g. hypertension, atrial fibrillation and other heart diseases, chronic obstructive pulmonary disease, type 2 DM, and osteoarthritis etc. were attempted registered from the medical records as comparison in the linear

regressions analysis, however due to lack of standardized registration in the medical records it was not comparable and applicable.

Another condition occurring post-stroke is fatigue which can impact patients with stroke and have severe impact in relation to the outcomes. Fatigue is a common and persistent condition following stroke, with an estimated prevalence ranging from 25% to 85% (135). This long-term fatigue—often lasting months or even years—may negatively affect both recovery trajectories and patient motivation to engage in extended rehabilitation efforts. In Study IV, several participants reported fatigue and reduced energy levels as ongoing challenges in their daily routines, highlighting the importance of addressing post-stroke fatigue as a barrier to sustained rehabilitation (112). Fatigue could therefore have been a valuable variable to include in the studies, both to enrich the analysis and to strengthen the interpretation of the findings. However, this approach would necessitate the completion of additional time-intensive questionnaires, potentially exacerbating the burden on patients during critical clinical situations.

Data collection was affected by several contextual, practical limitations, including time constraints among therapists, competing clinical priorities, unexpected patient discharges, and fluctuating patient conditions. Additionally, variation in data collection procedures across municipalities and among staff contributed to inconsistencies in the dataset. These inconsistencies were particularly evident in the level of detail provided regarding rehabilitation, and documentation of treatment sessions, including their content, exercise-intensity, and focus—especially within municipal rehabilitation settings. To address these challenges, several measures were implemented. These included regular site visits to rehabilitation centers to observe both individual and group-based treatment sessions, as well as ongoing communication with key therapists in neurological teams via phone and email to encourage more detailed documentation of clinical practices. Furthermore, calibration workshops were offered to all participating therapists and municipalities to enhance the reliability of physical function and balance assessments. The inclusion of additional data on participants' comorbidities and hospital readmissions would enhance the analysis by providing a more comprehensive understanding of factors influencing recovery trajectories. Such information could offer valuable insights into the complex challenges faced by individuals, thereby contributing to a more nuanced interpretation of rehabilitation outcomes.

5.3 *Goals in the rehabilitation and patient involvement*

The quantitative assessment of goal attainment within the cohort highlighted the extent to which rehabilitation goals were achieved. Additionally, the qualitative component of the thesis provided valuable insights into patient experiences and contextual factors influencing rehabilitation.

In the qualitative study, participants reported a lack of involvement in their rehabilitation process, including goal setting, and expressed experiencing unmet needs following stroke in relation to rehabilitation services. Notably, some participants described being motivated to engage in further rehabilitation and exercise yet were not offered appropriate options within their respective municipalities that aligned with their individual needs. There may be multiple underlying factors contributing to these experiences. One possibility is a lack of awareness or understanding among participants regarding available rehabilitation options. Alternatively, these experiences may reflect suboptimal communication from healthcare professionals, characterized by insufficient dialogue. A third potential challenge may lie in healthcare professionals' ability to identify patients and their next of kin who require enhanced health literacy. This includes a clearer understanding of available options, and a deeper awareness of the potential consequences associated with their healthcare decisions. To some degree this could be attributed to the therapists' time constraints, high workloads, or the absence of structured tools designed to facilitate more effective collaboration between patients and professionals. Fernandes et al in 2024 (136) conducted a scoping review identifying several motivational strategies employed by healthcare professionals in stroke rehabilitation. Notable strategies included setting attainable goals, fostering therapeutic alliances, tailoring rehabilitation and enhancing patients' health literacy, and programs to individual needs. Improving health literacy is a critical step toward enabling patients and their relatives to better understand the services offered by the healthcare system, thereby contributing to the reduction of health inequalities. This topic has gained increased attention following the Danish Health Act (28) which emphasizes the importance of health literacy and patient involvement in clinical practice. A key finding by Elvén et al (137) was that patients with stroke experience different aspects of patient-centeredness strategies in relation to their acute stroke setting, but without proper facilitation in terms of clinical reasoning. This creates tension in the recovery process and increases the risk of patients "surrendering" to adhere to the goals/decisions set by healthcare professionals. In some cases, this passive acceptance may partially explain why many participants reported difficulty relating to the goals imposed during cross-sectoral rehabilitation. Moreover, the imbalance of power between patients and therapists may further exacerbate health inequalities, underscoring the need for more equitable and collaborative rehabilitation practices. Consistent with Fernandes et al, Oyake et al (138) found that goal setting can serve as a motivational strategy in stroke rehabilitation. However, the process of establishing attainable and individualized goals is often challenged by factors such as patient age, cognitive and psychological status, environmental context, type of rehabilitation service, physical limitations, and personal preferences (139). These factors were not reflected in the findings of Study III. However, in addition to the qualitative study it would be valuable to have included interviews with therapists from both municipal and hospital settings to

gain insight into their practices regarding goal setting and patient involvement. In this thesis, the patient perspective has been prioritized due to its critical role and profound impact on the lives of patients with stroke. While goal setting is considered an integral component of rehabilitation outcomes, its incorporation into evaluation remains challenging due to the lack of standardized procedures and validated assessment tools. Further investigation into the specific rehabilitation goals, including their categorization and an analysis of goal attainment, represents a key element in deepening the understanding of the rehabilitation process. This approach can shed light on how participants' goals were formulated, adjusted over time, and in some cases, set at levels that may have been overly ambitious and therefore unattainable.

Both Study III and the qualitative study highlighted the role of treatment interventions, including exercise, which may be delivered either individually or in group-based settings. Fujii et al (140) reported that team-based exercise was more effective in enhancing both cognitive and physical functions among older, community-dwelling adults compared to those who exercised alone or did not engage in exercise at all. Notably, participants in team-based programs exhibited greater improvements in lower limb strength, which may be attributed to higher adherence rates and the social support inherent in group-based activities (140). In the municipal rehabilitation setting, exercise along with other therapeutic modalities were delivered through a combination of individual and group-based sessions (more often group-based) as reported by therapists in Study III and by participants in the qualitative study. Additional rehabilitation modalities included dual-task training, functional electrical stimulation, manual assessment, and treatment techniques, as well as fine motor coordination exercises aimed at enhancing hand–eye coordination. A more detailed description of the rehabilitation efforts provided within the municipalities could have offered deeper insight into the circumstances under which goals were achieved or not. In some instances, participants described engaging in exercises at home or in nearby environments. These settings were often perceived as more relatable to ADL, although they sometimes limited the types of exercises available—particularly those requiring specialized equipment for more intensive strength training.

Group-based exercise offers rehabilitation centers an efficient means of utilizing available resources for post-stroke treatment. However, the effectiveness of this modality depends on the participants' ability to engage in group sessions. Individuals with less severe cognitive impairments, better mobility, and lower levels of fatigue may be more likely to benefit from and adhere to group-based programs. Conversely, individuals who are wheelchair-bound or have significant cognitive impairments or energy deficiency due to fatigue e.g., may require more intensive, individualized attention from therapists as reported by participants in the qualitative study. This need for tailored support can limit

their participation in group settings and potentially reduce their motivation to adhere to the rehabilitation program over time which to some degree was experienced by participants and highlighted in the qualitative study. Reduced adherence to rehabilitation may partially explain the low proportion of fully achieved goals observed in Study III at the completion of the rehabilitation period, the length of the rehabilitation program defined as the number of sessions appears to influence outcomes. Adherence to the rehabilitation program—specifically attendance at both baseline and post-rehabilitation assessments within the municipal setting—also appeared to influence goal attainment, thereby lending support to this interpretation. Additionally, higher baseline scores of physical function or physical balances were associated with increased goal achievement as shown in Study III. This finding may suggest that patients with lower baseline scores could benefit from more frequent attendance and tailored follow-up, as they may require greater support in adjusting goals and progressing effectively through their rehabilitation course. It is important to interpret goal achievement data with caution. The rigid classification system—categorizing goals as either achieved, partially achieved, or not achieved—may not accurately reflect the nuanced nature of goal evaluation in clinical practice. Interpreting partial achievement remains particularly challenging, as it may reflect minimal progress (e.g., achieving one out of eleven sub-goals) or substantial advancement toward full goal attainment. This ambiguity raises the question of whether a classification of "partially achieved" should be considered closer to "achieved" or "not achieved," highlighting the need for more nuanced evaluative frameworks that better reflect individual progress. Furthermore, these assessments were conducted by therapists employed within the municipalities, who may have a tendency to rate goals for their own patients more favorably, potentially leading to an overrepresentation of goals marked as achieved or partially achieved. As noted by participants in the qualitative study, the timing of goal setting and evaluation plays a critical role in the recovery process following stroke. Goals established during the acute phase may not reflect the patient's evolving priorities and capacities and may later be perceived as less meaningful. This concern also extends to the timing of the rehabilitation plan itself, which may influence its perceived relevance and effectiveness. These findings underscore the importance of aligning rehabilitation planning and goal-setting processes with the patient's stage of recovery to ensure engagement and meaningful progress. Although not a comprehensive solution to the complex challenges in stroke rehabilitation, Scobbie et al (141) proposed the use of the Goal setting and Action Planning framework as a means to enhance goal adjustment, reduce patient disengagement, and promote informed decision-making. This framework aims to support a more collaborative and individualized approach to rehabilitation, aligning therapeutic goals more closely with the needs and preferences of patients with stroke. For successful integration into Denmark’s cross-sectoral rehabilitation system, careful attention must be given to ensuring that implementation is supportive, feasible,

and sustainable. This includes consideration of organizational structures, interprofessional collaboration, and the availability of resources necessary to embed the framework effectively into routine practice. With the implementation of the Danish Health Reform (142) efforts to enhance coordination between existing healthcare systems and to restructure specialized and advanced rehabilitation services aim to bring care closer to patients' homes. By leveraging regional expertise and treatment capabilities, these changes may contribute to improved healthcare quality through increased standardization and strengthened collaboration between regions and municipalities. Such political developments have the potential to benefit patients with severe chronic and disabling conditions—such as stroke and other neurological diseases—by facilitating access to more localized, specialized care, thereby supporting better recovery outcomes through expanded treatment opportunities.

Although our quantitative studies did not reveal disparities related to socioeconomic status operationalized as educational level—this finding may be interpreted as a positive indicator of equity. Nevertheless, several participants in the qualitative study reported challenges in attending exercise sessions, primarily due to post-stroke sequelae. Some also felt that the rehabilitation services offered were not adequately tailored to their impairments. Participants described seeking supplementary care to address unmet needs, which may represent a coping strategy but could, over time, contribute to widening health inequalities. Busija et al (143) identified differences in premorbid functioning and socioeconomic background between patients with stroke who participated in research and those who did not. Previous research by Kruse et al has highlighted social inequalities in stroke rehabilitation, with factors such as age, stroke severity, and sociodemographic characteristics influencing access to care (144). Similarly, Sommer et al reported that 40% of patients dropped out of municipal cardiac rehabilitation programs, with two-thirds of these dropouts occurring during the transition from hospital to municipal care (145). These findings suggest that older and more severely impaired patients may be particularly difficult to retain in long-term, cross-sectoral rehabilitation programs, and may also be more challenging to recruit. Participants in our qualitative study described how their multimorbid conditions and severe sequelae posed significant challenges to engaging in rehabilitation within municipal settings. Moreover, the lack of peers with comparable impairments appeared to influence their willingness to participate, as some expressed a preference for training alongside individuals with similar functional limitations rather than being the most severely impaired member of the group. Targeted efforts to address the needs of these subgroups could help mitigate the observed health inequalities. Moreover, implementing individualized strategies that enhance motivation, and self-efficacy may offer a promising approach to supporting patients with severe post-stroke sequelae. Such strategies have been shown to improve self-monitoring and problem-solving abilities, thereby

contributing to more successful rehabilitation outcomes (146).

The qualitative design was chosen to complement the quantitative studies included in this thesis by offering insight into patients' lived experiences of rehabilitation. This was important, as it allowed the thesis to combine population-level patterns with an understanding of individual perspectives. The sampling strategy was purposive and sought to include variation across functional levels, municipalities, and demographic factors. This strategy strengthened transferability, but it also introduced certain limitations: participants were relatively resourceful patients with stroke, and individuals with severe aphasia or very low mobility were underrepresented**.** As a result, the findings primarily reflect the perspectives of those able to participate in interviews without extensive support. The interviewer's professional background as a physiotherapist provided clinical insight. At the same time, the PhD student was a novice in qualitative research and had no prior experience conducting or analyzing interviews. This inexperience posed both a challenge and an opportunity: while the interview situation required close methodological guidance, it also enabled an openness to learn and reflexivity. To address this, reflexive thematic analysis was chosen, as it offers a structured yet flexible six-phase approach. The relative clarity of its analytic steps provided valuable scaffolding for an inexperienced qualitative researcher, while still allowing space for critical interpretation and reflexive engagement**.** Researcher triangulation and analytic journaling were applied to enhance transparency and reduce the influence of pre-understandings. Regular supervision and discussions within the interdisciplinary research team further supported the analytic process and mitigated the risk of novice bias. Finally, the timing of the interviews varied substantially, from shortly after rehabilitation to more than a year later (11 – 430 days). This variation meant that some participants reflected on their experiences while still in an early recovery phase, whereas others spoke from the perspective of living with stroke in the longer term. This diversity enriched the analysis, but it also introduced heterogeneity that may have influenced the way challenges and needs were articulated**.**

5.4 *Strengths & limitations*

Despite challenges, a strength of the thesis was the use of well-established assessment tools e.g., 30sCST and BBS that are routinely applied in both hospital and municipal rehabilitation settings. Their widespread use facilitates cross-sectoral comparability and enhances the generalizability of the findings. Balance is considered a patient-centered outcome due to its implication in everyday mobility and ADL-functions. Moreover, HRQoL was included as a patient-reported outcome measure, reflecting the importance of capturing subjectively rated health of recovery. Monitoring HRQoL over a rehabilitation period of three to six months allows for the evaluation of meaningful changes in patients' perceived well-being and functional status (147) even when not all patients regain full health

state after six months.

An additional strength in capturing the complexity of cross-sectoral rehabilitation following stroke was the use of a multiple method approach to longitudinally follow, measure, and explore the cohort of patients with stroke. The integration of qualitative and quantitative methodologies provided a comprehensive perspective, contributing to a deeper understanding of cross-sectoral rehabilitation and its impact at both the population and individual levels. While quantitative methods contribute generalizability and enable comparisons between the study population and the broader population, the exploratory and inductive nature of qualitative inquiry—facilitates the uncovering of nuanced insights into lived experiences that may remain inaccessible through quantitative approaches alone. A key challenge in thematic analysis is allowing sufficient time for the development of initial themes, rather than assuming they are readily embedded in the data and merely awaiting extraction (109). The process of triangulating these preliminary themes with my co-supervisors—drawing on our respective professional backgrounds—alongside presenting and discussing the themes, contributed meaningfully to the refinement of the final thematic structure.

A final strength of the thesis was the relatively large number of participants with detailed data, which exceeds that of comparable previous studies. While this made the cohort more challenging to monitor longitudinally, it also provided a more robust dataset for statistical calculations and estimations. Furthermore, we believe the cohort ultimately represented a study population that was comparable to the in-hospital stroke population with potential for continued rehabilitation within municipal settings.

The absence of detailed data resulting from unstructured goal reporting presents a significant limitation, as it complicates quantification and shifts the analytical focus toward achievement status rather than process evaluation. Moreover, the lack of comprehensive documentation regarding rehabilitation efforts—particularly in relation to exercise intensity, session durations, and adverse effects such as pain, falls, or dizziness—represents a substantial barrier to analysis. This limitation hinders efforts to unpack the complexities of rehabilitation, often referred to as the 'black box' of post-stroke recovery.

Another notable limitation was the presence of missing data on PA obtained using the SENS motion sensors, as well as incomplete recordings related to the 30sCST and the BBS. The LMM analysis requires a substantial amount of data to accurately estimate longitudinal progress. Although the method is capable of handling data that are missing at random or completely at random its reliability diminishes when these assumptions are violated, potentially compromising the precision of the results (148) and challenging the boundaries of the statistical model.

A final limitation of the study is the absence of systematic measurement or documentation of fatigue

in relation to cross-sectoral rehabilitation. Throughout the data collection process—encompassing both quantitative and qualitative components—it became increasingly evident that fatigue constitutes a significant post-stroke impairment, closely linked to participation and activity domains within the ICF framework (85). Several participants described challenges related to fatigue and reported using personal energy diaries to monitor daily energy expenditure, identify energy-consuming activities, and recognize those that contributed to energy restoration. Thus, a systematic assessment method might add another angle to the recovery process.

6. Conclusions

Based on findings within the thesis we conclude that low levels of physical activity persist among patients with stroke during hospitalization and the first week following discharge. These reduced activity levels are clinically significant, as they may hinder recovery and contribute to increased social isolation—particularly among patients with severe impairments and multiple comorbidities. After adjusting for multiple variables, regression analyses did not reveal any statistically significant associations in the adjusted linear models. However, longitudinal analysis of repeated measures using the 30-seconds Chair Stand Test, and the Berg Balance Scale demonstrated improvements across all three time periods, with the most notable gains occurring between admission and discharge. Despite these improvements, participants' physical function and health-related quality of life, as measured by the 30sCST and EQ-5D-5L, remained below the levels observed in the general population at the end of rehabilitation. Notably, we identified associations between the number of potential exercise sessions and changes in both the 30sCST and BBS scores. Approximately 31% of participants fully achieved their rehabilitation goals. No significant disparities in goal achievement were observed based on sociodemographic or clinical factors such as age, sex, stroke type, educational background, marital status, rehabilitation level, discharge destination, or municipality. However, baseline and post-rehabilitation scores on the 30sCST and BBS were associated with partial goal achievement and unclear goal status. Finally, participants' experiences of cross-sectoral rehabilitation—from hospital to municipal services—were marked by challenges. These included inadequate goal setting in rehabilitation plans, limited patient involvement, and inflexible rehabilitation services that did not adequately meet individual needs.

7. Clinical implications

The present thesis identified persistently low levels of physical activity among patients with stroke during hospitalization and the first week following discharge. This period may represent an underutilized window of opportunity for optimizing rehabilitation outcomes. Clinically, these findings suggest the potential benefit of restructuring hospital environments to better encourage and facilitate physical activity among patients with stroke, thereby reducing sedentary behavior and promoting more meaningful engagement in rehabilitation.

However, as demonstrated both in this study and in the broader literature, it is essential that this focus on physical activity extends beyond the hospital setting and is integrated into the daily lives of patients with stroke. Enhanced support and motivation during hospitalization may increase physical activity levels, while the implementation of post-discharge interventions—such as instructional videos, mobile applications, or informational pamphlets—could further promote sustained engagement in physical activity.

Consistent evaluation throughout the cross-sectoral rehabilitation process, utilizing standardized assessment tools, may provide clearer insights into patient progress for both patients and therapists. Employing uniform measures across settings allows for more accurate monitoring of changes in physical function over time, as opposed to relying on a variety of disparate tests. Nevertheless, it is important to recognize that clinicians already have access to a wide array of assessment instruments.

The findings from Study II underscore the need for both increased intensity and duration of rehabilitation, as participants' physical function and health-related quality of life (as measured by the 30-seconds Chair Stand Test and HRQoL instruments) remained below population norms at the conclusion of rehabilitation.

From a clinical standpoint, there is a clear need to critically examine goal-setting practices and their evaluation, particularly considering the finding that fewer than one-third of participants fully achieved their rehabilitation goals by the conclusion of the program. The process of establishing meaningful and patient-centered goals is more complex and significant than merely assigning objectives for patients to follow. Moreover, challenges in conducting timely reevaluations are exacerbated by the increasing prevalence of multimorbidity among chronically ill patients, which places additional strain on the healthcare system.

Finally, qualitative data from this thesis highlight the necessity for more comprehensive patient involvement in goal setting, as well as a critical reassessment of current rehabilitation offerings. Existing programs may be perceived as generic and insufficiently tailored to the complex needs of patients with more severe post-stroke sequelae.

8. Future research

Implementing research with stronger practical involvement may offer significant benefits for both clinicians and patients. One approach to examining this is through a mixed-methods design, integrating qualitative insights into patient experiences—particularly regarding how their voices are acknowledged within the healthcare system—and analyzing how these experiences align with the goals set by therapists to evaluate progress or maintain status quo throughout the rehabilitation process.

To promote PA, especially among patients recovering from stroke, a promising research avenue could involve assessing the impact of a digital health application designed to encourage PA during hospitalization and in the post-discharge period. Such an intervention could be evaluated in terms of its effectiveness and long-term sustainability among participants.

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Appendices

Appendix A: Participant study information

Deltagerinformation om deltagelse i et videnskabeligt forsøg

Forsøgets titel: Tværsektoriel genoptræning efter apopleksi

Vi vil spørge, om du vil deltage i et videnskabeligt forsøg, der udføres af Gabriel T. Notkin i samarbejde med Neurologisk Afdeling, Nordsjællands Hospital (NOH)?

Før du beslutter, om du vil deltage i forsøget, skal du fuldt ud forstå, hvad forsøget går ud på, og hvorfor vi gennemfører forsøget. Vi vil derfor bede dig om at læse denne deltagerinformation grundigt.

Du vil blive inviteret til en samtale om forsøget, hvor denne deltagerinformation vil blive uddybet, og hvor du kan stille de spørgsmål, du har om forsøget. Du er velkommen til at tage et familiemedlem, en ven eller en bekendt med til samtalen.

Hvis du beslutter dig for at deltage i forsøget, vil vi bede dig om at underskrive en samtykkeerklæring. Husk, at du har ret til betænkningstid, før du beslutter, om du vil underskrive samtykkeerklæringen.

Det er frivilligt at deltage i forsøget. Du kan når som helst og uden at give en grund trække dit samtykke tilbage. Det vil ikke have betydning for din behandling.

Formål med forsøget

Blodprop i hjernen eller hjerneblødning (også kendt som apopleksi) rammer årligt 12.500 danskere og er på verdensplan den anden hyppigste dødsårsag og tredje hyppigste årsag til invalidering. Op mod halvdelen af de personer der rammes af sygdommen, får én eller flere følger i form af kraftnedsættelser, talebesvær, samt hukommelses- og koncentrationsproblemer. Grundet disse alvorlige og ofte blivende udfordringer hos personerne er der derfor behov for grundig genoptræning i den efterfølgende tid.
Det anbefales at genoptræning efter blodprop i hjernen og hjerneblødning starter allerede under hospitalsindlæggelsen og fortsætter efter udskrivelsen i kommunalt regi. Genoptræningen planlægges med afsæt i en genoptræningsplan som udarbejdes af hospitalsfysioterapeuten med flere faggrupper i samarbejde med patienten under indlæggelsen. I tillæg til den planlagte genoptræning anbefales patienterne at være fysisk aktive i deres hverdag for at forebygge nye tilfælde af blodprop og hjerneblødning.

Formålet med dette projekt er at undersøge det genoptræningstilbud patienter med blodprop eller hjerneblødning tilbydes både under indlæggelse og efter udskrivelse. Målet er at få viden som kan medvirke til at styrke det sammenhængende træningsforløb på tværs af hospital og kommune og derved medvirke til at forbedre behandlingen af patientgruppen.
I studie I, måles der på hvor aktive patienterne er i perioden fra udskrivelsen og til opstart af genoptræning i kommunen. I studie II, undersøges hvad der sker med patienternes fysiske funktion, balance og livskvalitet igennem et tre måneders genoptræningsforløb. I studie III undersøges hvorvidt patienterne opnår deres tidligere definerede målsætninger fra genoptræningsplaner, og i studie IV

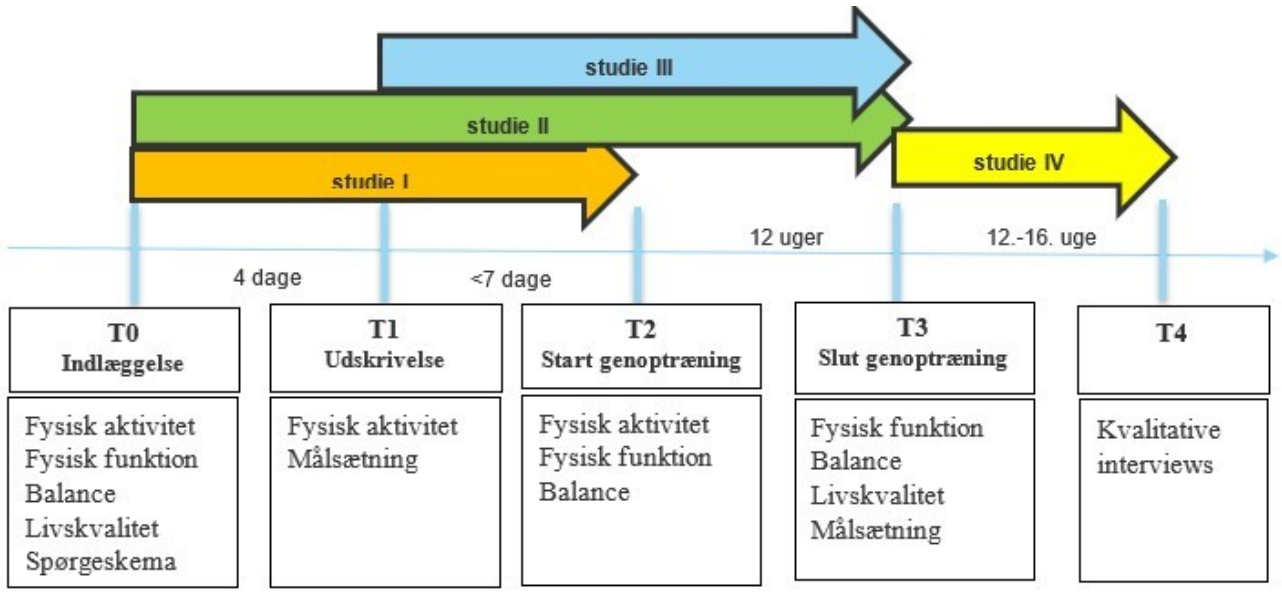
hvad den patientoplevede værdi af det samlede genoptræningsforløb og træning er for patienterne herunder brugen af genoptræningsplanen. Vi forventer at 117 personer med apopleksi vil deltage i forsøget igennem projektperioden på 3 år.

Plan for forsøget

Forsøget forløber imens du er indlagt på Neurologisk Afdeling, NOH, frem til og med din kommunale genoptræning og vil bestå af to funktionstest gentaget tre gange i perioden: under indlæggelse, ved start af kommunal genoptræning og i slutningen af den kommunale genoptræning se Figur 1. De to funktionstest er 30 sekunders rejse/sætte-sig test (fysisk funktion) og Bergs Balance Skala (balance). Desuden vil du i første del af perioden frem til du er startet genoptræning i kommunen skulle bære en aktivitetsmåler SENS Motion® på låret, SENS der sættes på med et plaster. indsamler data om dit bevægelsesmønster døgnet rundt (fysisk aktivitet). Den overvåger IKKE hvor du bevæger dig, men kun hvordan.
Du vil også under indlæggelsen få udleveret et spørgeskema om din uddannelse, arbejde, om du er gift/ugift og din livskvalitet (livskvalitet) ved indlæggelsen/afslutningen af din genoptræning. Spørgeskemaet forventes at tage under 5 min at udfylde. Du vil blive spurgt om hvilket mål du har for din genoptræning (målsætning) ved udskrivelse/afslutning af kommunal genoptræning. Endelig vil du blive inviteret til at deltage i et opfølgende interview med Gabriel T. Notkin efter at du har gennemført dit genoptræningsforløb i kommunen. Interviewet kan foregå i dit hjem, der hvor du træner eller hvor du ønsker det. Vi beder også om lov til at hente disse oplysninger fra din patientjournal om:

- Alder
- BMI
- Sværhedsgrad af din apopleksi

Oplysningerne vil indgå i en overordnet beskrivelse af deltagerne i anonymiseret form og i de statistiske udregninger af resultaterne. Med dit samtykke giver det Gabriel T. Notkin og Neurologisk Afdeling NOH direkte adgang til relevante helbredsoplysninger i journalen for at kunne gennemføre, overvåge og kontrollere forsøget. Der vil i forsøget blive behandlet personoplysninger. Databeskyttelsesloven og databeskyttelsesforordningen vil blive overholdt. Der udtages ikke biologisk materiale i forsøget.



Figur 1: Oversigt over tidsperioder i projektet

Nytte ved forsøget

For dig som deltager kan du få mulighed for at blive hørt omkring din oplevelse af at indgå i et samlet genoptræningsforløb på hospital og i kommune. Du vil samtidig få foretaget målinger gennem perioden for at se om du bevæger dig mere, bliver stærkere eller opnår bedre balance og livskvalitet. Denne viden vil kunne komme andre patienter med blodprop i hjernen eller hjerneblødning til gavn, idet det hjælper med ny viden om hvordan genoptræningen virker for patienterne. Samtidig giver det viden om hvordan patienterne/borgerne blive inddraget i deres genoptræning på hospital og i kommune.

Bivirkninger, risici, komplikationer og ulemper

Der forventes ingen alvorlige bivirkninger ved at deltage i forsøget. Alle bivirkninger eller komplikationer opstået i forbindelse med deltagelse i forsøget vil blive opgjort i forbindelse med offentliggørelse af resultaterne. Hvis du oplever hudirritation eller plasterallergi fra aktivitetsmåleren, beder vi dig om at tage denne af og aflevere eller sende den i en konvolut til **Gabriel T. Notkin, Neurologisk Afdeling, Fysioterapiafsnittet 0721 Opgang 58, plan 3, Dyrehavevej 29, 3400 Hillerød**.

Forsøgets risici	Hyppige/ikke alvorlige	Sjældne/alvorlige	Langvarige
Bivirkninger	Forbigående muskeløm-hed som følge af træning.	Få personer oplever plaster-allergi/hudirritation af at have SENS-plaster påkli-stret over flere dage.	Ingen kendte
Risici	Ingen kendte	Ingen kendte	Ingen kendte
Komplikationer	Ingen kendte	Ingen kendte	Ingen kendte
Ulemper	Ingen kendte	Ingen kendte	Ingen kendte

Der kan være risici ved forsøget, som vi endnu ikke kender. Vi beder dig derfor om at fortælle, hvis du oplever problemer med dit helbred, mens forsøget står på. Hvis vi opdager bivirkninger, som vi ikke allerede har fortalt dig om, vil du naturligvis blive orienteret med det samme, og du vil skulle tage stilling til, om du ønsker at fortsætte i forsøget.

Udelukkelse fra og afbrydelse af forsøg

Forsøget afbrydes kun hvis Gabriel T. Notkin fratræder sin stilling hos Neurologisk Afdeling, NOH. Alle deltagere vil blive informeret hvis forsøget mod forventning skulle blive afbrudt.

Oplysninger om økonomiske forhold

- Forsøget er initieret af Gabriel T. Notkin i samarbejde med Neurologisk Afdeling, NOH, og vil blive udført i tæt samarbejde med de omkringliggende kommuner i Nordsjælland.
- Der er foreløbig givet økonomisk støtte fra Ph.d.-Startmidler- og lønpuljen på NOH, Tværspuljen Region H og Fru Olga Bryde Nielsens Fond. Øvrige fonde søges om yderligere støtte.
- Støttemidlerne på 430.000 kr. administreres af ledelsen på Neurologisk Afdeling, NOH. Der udbetales ikke vederlag eller andre goder ved deltagelse i forsøget.

Adgang til forsøgsresultater

Forsøgets resultater vil blive offentliggjort når alle data er gjort op og forsøget er afsluttet. Resultaterne vil blive viderebragt i patientforeninger, på nationale og internationale forskningskonferencer, og i de nordsjællandske kommuner samt på forskningsarrangementer på NOH. Resultaterne forventes at være klar i slutningen af år 2025.

Vi håber, at du med denne information har fået tilstrækkeligt indblik i, hvad det vil sige at deltage i forsøget, og at du føler dig rustet til at tage beslutningen om din eventuelle deltagelse. Vi beder dig også om at læse det vedlagte materiale "*Forsøgspersonens rettigheder i et sundhedsvidenskabeligt forskningsprojekt*". Hvis du vil vide mere om forsøget, er du meget velkommen til at kontakte Gabriel T. Notkin,
gnot0001@regionh.dk, Neurologisk Afdeling, Fysioterapiafsnittet 0721 Opgang 58, plan 3, Dyrehavevej 29, 3400 Hillerød, tlf.: 48 29 42 48
Med venlig hilsen
Gabriel T. Notkin
Indsæt underskrift

Videnskabsetisk Komités projekt nr. 77236, version 1, dato 11.05.2022

Appendix B: Written consent

Informeret samtykke til deltagelse i et sundhedsvidenskabeligt forskningsprojekt.

Forskningsprojektets titel: **Tværsektoriel genoptræning efter apopleksi – patientinddragelse og fysisk aktivitet og formåen før og efter udskrivelse fra Nordsjællands Hospital**

Erklæring fra forsøgspersonen:

Jeg har fået skriftlig og mundtlig information og jeg ved nok om formål, metode, fordele og ulemper til at sige ja til at deltage.

Jeg ved, at det er frivilligt at deltage, og at jeg altid kan trække mit samtykke tilbage uden at miste mine nuværende eller fremtidige rettigheder til behandling.

Jeg giver samtykke til, at deltage i forskningsprojektet, og har fået en kopi af dette samtykkeark samt en kopi af den skriftlige information om projektet til eget brug.

Forsøgspersonens navn: _____

Dato: _____ Underskrift: _____

Ønsker du at blive informeret om forskningsprojektets resultat samt eventuelle konsekvenser for dig?:

Ja _____ (sæt x) Nej _____ (sæt x)

Erklæring fra den, der afgiver information:

Jeg erklærer, at forsøgspersonen har modtaget mundtlig og skriftlig information om forsøget.

Efter min overbevisning er der givet tilstrækkelig information til, at der kan træffes beslutning om deltagelse i forsøget.

Navnet på den, der har afgivet information:

Dato: _____ Underskrift: _____

Projektidentifikation:

Papers I-IV