Physiotherapeutic perspectives on balance control after stroke: exercises, experiences and measures
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Physiotherapeutic perspectives on balance control after stroke: exercises, experiences and measures
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Abstract


The overall aim of this thesis was to investigate physiotherapeutic perspectives on balance after stroke, in terms of exercises, experiences and measurements. Study I was a pilot randomized controlled trial with 46 persons who had had a stroke, 24 of whom were included in the intervention group and 22 who were included in the control group. The intervention consisted of 8 weeks of body awareness therapy (BAT). There were no significant differences over time between the groups in the outcome measures of balance, walking, self-reported balance confidence and quality of life. Study II had a qualitative design using content analysis. Participants in the intervention group from Study I and the four physiotherapists who had been in charge of the BAT were interviewed. One overall theme emerged: “Simple yet challenging”, which was based on six categories. Study III investigated the validity and test-retest reliability of the Six-Spot Step test (SSST), an instrument used to assess the ability to take load on each leg. A cross-sectional design with 81 persons who had had stroke was performed. The convergent validity was strong to moderate, and the test-retest reliability was good. In Study IV a mixed method design including both qualitative and quantitative data collection was used. The participants’ experiences of balance and its influence in everyday life were presented in two themes: “Feeling dizzy and unstable is a continuous challenge” and “Feeling trust and confidence despite dizziness and unsteadiness”. Taken together, the different data sets provided complementary and confirmatory information about balance. All participants experienced the balance limitations as a continuous challenge in everyday life, yet they also felt trust and confidence.

In summary, BAT can be a complement in physiotherapeutic stroke rehabilitation and the SSST can be used as a measuring instrument of walking balance in persons with stroke. Living with balance limitations was experienced as a challenge but the participants were still able to manage their everyday life and activities.

Keywords: Stroke, balance, physiotherapy, measures, experiences

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# Abbreviation

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>BAT</td>
<td>Body Awareness Therapy</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WCPT</td>
<td>World Confederation for Physical Therapy</td>
</tr>
<tr>
<td>ABC scale</td>
<td>activities-specific balance confidence scale</td>
</tr>
<tr>
<td>BBS</td>
<td>Berg balance scale</td>
</tr>
<tr>
<td>DGI</td>
<td>dynamic gait index</td>
</tr>
<tr>
<td>FSST</td>
<td>four square step test</td>
</tr>
<tr>
<td>NIHSS</td>
<td>national institutes of health stroke scale</td>
</tr>
<tr>
<td>SSST</td>
<td>six- spot step test</td>
</tr>
<tr>
<td>SF-36</td>
<td>short form 36</td>
</tr>
<tr>
<td>TST</td>
<td>modified timed stands test</td>
</tr>
<tr>
<td>TUG</td>
<td>timed up and go test</td>
</tr>
<tr>
<td>TUG cognitive</td>
<td>timed up and go test cognitive</td>
</tr>
<tr>
<td>ICC</td>
<td>intraclass correlation coefficient</td>
</tr>
<tr>
<td>SD</td>
<td>standard deviation</td>
</tr>
<tr>
<td>SE</td>
<td>standard error</td>
</tr>
<tr>
<td>SRD</td>
<td>smallest real difference</td>
</tr>
<tr>
<td>SRD%</td>
<td>a percentage value of the smallest real difference</td>
</tr>
<tr>
<td>SEM</td>
<td>standard error of the measurement</td>
</tr>
<tr>
<td>SEM%</td>
<td>a percentage value of the standard error of the measurement</td>
</tr>
</tbody>
</table>
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LIST OF PUBLICATIONS

This thesis is based in the following papers, which are referred to in the text by their Roman numerals:


Papers I-III have been reprinted with permission from the publishers: SAGE Publications Ltd, Elsevier Ltd, and Taylor & Francis Group.
BACKGROUND

Stroke

Stroke is the most common cause of serious, long-term disability among adults (1). The World Health Organization (WHO)’s definition of stroke is: “rapidly developing clinical signs of focal (or) global disturbance of cerebral function, with symptoms lasting 24 hours or longer or leading to death, with no apparent cause other than that of vascular origin” (2). Stroke events are either ischaemic (85%) or haemorrhagic (15%). Symptoms depend largely on the location and size of the stroke (3). Globally the burden of stroke is increasing, with the majority of the burden being in the low and middle-income countries (1). In Sweden there are about 25,000–30,000 new incidents of stroke per year (4, 5). The number of women who suffer from stroke is slightly lower than that of men. In both women and men, however, stroke is a disease mainly for the ageing population. The median age for having a stroke in Sweden is 74 years for men and 78 years for women (5). Although the incidence of stroke has declined, the prevalence of living with stroke has increased because of the ageing population. Stroke is the somatic disease requiring the most treatment days in hospital. The total social cost of stroke in Sweden is estimated to be SEK 18.3 billion annually (5, 6).

Having a stroke is often a life-changing event, as many stroke survivors go from being independent to being dependent. Motor impairment with muscular weakness and limited muscular control is seen in about 80% of persons with stroke (7, 8). After a stroke, impaired postural stability and mobility are common due to various deficits such as hemiparesis, affected sensory function, and spasticity (8). Besides causing impaired postural stability, hemiparesis can also lead to asymmetrical posture, restricted walking balance and dependency in activities of daily living (9-11). Many activities of daily living require the ability to perform activities simultaneously, such as performing a secondary task while walking, which can be challenging for persons with stroke (12, 13). With asymmetric stance and impaired balance, there is a high risk of falling (14, 15).

After stroke there is an acute phase where the patient sometimes is not medically stable. The duration of the acute phase varies depending on the severity of stroke. During the first week, spontaneous recovery often takes
The recovery after stroke is complex, usually a combination of spontaneous and learning-dependent processes, including restoring the functionality of damaged neural tissue (restitution), reorganization of partly spared neural pathways to relearn lost functions (substitution) and improvement of the disparity between the impaired skills of the patient and the demands of their environment (compensation) (16). Most improvements take place during the first 6 months, but functional improvement may continue even beyond that time (6, 16). Regaining their walking ability and being part of the society are important factors for many stroke survivors (18).

**Balance**

The word “balance” is often used in association with terms such as “stability” and “postural control”. In this thesis, “balance” is used synonymously with “postural control”. According to Shumway-Cook and Woollacott (19), postural control is an interaction between the individual, the task and the environment. Having postural control involves controlling one’s position in space for stability by keeping the centre of mass within the base of support. All activities require postural control and every task has an orientation component and a stability component. However, the stability and orientation requirements will vary depending on the task and the environment (20). To keep the body in position requires a complex interaction of the musculoskeletal, neuromuscular, and cognitive systems (19). In persons with stroke all the systems involved in balance may be negatively affected (19); therefore, balance is often impaired after stroke (8, 9, 16, 17, 20, 21).

To be in balance requires the ability to be in equilibrium while standing and while moving. This includes the ability to shift weight from side to side and back and forth and to make flexible movements (19). This may be challenging for persons after stroke, because of muscle weakness, spasticity and impaired sensory function. The base of support may be compromised owing to limited ability to take load on both legs and an asymmetric posture might be seen (9, 14). Walking balance can be described as the ability to control the centre of mass within the base of support so as to remain upright while walking (10).
Balance includes different types: static balance, which aims to maintain a stationary upright position; dynamic balance, which maintains the balance while moving; proactive balance, which prepares the body for a shift of the centre of gravity; and reactive balance, which includes a movement or a muscular response to have, the ability to maintain stability when something unforeseen occurs (19). In physiotherapeutic assessment and treatment all these types need to be recognized and targeted (7).

**Physiotherapy and rehabilitation**

**Definitions**

According to the World Confederation for Physical Therapy (WCPT), physiotherapy is a service provided by physiotherapists to individuals and populations to develop, maintain and restore maximum movement and functional ability throughout their lifespan. Physiotherapists are concerned with identifying and maximizing quality of life and movement potential within the spheres of promotion, prevention, treatment/intervention, habilitation and rehabilitation (22). Physiotherapy is based on knowledge about the body and its movement needs, which is central to determining strategies for diagnosis and interventions. Rehabilitation is described by the WHO as a process that enables the individual to identify problems and reach his or her optimal ability, with the aim to facilitate independence and social integration (23).

**Rehabilitation after stroke**

Rehabilitation after a stroke starts early, with functional exercises and respiratory care. There is strong evidence that rehabilitation after stroke should focus on functional exercises, and be intense (24). Rehabilitation after stroke is life-long and the overall aim is to enable activities of daily living. Stroke rehabilitation should focus on each patient’s needs and be individualized and task-oriented (17, 25-31). Multidisciplinary team care, in which the physiotherapist is one of the members of the team, plays an important role in stroke rehabilitation (32). Recovery can continue for months or years after stroke, well beyond the formal rehabilitation period. It is therefore important to continue training (21, 33).
**Physiotherapy after stroke**

In persons with residual disability after stroke, balance impairment is often the reason for enlisting the support of a physiotherapist (22). With the goal being to prevent falls, one focus in physiotherapy is to improve walking and balance ability (29, 34). It is also important to enhance balance confidence to further improve walking capacity to enable participation in everyday life (35, 36). There are several studies that have shown positive impact on balance and walking using environment-specific training (30), as well as strength and fitness training (27, 28, 37) and specific walking training (29). However, there is limited knowledge about what is the most beneficial type of training for stroke patients (38). A physiotherapeutic method focusing on stability limits and postural control is Body Awareness Therapy (BAT). In Sweden, BAT is performed in primary health care but not regularly in persons after stroke.

**Body Awareness Therapy**

Body Awareness Therapy is often led by a physiotherapist and can be conducted individually or in groups. The method is inspired by Tai Chi movements, focusing on postural stability by challenging a person’s stability limits (39, 40). Body Awareness Therapy can be described from two perspectives: the experience of the body (the experience dimension) and the actions and behaviour in movement and activities (the movement dimension) (41). The focus of BAT is on finding a new attitude towards the body, thus strengthening the person’s resources, and integrating them into everyday life. A core movement is stimulation of the central axis through weight transfers from left to right, and rotation around the centre of the body. By including these simple repetitive movements that challenge a person’s stability limits, postural control can be improved (39, 40).

Another central element of BAT is to make the person aware of their movements and of their own body, as well as making them reflect on how their body feels when performing the movements. To perform a movement slowly many times gives the person the possibility to experience the body and its limits. Movements can be performed in supine or, sitting position or standing. Balance control, free breathing and coordination are integrated in the movements. Body Awareness Therapy has been used for various conditions in different physiotherapy contexts, e.g. for psychiatric disorders (41, 42), chronic pain (43) and schizophrenia (42), in traumatic
femoral amputees (44), and for eating disorders (45) and irritable bowel syndrome (46). Reported positive effects are improved quality of life (45, 46), self-efficacy, body awareness and attitude towards the body, as well as improved self-esteem (41, 42) and also reduced pain (43). Body Awareness Therapy has not previously been used as a balance exercise, but in a study by Sjodahl et al, the outcome measure was gait and, among other results, the authors report decreased need of walking aids in a group of persons with unilateral transfemoral amputations (44).

**Balance measurements**
In clinical practice and research it is important to evaluate changes, improvements or deteriorations after an intervention. It is vital that the measuring instrument reflects the impairments, activity limitations or restrictions of interest. It is also important that the measure is both reliable and valid, and that it is suitable for the functional level of the patient: neither too easy nor too difficult. To facilitate the usability of a measure it is preferable that the procedure should be quick and easy and possible to perform in different environments.

There are advanced laboratory facilities aimed at measuring balance, but in clinical practice, advanced technological devices are often not available. In physiotherapy clinics, balance and walking are often evaluated by different functional tests, such as the Timed Up and Go (TUG) test (47) and different tests of walking such as speed, endurance and dual-task performance tests (48-50).

To measure balance an instrument should include different types of balance such as static, dynamic, and pro- and reactive balance (19). Another aspect of balance is subjectively experienced balance performance. Examples of instruments of subjective experience of certain limitations, such as fear of falling or self-rated balance confidence, are the Falls Efficacy Scale and the Activities-specific Balance Confidence Scale (51, 52). Balance confidence is a usable factor in enhancing and predicting balance and walking ability post-stroke (35, 53-55).

To measure balance in persons after stroke there are several valid and reliable measurements used in both clinical practice and research, such as the Berg Balance Scale (BBS) (56, 57), the Dynamic Gait Index (DGI) (50,
58) and the TUG test (47, 59). However, the asymmetric weight distribution (17) may not be fully captured by these instruments and therefore the question arises whether the measure called Six-Spot Step Test (SSST) (60) could be of use. This test was originally developed as a walking test for persons with multiple sclerosis (MS) (60). It includes a dual-task challenge with a forced weight shift from one foot to another, while walking a short distance. The SSST can be seen as a measure of walking balance including a dual-task.

The SSST could provide a comprehensive picture of walking capacity after stroke, but its psychometric properties, validity and reliability in persons with stroke need to be evaluated prior to using it in clinical practice and research.

**Experience of balance after stroke**

To get a more comprehensive picture of balance limitations after stroke it is important to also focus on the individual’s perspective. An important part of balance assessment is to gather self-reported information on participation in social roles and activities. To develop more individualized rehabilitation interventions and to more individually describe a person’s balance, knowledge about both perceived and measured balance is required (35, 61).

Qualitative studies in which persons with stroke have had the opportunity to describe their experience of balance control in everyday life are scarce. Having good balance is described as an important factor in outdoor walking and participation in exercises (62, 63). Experience of fears related to falls (64, 65) can vary from limited awareness to pervasive fear (65). Smith et al suggest that discussing strategies and assessing fear of falling could help the persons to manage their fears (64). To have sufficient balance is mandatory for activity and participation but there is a lack of knowledge about how persons who have had a stroke experience their own balance. This could be a barrier to understanding the complexity of impaired balance and to further developing patient-centred interventions.
RATIONALE

After a stroke many persons remain chronically disabled, with a need for further rehabilitation. Rehabilitation focusing on balance and walking is a way to increase activities and perceived participation in society.

The movements in BAT aim to challenge the limits of stability and strengthen the patient’s own resources. Studies using BAT in different diagnosis groups have shown improved postural control. With its focus on balance, BAT may be beneficial also for persons with hemiparesis after stroke.

Body Awareness Therapy is often used and performed by physiotherapists in primary health care. There may be some differences in physiotherapists’ and patients’ descriptions of characteristics of a physiotherapy session. Therefore, to get a deeper and fuller description of a course of BAT it is valuable study to both the effects of the therapy, and patients’ and physiotherapists’ experiences of it.

Although there are several valid and reliable measures of balance for persons with stroke, there is a need to also measure unilateral limitations and asymmetric weight distribution during walking. The SSST includes these aspects of balance and can be used in the assessment procedure, but its psychometric proprieties have not been investigated for stroke. There are several studies presenting outcome of balance using test instruments and rating scales; however, few studies report on persons with stroke describing their balance limitations in their own words. By combining all these different perspectives, this thesis will investigate and contribute to a wider understanding and knowledge of balance in persons who have had a stroke.
AIMS

The overall aim of this thesis was to investigate different aspects of balance control after stroke, in terms of exercises, experiences and measurements.

In Study I the aim was to investigate the effects of BAT on balance, mobility, balance confidence, and subjective health status in persons with stroke. In Study II the aim was to describe the experience of an 8-week programme of BAT from the perspective of both persons with stroke, and physiotherapists. In Study III we aimed to investigate the convergent and discriminant validity and test-retest reliability of the SSST in persons with stroke. The aim of Study IV was to describe experiences of living with balance limitations after a first-ever stroke. A further aim was to investigate the concordance between experiences of balance limitations, perceived balance, and measured balance control in order to reach a more comprehensive understanding of balance in this population.
MATERIALS AND METHODS

Study design
Four separate data collection procedures were used in this doctoral thesis. Study I was a randomized controlled trial (RCT) with an experimental intervention consisting of 8 weeks of BAT and an untreated control group. Study II was a qualitative descriptive interview study. In Study III a cross-sectional design was used to investigate the validity and test-retest reliability of the SSST. In Study IV a mixed method design including both qualitative and quantitative data collection was used.

Sampling and participants
Table 1 presents background variables of the participants in Studies I–IV. In Studies I–III, persons diagnosed with stroke were recruited using convenience sampling through primary health care centres in Region Örebro County. In Studies I and II the inclusion criteria were: >6 months since onset of the most recent stroke, ability to walk a distance of 100 metres with or without assistance, and subjectively experienced balance impairment. Study I was a pilot study to evaluate BAT in persons with stroke and based on this type of study it was considered reasonable to include 20–25 participants in each group. Altogether 69 invitation letters were sent out by mail and after 1 week each person was contacted by phone and provided with verbal information about the study. Forty-six persons agreed to participate, of whom 24 were randomized to the intervention group and 22 to the control group. Randomization to intervention or control was conducted in blocks of four to six persons at each primary health care centre, using sealed envelopes that were opened after the baseline tests. For participants randomized to the control group, no further intervention was carried out, and all participants were instructed to continue with their usual daily activities. There were three dropouts in the intervention group.

All persons who completed the intervention in Study I were invited by mail and also by phone to participate in the interviews in Study II and all agreed to be interviewed. The four physiotherapists who were responsible for the BAT intervention were likewise invited to be interviewed and all agreed. They had further training and 15–20 years of clinical experience in
in BAT. A total of 21 persons with stroke and four physiotherapists agreed to participate in the study.

In **Study III** the inclusion criteria were: >6 months since onset of the most recent stroke, self-reported walking impairment, and walking ability of at least 10 metres with or without using a walking aid. We aimed to recruit about 80 individuals as recommended for reliability studies (66, 67). The persons with stroke received both written and verbal information about the study. Letters were mailed to them or handed to them by the physiotherapists at the health care center. Each person was thereafter contacted by telephone and provided with verbal information about the study. A total of 81 persons agreed to participate in the study.

In **Study IV**, the inclusion criteria were: having had a first-ever stroke in 2015–2016, living in Örebro County, and having reported impaired balance ability, unaffected speech, independence in toileting and dressing, and walking ability indoors and outdoors with or without a walking aid, in the 3-month follow-up questionnaire of the Swedish Stroke Register (*Riksstroke*). Study IV had a mixed method design (68) with a qualitative approach and it was aimed to include about 20 persons. A total of 45 persons were consecutively by mail and thereafter by phone to invite them to participate. As well as using a consecutive approach, a purposeful sampling was used based on background variables, such as age and sex, in order to achieve a maximum variation sample. Twenty persons initially agreed to participate; however, one person later declined further participation, thus giving a sample size of 19 participants.

Exclusion criteria in all studies were: having medical, physical or cognitive impairment that affected the ability to actively participate or to understand written and verbal instructions. Self-reported impairments other than stroke that significantly affected gait performance were further exclusion criteria.
Table 1 Background variables of the participants in Studies I–IV

<table>
<thead>
<tr>
<th>Variables</th>
<th>Study I Intervention group (n=24)</th>
<th>Control group (n=22)</th>
<th>Study II (n=21)</th>
<th>Study III (n=81)</th>
<th>Study IV (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean (standard deviation) (range)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, yrs</td>
<td>62.1 (11.4) (42–82)</td>
<td>65.6 (9.2) (42–81)</td>
<td>62.1 (10.9) (42–80)</td>
<td>70.3 (7.9) (51–86)</td>
<td>76.7 (11.8) (42–92)</td>
</tr>
<tr>
<td>Time since most recent stroke, yrs</td>
<td>4.1 (3.8) (0–15)</td>
<td>4.2 (4.5) (0–15)</td>
<td>4.0 (4.1) (0–15)</td>
<td>4.8 (5.0) (0.5–31)</td>
<td>15 (6.1) (4–22)*</td>
</tr>
<tr>
<td>N (%)</td>
<td>12 (50%)/12 (50%)</td>
<td>15 (68%)/7 (32%)</td>
<td>11 (52%)/10 (48%)</td>
<td>47 (58%)/34 (42%)</td>
<td>9 (47%)/10 (53%)</td>
</tr>
<tr>
<td>Male/female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemiparesis, right/left</td>
<td>11 (45.8%)/13 (54.2%)</td>
<td>15 (68.2%)/7 (31.8%)</td>
<td>11 (52.4%)/10 (47.6%)</td>
<td>35 (43.3%)/46 (56.8%)</td>
<td>10 (52.6%)/9 (47.4%)</td>
</tr>
<tr>
<td>Type of stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intracerebral infarction</td>
<td>16 (66.7%)</td>
<td>18 (81.8%)</td>
<td>13 (61.9%)</td>
<td>60 (74.1%)</td>
<td>16 (84.2%)</td>
</tr>
<tr>
<td>Intracerebral haemorrhage</td>
<td>8 (33.3%)</td>
<td>4 (18.2%)</td>
<td>8 (38.1%)</td>
<td>18 (22.2%)</td>
<td>3 (15.8%)</td>
</tr>
<tr>
<td>Subarachnoid haemorrhage</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>3 (3.7%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Previous strokes</td>
<td>1 (4.2%)</td>
<td>7 (31.8%)</td>
<td>1 (4.8%)</td>
<td>9 (11.1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>One or more falls in the past 3 months</td>
<td>9 (37.5%)</td>
<td>9 (40.9%)</td>
<td>8 (38.1%)</td>
<td>34 (42.0%)</td>
<td>7 (36.8%)</td>
</tr>
<tr>
<td>Walking aids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>8 (33.3%)</td>
<td>5 (22.7%)</td>
<td>7 (33.3%)</td>
<td>27 (33.3%)</td>
<td>8 (42.1%)</td>
</tr>
<tr>
<td>Unilateral support: walking stick/crutch</td>
<td>11 (45.8%)</td>
<td>14 (63.6%)</td>
<td>10 (47.6%)</td>
<td>25 (30.9%)</td>
<td>2 (10.5%)</td>
</tr>
<tr>
<td>Bilateral support: rolling walker</td>
<td>5 (20.8%)</td>
<td>3 (13.6%)</td>
<td>4 (19.0%)</td>
<td>23 (28.4%)</td>
<td>9 (47.4%)</td>
</tr>
<tr>
<td>Wheelchair outdoors</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>6 (7.4%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

*In Study IV, time since most recent stroke is given in months.
Body Awareness Therapy intervention in Study I

In the RCT the experimental intervention consisted of BAT conducted in groups for 8 weeks, 60 minutes once a week, in a quiet room at each of the four primary health care centres, one group per centre. Participating in four out of eight sessions was set as a minimum for each person taking part in the intervention. The intervention was led by physiotherapists with further training and 15–20 years of clinical experience in body awareness therapy. The choice of movements in the intervention was based on previous studies on BAT and BAT experience of the physiotherapists involved. Prior to the intervention the physiotherapists and researchers decided on a framework including a list of specific movements. The participants were instructed to wear comfortable clothes and no footwear so as to be able to be in contact with the floor during the movements.

The sessions started and ended with the participants sitting on chairs. Together with the physiotherapist, the participants reflected on the exercises, experiences, bodily and mental aspects, and their expectations before the upcoming session. The intention was that they should relate how the movements felt in their bodies, and how they had integrated the movements in their everyday life. All group sessions followed the same structure; however, exercises were individually adjusted and the intensity and degree of difficulty were increased by the physiotherapists over the 8-week period.

Movements were performed in sitting, standing and supine position. Participants were asked to focus on their breathing and the contact with the chair and the floor. They explored their stability limits by shifting their weight forward, back, and from left to right, until they felt in balance. In standing, the centre line was stimulated through rotation of the body, with the arms softly moving. The participants were encouraged to incorporate the movements in their daily life; however, no specific home exercises were given.
Measurements, Studies I, III and IV

Body function

The National Institutes of Health Stroke Scale: Items 5 and 6 was used to assess stroke severity (69). In item 5, with the patient in a supine position, the arm was lifted to 45 degrees; in item 6, also in supine position, the leg was lifted to 30 degrees. Performance was graded from 0 = able to hold the arm for 10 seconds/the leg for 5 seconds, to 4 = no movement in either arm or leg (Study III).

Modified Timed Stands Test: The TST is a measure of overall lower extremity function and has been found to be valid in rheumatoid arthritis and other chronic diseases (70). Time was noted as the participants rose from a chair ten times. Participants were permitted to use the hand rails on the chair (71) (Studies I and III).

Dynamic balance

Berg Balance Scale: Score on the BBS was the primary outcome measure in Study I. The BBS measures the ability to assume and maintain a given position while performing a voluntary movement. The scale consists of 14 tasks of varying difficulty that are found in the activities performed in everyday life. One task is to rise from sitting to standing position, another to reach forward, or to pick up something from the floor or stand on one leg. The tasks are graded 0–4. The BSS is a reliable and valid measure for persons with stroke (57, 72) (Study I).

Timed Up and Go test: The TUG test was developed as a measure of functional mobility (47) and has been found to be valid and reliable in persons with stroke (59). In the TUG test the time is recorded when the person rises from a chair, walks 3 metres, turns and walks back and sits down again (47) (Studies I and III).

The Timed Up and Go cognitive: The TUG cognitive test is a measure of functional mobility including a dual-task measure. The TUG cognitive has prognostic validity and can be used to predict falls in elderly people (73). In the TUG cognitive the time taken for the person to perform the TUG test while repeatedly subtracting 3 from a randomly chosen number is recorded (74) (Study I).
Four Square Step Test: The FSST is a clinical test of dynamic standing balance. The FSST has good intra- and interrater reliability as well as validity in stroke (75, 76). The FSST tests the ability to quickly step over four sticks of 2.5 cm height placed on the floor at 90 degrees to each other and marking four squares. The person steps forward, backward and sideways, first in a clockwise and then in an anti-clockwise direction, putting most of the load on one leg at a time but making contact with the floor in each square with each foot (77). The time was noted as the participants completed the task without touching a stick. Two trials were performed and the mean value of these was calculated (Study III).

Walking balance

Dynamic Gait Index: The DGI assesses dynamic balance in eight items representing different walking tasks. The DGI has been found to be valid and reliable, with good interrater reliability, in persons with stroke (58). The tasks are: changing walking speed, walking while turning the head, walking around or over obstacles, and walking with a pivot turn. Performance in each item is rated by the physiotherapist on a 4-point scale ranging from 0 = severe impairment, to 3 = normal walking ability without a walking aid. The maximum total score is 24 points (50) (Study III).

Six-Spot Step Test: The SSST is performed in a taped walkway (test field) that is 5 metres long and 1 metre wide. A circle with a 20 cm diameter is marked in the middle of each end line of the test field. Two more circles of the same size are marked on each of the sidelines of the test field, with a distance from the end line of 1 metre and 3 metres on one side, and 2 metres and 4 metres on the other side. One of the end circles is empty and is used as the starting point. A cylindrical wooden block, with a diameter of 8 cm and a height of 4 cm, and weighing 134 grams, is placed in the centre of the other five circles (60) (see Figure 1). The test person starts in the empty circle at one of the short sides of the test field and the test starts when the participant first lifts one foot from the start circle. The instruction is to do the test in fast walking, criss-crossing from circle to circle and in each trial using the same foot to shove the blocks out of the circles. The test ends when the last block is shoved out of the end circle. The SSST was performed in four trials, and the mean value of these was...
calculated; two trials for shoving with the paretic and two for shoving with the non-paretic limb (60). The SSST had not been validated for stroke previously (Studies III and IV).

![Figure 1. Schematic overview of the Six-Spot Step Test (SSST) test field](image)

**Walking endurance**

**Six-minute walk test:** The 6-minute walk test is a measure of walking endurance that has been found to be valid and reliable in persons with stroke (48). In the 6-minute walk test in this study, the person walked during 6 minutes and the distance in metres was recorded. A track lap of 30 metres, with every third metre marked, was used (Study I).

**Balance confidence**

**Activities-specific Balance Confidence scale:** The ABC scale is a patient-reported questionnaire that assesses self-rated balance confidence when performing daily activities (51, 78). The ABC scale has been found to be valid and reliable in persons with stroke (79). A validated Swedish version of the ABC scale was used (79). Using an 11-point scale, the participants reported how safe and secure they felt when performing 16 different indoor and outdoor activities, ranging from 0% = not at all safe and secure, to 100% = completely safe and secure. The item scores were summarized and then divided by 16 (the number of items) (Studies I, III and IV).
Quality of life

Short Form 36: Subjective mental and physical perceived health status was measured using the Swedish version of the Short Form 36 (SF-36) Health Survey questionnaire (80, 81). The SF-36 contains 36 questions grouped into eight health domain scales. Two aggregated summary scores were calculated, the physical component summary score and the mental component summary score. A higher score indicates better subjective health status (Study I).

Data collection

In all the studies the data were collected in a consistent order, starting with background variables such as demographic characteristics, then progressing to use of walking aids, and self-reported number of falls during the last 3 months.

Study I: In Study I, data collection took place at four health care centres from October 2011 to December 2012 and was performed by four clinically experienced physiotherapists. The follow-up tests were conducted 1 and 6 weeks after the intervention period (9 and 14 weeks post-baseline, respectively). All measures were performed in a standardized order and if walking aids were used, they were used during all test occasions. The same physiotherapists performed the pre-, post- and the follow-up testing using the BBS, TUG test, TUG cognitive test, 6-minute walk test and TST. The ABC scale and SF-36 were completed by the participants.

Study II: In Study II the individual semi-structured interviews (82) with the participants took place at the participants’ respective health care centre about 1 week after the intervention ended, from December 2011 to January 2013. The doctoral student (M.L.A.L.) conducted all the interviews. An interview guide was used, covering experiences of changes in the body, balance and daily living, as well as reflections on the structure and content of the intervention. The interviews lasted between 10 and 40 minutes. For practical reasons, the four physiotherapists were interviewed in pairs. The same interview guide as used for the participants was used for the physiotherapists. The interviews were conducted by the doctoral student (M.L.A.L.) and a second author (A.F.), and lasted approximately
1.5 hours each. All interviews were audio-recorded digitally and transcribed verbatim.

**Study III:** The data collection took place at five primary health care centres in Örebro county in Sweden from June 2014 until November 2015. The tests were performed by five physiotherapists specialized in neurological physiotherapy, including the author, M.L.A.L., performing 70% of the data collection. The tests were performed on two occasions, 3–7 days apart. The tests were performed in a standardized order, starting with the ABC scale, followed by the TST, the FSST, the DGI, the TUG test and, finally, the SSST. To keep all conditions as stable as possible, the same physiotherapist performed the tests on both occasions, at the same location in an ordinary hallway at the primary health care centres, and at around the same time of the day. If the person needed a walking aid, it was used during both test occasions. At the first test occasion all balance and walking tests were performed; on the second test occasion only the SSST was performed. The participants were instructed not to change their activity habits between the two test occasions. During the tests they wore comfortable shoes and if necessary they could rest between the measures.

**Study IV:** Data were collected in Örebro County from October 2016 to January 2017. The data collection was conducted at a place chosen by the participants, in the participants’ home (n=16) or at their health care centre (n=3). The data consisted of qualitative interviews and data from measurement of balance using the SSST and the ABC scale. All data were collected on the same occasion, starting with the interview. The semi-structured individual interviews started with a broad initial question, followed by more specific questions based on the study’s aim (68). The participants were asked to describe their experience of balance and balance impairment in their everyday life, including strategies to handle situations that challenged balance control, and how impaired balance affected their life. The doctoral student (M.L.A.L.) conducted the data collection. The interviews took 20–60 minutes, and all interviews were audio-recorded digitally and transcribed verbatim. One pilot interview was performed to test the procedure. The pilot interview was not included in the total sample.
Data analysis

For the statistical analyses, SPSS version 21.0 and 22.0 (IBM Corp, Armonk, NY, USA) and SAS version 9 (SAS, Cary, NC, USA) were used. To present baseline characteristics and results of the outcome measures, descriptive statistics with mean, standard deviation (SD), minimum and maximum for continuous variables, and number and percentage for categorical variables were used. The confidence interval was 95% and the level of significance was set at 0.05.

In Study I intention-to-treat analysis was performed, with data from the last test carried forward. Differences between the intervention and control groups were analysed using independent sample t-test. Paired sample t-test was used to investigate changes within the groups: from baseline at week 0 to follow-up at week 9, and from baseline at week 0 to follow-up at week 12–14.

In Study II a qualitative content analysis was performed using an inductive approach. Both manifest and latent content analysis were performed (83). The analysis was conducted using the software program Microsoft Word. The physiotherapists’ and patients’ interviews were analysed separately in the manifest analysis until the preliminary categories were identified. The preliminary categories from the respective data sets were then merged based on common content, and abstracted into six categories and one joint theme covering the content from the perspectives of both the patients and the physiotherapists.
The analysis steps, described in greater detail, were:

Manifest analysis (analysis close to the text):
1. The text was read through and listened to several times by the authors.
2. Meaning units were identified.
3. Each meaning unit was condensed and labelled with a code, while still preserving the core meaning.
4. The codes were sorted and abstracted into preliminary categories, illustrating the manifest content of the data.
5. The preliminary categories identified from the analyses of the physiotherapists’ and patients’ interviews were merged, based on common content, and abstracted into categories.

Latent analysis (interpretation of the underlying meaning):
6. The categories were reflected on, discussed, and either changed or retained. The aim was to identify and formulate an underlying theme combining the different parts into a whole.

In Study III, to evaluate the convergent validity between the first test session of the SSST and the other measures, Spearman’s and Pearson’s correlation coefficients were calculated with correlation coefficients <0.30 interpreted as weak, 0.30–0.59 as moderate, and ≥0.60 as strong (84). Evaluation of validity includes defining the extent to which an instrument measures what it intended to measure (85); convergent validity means that two measures are believed to reflect the same phenomenon while discriminant validity reflects measures that are believed to assess different characteristics (85).

Reliability testing by definition includes evaluating reproducibility of values of a test in repeated trials in the same individual(s) (67). To fully assess the reliability of a measurement tool, several statistical methods are needed (86). The intraclass correlation coefficient (ICC) is one (87). The ICC reflects the agreement between two measurements. Here, ICC_{2,1} was used since this also provided the basis for the calculations of the standard error of the measurement (SEM).
The SEM and the smallest real difference (SRD) are other statistical methods used. The SEM is calculated as the square root of the within-subject mean square error from the analysis of variance (67, 88). The SEM% indicates measurement error independent of the units of the measurement. The SEM% represents the limit for the smallest change that indicates a real change for a group of individuals. To define the limit for the smallest change that indicates a real change for a single individual, the SRD (89) was used. Also, the SRD can be divided by the mean of the measurements and multiplied by 100, to give a percentage value (SRD%) (59, 86). Wilcoxon’s signed-rank test was used for analysis of systematic changes between the repeated measures. A Bland-Altman plot was used to visually present the data (90). Bland-Altman plots are useful for determining whether the difference between the measurements is dependent on the mean of the measurements. The possibility of heteroscedasticity can be addressed by performing the Pearson’s correlations coefficient test between the mean and the absolute difference between test 2 and test 1 and the mean values of the two sessions (91, 92). An outlier was considered to be present when the difference between the two tests sessions exceeded 2 SDs.

In **Study IV** the qualitative and the quantitative data were analysed separately (68, 93). The qualitative analysis was performed using the software program NVivo 11 (QSR International, Victoria, Australia), using an inductive qualitative content analysis. The analysis covered both the manifest and the latent content (83). The analysis in Study IV was performed in the same stepwise order as in Study II up to step 4. In Study IV a latent analysis was performed as the next step and in the latent analysis the categories were reflected on in order to identify underlying themes combining the parts into a whole. Two themes were finally identified, reflecting the interpretation of the underlying meaning.

For the statistical analyses, SPSS version 22.0 (IBM Corp, Armonk, NY, USA) was used. The results together with the baseline characteristics were presented by descriptive statistics, median, mean, SD and percentages.

The mixed analysis was performed in a stepwise procedure (see Figure 2). The qualitative and quantitative data were first separately analysed. In the final step, using the qualitative categories as the starting point, an overall interpretation of any emerging pattern was performed, by adding
quantitative data into a joint display with the categories. The median SSST and ABC outcome for the individuals represented in each category were calculated, to determine whether there were any visible patterns emerging from the data. In this step, by going beyond numbers and allowing the results from the different data sets to complement each other a mixed result emerged.

Figure 2. Overview of the stepwise procedure in Study IV
ETHICAL CONSIDERATIONS

All four studies (I–IV) have been approved by the Regional Ethical Review Board, Uppsala, Sweden (Studies I–II: 2011/085, Study III: 2014/058, Study IV: 2016/307 and 2016/307-1). Study I was registered in the Clinical Trials Database (NCT01613339). All studies were conducted according to the tenets of the Declaration of Helsinki regarding ethical principles for medical research (94, 95).

All participants received both verbal and written information about the respective study, and gave a written consent. In Studies I–III the participants were a convenience sample of persons with stroke visiting the primary health care centre. They were recruited by physiotherapists with experience in neurological stroke rehabilitation. The doctoral student (M.L.A.L) worked part-time at one of the primary health care centres but had no ongoing professional contact with any of the participants. Participants in Study IV were identified from the Swedish Stroke Register (Riksstroke) and were contacted by mail and phone and had no earlier contact with the physiotherapist responsible for the recruitment. It is possible that persons who frequently visited the primary health care centre may have felt obliged to participate in the studies. For this reason, all persons were assured by the physiotherapist responsible for the recruitment that participation was voluntary, that they could leave the study at any time without giving any reason and that participation in the study did not affect other therapy at the primary health care centre (94).

One ethical consideration is that performing a balance test might bring the fact of impaired balance back to the person’s mind. Other aspects that could have impact on the persons mind is the interview sessions. Therefore in Studies II and IV the persons had the opportunity to choose the interview location and determine where they would take the balance tests. If the interview session or the balance measure recalled any negative feelings or any concerns related to the study they could contact the author at any time. The author could help arrange for participants to get psychological help if needed. None of the participants in any study reported any negative aspects or asked for further help.

Further, since all of the participants had impaired balance there was a risk for accidental falls when performing the balance measures. The balance
measures in the studies were, however, measures usually performed in clinical practice and the physiotherapists responsible for the data collection were used to applying these tests.

In order to preserve confidentiality, all data and interview transcripts were provided with a code and no unauthorized persons had access to information about the participants. The data have been confidentially handled and are presented separately for each group. In the qualitative studies we have coded citations and have here cited them verbatim (96).
RESULTS

Study I. Body Awareness Therapy in persons with stroke: a pilot randomized controlled trial

There were no significant differences in outcome measures over time between the intervention group and the control group. Within the intervention group, significant differences were found between the baseline test and the follow-up test at week 9 for the BBS, where the mean change in the intervention group was 3.6 points and in the control group 0.9; and at week 14, where a mean change of 3.6 points was measured in the intervention group versus 1.3 points in the control group. Significant differences were also found within the intervention group at follow-up week 9 for the TUG cognitive test and the 6-minute walk test, and at week 14 for the TUG cognitive test. Within the control group, significant improvements were found between baseline and the follow-up test at week 14 for the TUG cognitive test and the modified TST.

Study II. Body Awareness Therapy for patients with stroke: experiences among participating patients and physiotherapists

An overall theme, “Simple yet challenging”, emerged from the latent content analysis of the six categories, figure 3. The word “simple” describes small movements and simple exercises which everyone was able to participate in, regardless of functional status. “Simple” also illustrates the fact that no special equipment was needed. On the other hand, it was “challenging” for the patients who had physical impairments post-stroke, to face their limitations when performing the balance movements. It was also a challenge to be aware of and contemplate their bodies, and to mentally concentrate and stay focused.
Both patients and physiotherapists described changes after the BAT intervention. Changes such as improved balance were reported by patients and physiotherapists alike. Some patients reported less use of walking aids and several said that after the intervention they were able to walk longer distances, and had better posture. Improved balance in many ways led to increased self-confidence. For example, one patient reported taking the step towards walking in open spaces with no support. The patients expressed that the movements and the way of thinking in BAT were useful in everyday life. Several described using the weight shifting movements to place weight on both sides of the body. Almost all the patients reported that BAT left them with a general positive feeling and with an increased sense of wellbeing and peacefulness in their bodies. The physiotherapists agreed with the patients regarding the patients’ wellbeing and peacefulness. On the other hand, the intervention brought certain challenges. One of these, which was mentioned by both physiotherapists and patients, was related to concentration. Some participants were frustrated at not being aware of or able to feel certain parts of the body because of the effects of stroke; according to the physiotherapists, needing to deal with these frustrations was challenging.
Under the category “Integrated knowledge” (Figure 3) both the patients and the physiotherapists expressed that the movements were useful in everyday life, as expressed in the quotations below.

... I think it’s an excellent complement [to regular training] ... certain things that I feel are clearly going to be useful to me at home ... Not all of the exercises, but ... the thing about walking ... when I walk, how I should hold myself so that I can ... relax and feel, how can I say this, the weight or the balance, if you can call it that ... just the bit about ... how I should position my body – how straight I am, if I am straight, left and right sides ... I try to equalize the pressure on each side, if I can put it that way. Because it’s often been one side that has had to bear most of the load ... (Participant 21)

... he found he could concentrate, he could use [the exercises] in his daily life to reduce his spasticity ... (Physiotherapist)

**Study III. Validity and test-retest reliability of the Six-Spot Step Test in persons after stroke**

The SSST demonstrated strong convergent validity with the TUG test, DGI and FSST, and moderate convergent validity with the TST and the ABC scale (Table 2). Table 3 presents the mean values from the two test sessions of the SSST. Participants walked significantly faster while shoving the blocks with their non-paretic leg. Thirty-one participants (38%) used one or two canes or crutches to perform all tests.

The mean difference between the first and the second test was about 1 second (Figure 4) (Table 3). The Bland-Altman plot gives more values under the line than above, illustrating a better performance in the second test, where 57 (70%) of the participants improved on their performance in test 2 (Figure 4). The plot also shows that the intra-individual SD increased with increased time taken to perform the SSST (Figure 3). Indications of heteroscedasticity, with larger variability for higher test values, were also seen in the plot. Pearson’s correlation coefficient for the absolute difference between test 2 and 1 and the mean of the two sessions was 0.70. One outlier was found (Figure 4), and after it had been removed, heteroscedasticity diminished to a value of 0.60. The test-retest results of the SSST are presented in Table 3. The ICC values for the SSST ranged from 0.93 to 0.96. The SEM% values ranged between 14.7%
and 20.0%. The SRD% values ranged between 40.8% and 55.4%; the lowest value is based on the mean of the four trials on the SSST (Table 2).

Table 2 Correlations between the Six-Spot Step Test (SSST) and the other tests, using Pearson’s correlation coefficient for timed measures and Spearman’s correlations for rating scales

<table>
<thead>
<tr>
<th>Test</th>
<th>Correlation coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timed Up and Go (TUG) test, seconds</td>
<td>0.918</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Four Square Step Test (FSST), seconds</td>
<td>0.857</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Timed Stands Test (TST), seconds</td>
<td>0.568</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dynamic Gait Index (DGI), points (0–24)</td>
<td>-0.832</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Activities-specific Balance Confidence (ABC) scale, %</td>
<td>-0.596</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
### Table 3 Results of the Six-Spot Step Test (SSST) n=81 performed on two test occasions and showing scores for shoving with the paretic versus the non-paretic limb, and the test-retest results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Occasion 1</th>
<th>Occasion 2</th>
<th>Difference test 2-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean time</td>
<td>Mean time</td>
<td>Mean (SD) Limits of</td>
</tr>
<tr>
<td></td>
<td>(SD), (SD),</td>
<td>(SD), (SD),</td>
<td>agreement</td>
</tr>
<tr>
<td></td>
<td>seconds/</td>
<td>seconds/</td>
<td>Median</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>Median</td>
<td>(min; max)</td>
</tr>
<tr>
<td>Mean of four SSST measures</td>
<td>23.7 (15.8)/</td>
<td>22.7 (17.7)/</td>
<td>Mean (SD) Limits of</td>
</tr>
<tr>
<td></td>
<td>17.1</td>
<td>16.1</td>
<td>agreement</td>
</tr>
<tr>
<td></td>
<td>(9.1; 85.6)</td>
<td>(8.6; 96.4)</td>
<td>Median</td>
</tr>
<tr>
<td>Mean of two measures shoving with the paretic limb</td>
<td>25.0 (16.8)/</td>
<td>24.1 (19.8)/</td>
<td>Mean (SD) Limits of</td>
</tr>
<tr>
<td></td>
<td>18.0</td>
<td>16.7</td>
<td>agreement</td>
</tr>
<tr>
<td></td>
<td>(8.9; 86.8)</td>
<td>(9.3; 106.5)</td>
<td>Median</td>
</tr>
<tr>
<td>Mean of two measures shoving with the non-paretic limb</td>
<td>22.4 (15.6)/</td>
<td>21.4 (16.1)/</td>
<td>Mean (SD) Limits of</td>
</tr>
<tr>
<td></td>
<td>16.6</td>
<td>16.0</td>
<td>agreement</td>
</tr>
<tr>
<td></td>
<td>(8.7; 98.7)</td>
<td>(7.8; 87.2)</td>
<td>Median</td>
</tr>
<tr>
<td>Difference of shoving between the paretic and the non-paretic limbs</td>
<td>2.6 (7.3)/</td>
<td>2.7 (6.9)/</td>
<td>Mean (SD) Limits of</td>
</tr>
<tr>
<td></td>
<td>1.4</td>
<td>0.99</td>
<td>agreement</td>
</tr>
<tr>
<td></td>
<td>(-26.2; 24.6)</td>
<td>(-21.9; 31.5)</td>
<td>Median</td>
</tr>
</tbody>
</table>

CI = confidence interval; ICC$_{2,1}$ = intraclass correlation coefficient; SEM = standard error of measurement; SEM% = standard error of measurement, in per cent values; SRD = smallest real difference; SRD% = smallest real difference
**Figure 4** Bland-Altman plot showing the mean time (in seconds) achieved in test 1 and test 2. Dotted lines represent means (bold dotted line) and limits of agreement (light dotted line).
Study IV. “I can still manage” – a mixed method study of balance after stroke

All participants experienced the balance limitations as a continuous challenge in everyday life, yet they also felt trust and confidence. Two themes, “Feeling dizzy and unstable is a continuous challenge” and “Feeling trust and confidence despite dizziness and unsteadiness” and seven categories emerged from the latent analysis of the interview data. Both themes illustrate that the impaired balance caused feelings of dizziness and unsteadiness.

The first theme, “Feeling dizzy and unstable is a continuous challenge”, contains the participants’ descriptions of balance as a constant feeling of dizziness and unsteadiness. Muscle weakness was expressed as limiting balance in daily life and this caused feelings of anxiety, insecurity and frustration. For many, the balance limitations became more prominent in the dark. The first theme also contains descriptions of the dependence on physical support and the experience that everything took a lot of time.

“...I don’t take long walks nowadays...I feel a little wobbly...because of that ‘balance business.’” (Participant 2)

“...get dressed, but it takes so much more time than what it used to take...Things that used to be practically automatic now take time.” (Participant 17)

In the second theme, “Feeling trust and confidence despite dizziness and unsteadiness”, the participants described their capacities and feelings of confidence about still being able to do things themselves in spite of their balance impairment. Balance in everyday life was limited, yet the participants were, to a varying degree, active in social activities. They described having accepted their new life situation and said they were confident in their ability to manage their everyday activities.

“... they help me, they do, but that...I’m stubborn person and I want to manage on my own for as long as I can...”(Participant 11)

“...You can’t say there have been problems; rather...small challenges have arisen, but nothing so significant that I was not able to deal with it.”(Participant 17)
Results for the quantitative measures were: a median time of 20.24 seconds (range 8.9–113.3) for the SSST, and a median score of 67.5 (range 29–98) in the ABC scale.

The mixed results illustrating that almost all participants are represented in every qualitative category. There was no explicit association between those scoring low on the ABC test and/or walking slowly in the SSST, and the categories representing experiences of limitations, nor between those scoring higher, walking faster and categories not showing limitations. The different data sets provide different, somewhat complementary and confirmatory information on balance. The mixed results illustrate that impaired balance can be experienced as a challenge and, at the same time, that the individual can feel trust and confidence, no matter how they score on the ABC scale or perform on the SSST.
DISCUSSION

Results summary
The overall aim of this thesis was to investigate different aspects of balance after stroke, in terms of exercises, experiences and measurements. The first two studies evaluated using BAT in people with stroke. In the RCT no significant differences over time were found between the intervention group after 8 sessions of BAT and the controls. In the qualitative evaluation the participants who had been included in the intervention group described that exercising with BAT resulted in experience of improved balance, as well as a feeling of harmony. Also, they related that it was possible to integrate the BAT movements in their daily life.

The SSST showed strong convergent validity with other instruments of walking and high test-retest reliability. The mixed method results of a low to moderate self-rated balance confidence and slower performance in the walking test did not signify more negative experiences of balance. The qualitative data included participants’ descriptions of experience of dizziness and unsteadiness. Despite continuous challenges with balance, they were able to manage their everyday life and activities.

Body Awareness Therapy in persons with stroke
In the quantitative evaluation, there were no significant differences over time in any of the outcome measures between the groups. However, regarding the primary outcome measure in Study I, BBS score, we found a significant improvement over time in the intervention group compared with no improvement in the control group. To the best of our knowledge, only two other studies have applied BAT in persons with stroke. Recently Bang and Cho (97) presented an RCT evaluating the effects of BAT on balance performance in persons with chronic stroke, and Bang et al. presented another RCT on effect of BAT on visual spatial neglect in persons with acute stroke (98). In both studies 15–20 minutes of BAT had been offered as an add-on therapy to walking or task-oriented training (97, 98). Of the two, the sample with chronic stroke were the most comparable to our sample. In that small study twelve persons with chronic stroke were randomized to 20 minutes of BAT and 30 minutes of walking training, five times a week, for 4 weeks. The control group received
walking training for 30 minutes, five times a week, for 4 weeks. Bang and Cho present significant between-group differences on BBS and TUG results (97).

There are both differences and similarities between the study by Bang et al (97) and Study I in this thesis. The BAT intervention in both studies was based on the same framework of movements, but the intensity of BAT in Bang et al was much greater and their intervention consisted of both BAT and walking training. By contrast, in our Study I the intervention consisted only of BAT and the controls received no intervention. These studies together suggest that BAT can be used as a complement to physiotherapy but further studies are needed to evaluate the specific effects that BAT may have for patients with stroke, as well as which exercises are the most suitable and at what intensity. In studies including other patient groups, such as fibromyalgia patients (99) and transfemoral amputees (44), the intervention lasted much longer, namely, once a week for 3 months (99) and 10 months (44). Based on these studies it can be deduced that longer and more intensive interventions with BAT are optimal. On the other hand, all these studies have small patient samples and the results should be interpreted with care. There is no gold standard for what constitutes the most beneficial physiotherapeutic training for stroke patients (37). As BAT consists of simple, repetitive movements, with the aim of strengthening the person’s resources and finding a new attitude towards the body, it can be seen as a complement to balance training in persons with stroke.

In the qualitative study (Study II), exercising with BAT was described as simple yet challenging. The participants experienced that they had to face their limitations and explore stability limits in different positions, as well as using varying body weight distribution. We were not able to measure body weight distribution. In the study by Sjodahl et al in participants with transfemoral amputation, a more symmetric body weight distribution and less use of walking aids was reported (44). The authors used gait analysis and force plates to examine changes in the legs post-intervention (44). In future research in persons with stroke (a population who often experience difficulties with weight distribution), it would be interesting to use force plates when evaluating BAT.

In Study II both the patients and the physiotherapists were interviewed. The results showed that the narratives of the physiotherapists and the
participants were mostly similar. Despite some differences pertained to physiotherapists’ and patients’ perspectives of a physiotherapy session where both parties were involved. A physiotherapist’s perspective will probably reflect and be based on theoretical knowledge while patients’ perspectives are built on each individual’s previous life, habits and bodily experiences (100). In Study II, the physiotherapists’ narratives strengthened and confirmed the experiences of the persons with stroke. Both parties described that the movements had an impact on balance performance and also that the movements could be integrated in everyday life. Some also mentioned that they experienced increased self-confidence. Similar findings, with experience of better contact with the body, increased awareness of movement behaviour and changes in posture and balance, were also seen in persons with schizophrenia and their physiotherapists (42, 101). Feelings of harmony and a sense of wellbeing and peacefulness were reported by the patients in our study. The physiotherapists observed reduced tension in the patients, as well as new experiences of connecting with the body. Similar results have also been reported by Hedlund and Gyllensten (101) and Gyllensten et al (102) who studied experiences of BAT in schizophrenia populations.

In our study, BAT was described as mentally challenging by both the patients and the physiotherapists. In BAT, a patient has to listen to the body by focusing on both doing and what is experienced by the body. The physiotherapeutic focus in BAT is on resources, and not limitations (102). The patients expressed that it was a challenge to be focused and work through the mind, by thinking of and observing the body and being aware of both sides of the body. The physiotherapist confirmed this description and described the challenge of being the group leader when the participants had difficulty with concentration. A possible explanation for concentration difficulties could be cognitive deficits and difficulties with doing several things at the same time (8). Cognitive status and fatigue were not examined, which can be seen as limiting factors and important variables to consider in future studies.

What was highlighted by almost all participants was the value of being part of a group with other persons with stroke. Group activities are often seen as valuable (103) and the participants felt comfortable to share similar experiences and appreciated the opportunity to do so. Although no effects were identified in Study I, the positive experiences narrated by
participants in the qualitative study suggest further studies to evaluate BAT in stroke. Previously, positive effects and experiences of BAT have been presented in both qualitative and quantitative studies (42-45). Body Awareness Therapy gives the opportunity to focus on the body while performing weight shifts and rotations. An intervention in which BAT is combined with more stroke-specific movements such as stepping and walking tasks might be a good alternative for increasing balance performance in persons post-stroke.

Properties of the Six-Spot Step Test in persons with stroke

Balance deficits can be a continuous challenge for persons post-stroke, as can taking load on the hemiparetic leg (9, 17). This thesis investigated the psychometric properties of a measuring instrument, the SSST, which includes several components that may be challenging for people with hemiparesis after stroke. These components include dual tasks, such as weight shifts or kicking with one leg while walking, and also a cognitive component to plan the performance. Multiple tasks are often performed simultaneously in everyday activities. A measure that has a close relation to everyday life performance can be expressed as ecologically valid (104, 105). To improve balance, challenging dual-task exercises are preferred (106, 107), as plain walking might not be enough of a challenge (19).

In Study III in this thesis, the SSST showed strong convergent validity with the TUG test, the DGI and the FSST. Most previous studies of the SSST were performed in people with MS (60, 108-110). In a study by Fritz et al (108), a strong correlation between the SSST and the TUG has been shown. Tests involving longer distances, such as the 2-minute and 6-minute walk tests, have also been used in studies by Fritz et al (108) and Sandroff and colleagues (108, 110). Sandroff et al also showed moderate to strong correlation with balance confidence. They highlighted the novelty of the SSST as a measure of ambulatory function also including elements of balance confidence. In this thesis the SSST also showed moderate correlations with the ABC scale and therefore the SSST could give valuable information about feelings of confidence in ability to carry out activities at home and in the community, as assessed by the ABC scale. The correlation coefficients between the SSST and the FSST and the DGI indicate that the SSST can capture dynamic balance also in persons with stroke.
The ICC$_{2,1}$ values for the SSST in Study III in this thesis ranged from 0.93 to 0.96. In the study by Pavan et al, 75 persons with MS performed the retest after 2 hours with about the same median time in both tests and with an ICC at 0.98 (109). In the study by Nieuwenhuis et al, 41 persons performed the retest after 1–2 hours, with an ICC value of 0.95 (60). A difference between the MS studies and Study III in this thesis was the time between the test and the retest. In Study III the retest was performed after 3–7 days. This time limit was set to avoid a possible learning effect. The participants were instructed not to change their activity habits between the two test occasions and in persons who had their stroke onset more than 6 months previously no differences are to be expected in such a short time. In a study by Callesen et al (111) the retest was taken after 2 days, likewise showing high ICC values.

Based on the high SRD% and SEM% values in the present study, the most suitable way of applying the SSST is to calculate a person’s mean time for four trials during which they shove twice with each leg. This is how the SSST was applied in the original study by Nieuwenhuis et al (60) in people with MS.

Due to stroke deficits, persons with stroke often have a hemiparetic side (8). Therefore, in Study III the test-retest involved shoving with both the paretic and the non-paretic limb. The reliability values were high for both performances. Participants achieved a faster performance in the SSST when standing on their paretic leg while shoving the block with their non-paretic limb, compared with the opposite. The paretic limb often lacks strength and coordination and in our study population this might have made the test more challenging and slowed down the performance. Another possible explanation for a faster performance when shoving with the non-paretic side could be the possibility to take a quick step with that leg to restore balance after the kick.

The variability of within-subject measurements in our study showed limited sensitivity for detecting changes beyond the error threshold due to fairly high SEM% and SRD% values. There are no universally accepted limits for SEM% but Flansbjer et al (59) suggest that values ≤10% are clinically relevant with respect to sensitivity. When introducing a new
measurement it is important that it is valid and reliable in its context, as well as being usable.

The SSST was easy and quick to perform in the primary health care settings as in the home environment and the participants enjoyed the “game like” kicking in the test, as has also been reported in a previous study using the SSST (108). Based on the results of this study, the SSST is a valid measure of balance during walking; however, its sensitivity for capturing changes over time needs to be further evaluated.

**Living with balance limitations after stroke**

Having postural control is an interaction of the individual with the task to be done and the environment (19). To investigate these three perspectives of balance control we set up a mixed method study including a measure of balance during walking, assessment of balance confidence, and qualitative interviews. The participants described that despite the continuous balance challenges they were able to manage their lives. Have active coping strategies had previously been found to have a positive impact on quality of life after stroke (112, 113) and subjectively experienced wellbeing was seen to be related to the ability to manage the consequences of stroke (112). The results in the instruments testing balance during walking and balance confidence complemented the narratives in the interviews.

Several of our participants expressed that dizziness was a problem. This finding has also been reported in other studies and dizziness can be a barrier to community participation (64, 65). Balance and dizziness were experienced as a challenge when walking outdoors. However, walking outdoors was important to several participants. It was something they did every day, and it was a daily routine they did not want to miss. For others, it was more like training or part of activities such as going to the grocery store or to church. Outermans et al (62) described what keeps people after stroke from walking outdoors. They stated that outdoor walking is linked to the intention to walk, as well as to walking ability and the opportunity to walk (62). All these three factors related to outdoor walking were in a certain way also linked to the experience of balance in Study IV. In the narratives, experience of balance was closely related to the participants’ intention and to their attitudes to balance confidence. It was also related to their ability, in terms of functional impairments, and to the opportunity
they had, of carrying out activities such as visiting friends. Walking and balance seem to be close related, as also mentioned by Simpson et al (63). In the present study all participants were able to walk in the community; in future studies it would be interesting to investigate balance experiences in persons with greater walking limitations.

Experiences of balance also included feelings of fear of falling. To have something to grab on to, such as walking aids, another person or a wall, was expressed by several of the participants as giving feelings of safety. Feelings of fear of falling in relation to balance and walking are also mentioned by Simpson et al (63). In their study, fear of falling and losing balance was experienced as a barrier to exercise and community participation (63). Fear of falling is common among persons with stroke, and to help these persons to manage their fears related to falls it is suggested to talk about fear of falling (64). In this thesis the participants described fear of falling as a challenge; however, they said that they managed their life even despite this fear. In future research it would be of interest to establish which strategies can make persons with stroke feel in balance in relation to fear of falling.

The participants’ narratives and their scoring on the ABC scale were not always consistent. The participants had a median ABC score of 67.5%. In a study by Yiu et al, persons with stroke were reported to maintain lower balance confidence compared with controls for at least 12 months post-stroke (114). A balance confidence score of <80 indicates that there is room for improvement (78). Even though the participants in our study rated perceived balance confidence as low to moderate (67.5), they expressed feelings of acceptance, indicating that they had found solutions in their post-stroke life. These findings are similar to a study by Kubina et al (2013), in which persons with stroke highlighted the importance of being in charge of decisions and contributing in social relationships (115). To get a broader perspective, gain further knowledge and involve these persons in balance rehabilitation, a mix of measured balance, self-rated balance and asking the persons about experience of balance is preferred.
Methodological considerations

To meet the overall aim of this thesis, which includes both qualitative and quantitative studies. We have described and investigated balance from different perspectives such as exercise, measuring instruments and experiences.

Measurements

The included measurements were chosen for different reasons. The objective as well as the subjective measures covered the different types of balance: dynamic balance (e.g. balance while walking) and static balance. The instruments are often used in stroke rehabilitation. However, measures of cognitive functions and fatigue, if repeated, might have captured more subtle changes when evaluating BAT. A gait analysis with force plates might also have captured changes in balance performance. In Study III a cognitive test and a test screening for falls would have been valuable for testing the usability of SSST as a test in everyday life.

In Studies II and IV the data source was qualitative interviews. The credibility was strengthened by the fact that all the qualitative interviews were performed by the doctoral student (M.L.A.L), who is clinically experienced in balance and stroke rehabilitation. To increase dependability and ensure that all interviews concerned the same topics, interview guides were used in both studies (104).

Participants

Recruitment of the participants in Studies I–III was by convenience sampling of persons visiting the primary health care centre. Convenience sampling has limitations, such as that persons participating in clinical studies have volunteered to participate and are often positive towards the research and study method and motivated to improve, which may have influenced the results in these studies, and may therefore threaten the external validity. In Study I the participants were informed that they would be allocated to either the control or the intervention group. Some of the participants allocated to the control group expressed disappointment at not receiving the intervention and started exercising on their own. This may explain the improvement seen in some of the measures for the control group and, again, this constitutes a threat to the external validity (104).
In Study I it was considered reasonable to include 20 participants in each group because the study had an exploratory approach as BAT had not previously been used in persons with stroke. In Study II the sample size was based on the qualitative aim to achieve an in-depth understanding (83); also, it was aimed to include all participants from the intervention group in Study I. In Study III the sample size of 81 persons was selected based on recommendations in the literature (59, 66, 67). The sample size in Study IV was based on the mixed method procedure (93). Priority was given to the qualitative data (83) and it was intended that both qualitative and quantitative data should be from the same population (93), ending in a relatively small quantitative data collection.

Data collection

In all four studies the data collection was performed in a standardized order and the test protocol was followed carefully. In all studies the physiotherapists who participated in the data collection were specialized in neurological physiotherapy, with clinical experience in physiotherapy for patients with stroke. In Studies I and III, to strengthen the internal validity the physiotherapists were introduced to the study protocol, all the measuring instruments and the procedure. All conditions were kept as stable as possible. In Study I none of the physiotherapists performing the data collection participated in the intervention. They were not blinded, but they had no insight into the intervention. To increase the internal validity in Studies I and III, the same physiotherapists performed the retests, at the same location in an ordinary hallway at the primary health care centre, and around the same time of the day.

A limitation of Study I was that there was no reflection on the participants’ activity habits between the test occasions. The participants were instructed not to change their activity habits between the test occasions. However, just to be part of an intervention study can increase overall activity level. In future studies, using an activity log or diary or an activity bracelet would be valuable, to receive further knowledge on any side activities.

The intervention in Study I continued for 8 weeks. This time period was based on how physiotherapists in primary health care in the county usually conduct BAT, and was also selected for practical reasons such as
avoiding vacation periods and preventing high dropout rates. Longer interventions have been performed in one study by Gyllensten et al (41) and it is acknowledged that, to see changes over time, longer interventions may be needed. The selected movements were based on earlier BAT studies (39, 40) and the experience of the physiotherapists responsible for the intervention. All persons participating in the intervention in Study I, participated in the interviews in Study II. This can be seen as a strength; first, as both negative and positive experiences of BAT thus could be captured and, secondly, as the level of functioning after stroke differed between the individuals, a broad perspective of experiences could be reached.

Data analysis

In Study II, two out of the three authors (M.L.A.L) and (A.F) had a pre-understanding as physiotherapists in stroke rehabilitation, (A.A.C) is a registered nurse, experienced in qualitative methods. Studies III and IV also included a neurologist specialized in stroke (P.A). The mixed experience of the researchers may increase the credibility of the findings (116, 117) as it likely brought a broad perspective to the analysis. Throughout the qualitative analysis procedure, to support trustworthiness (83, 104, 116) the results were discussed and reflected on in a back and forth process and all authors were engaged in the data analysis in various steps. The analysis was performed in both the software programs Microsoft Word (Microsoft Corp., Seattle, WA, USA)’ and NVivo 11 (QSP International, Victoria, Australia). There are strengths and limitations with both. The analysis process is presented both in the text and in figures, with meaning units, categories and themes given. Quotes have been presented to support the text and further enhance the credibility of the study (83).
CONCLUSION

In summary, the pilot study evaluating effects of BAT in persons with stroke showed no significant differences in balance, mobility, balance confidence, and subjective health status after 8 weeks of BAT compared with an control group. According to the patients’ and physiotherapists’ narratives, exercising with BAT was simple but challenging. Experiences of improved balance as well as feelings of harmony were reported. However, further studies are needed to determine optimal intensity of intervention, exercises and outcome measures.

The SSST includes a weight shift in combination with a dual-task activity during walking, thus being a challenging instrument for persons with balance impairment after stroke. The SSST showed strong convergent validity with other instruments of gait and balance. The findings in this study suggest that the SSST can be used as a complementary measure of walking balance in stroke rehabilitation although sensitivity to changes over time must be further investigated.

Persons with balance limitations after stroke related that they were able to manage their life, although this could at times be challenging. Evaluation of balance during walking and self-rated balance confidence complemented the subjective narratives of living with balance limitations. The participants related that everyday life was challenged by the continuous feeling of dizziness and instability.
Clinical implications

- Body Awareness Therapy can be a complement in physiotherapeutic stroke rehabilitation; however, further studies are needed to establish optimal intensity and length of the therapy, as well as determine outcome measures.

- Body Awareness Therapy includes simple but challenging exercises that can be individually adjusted and are possible to perform for persons who have had a stroke.

- The Six-spot Step test can be a complementary measure of walking balance in stroke rehabilitation. It includes a dual-task activity and also has a game like aspect.

- To get a fuller picture of balance and an assessment of balance among persons who have had a stroke, perceived and measured balance can give valuable information. However, for an accurate description, this information should be complemented by asking these persons about their experiences and challenges.

Det övergripande syftet i doktorandprojektet var att undersöka och beskriva olika aspekter av balans hos personer som fått en stroke; avseende träning, mätinstrument, och upplevd balans. I Studie I undersöktes effekter av basal kroppskännedomsträning, i syfte att träna balans. Det är en metod som tidigare inte använts i behandling personer med stroke. Basal kroppskännedom är en metod med enkla rörelseövningar med fokus på rörelsekvalitet, kroppsmedvetenhet och rörelsebeteende. Centralt är att hitta en inre mittlinje i kroppen och utföra olika övningar som t.ex. tyngdöverföringar, hållningsövningar, rotationer runt mittlinjen och samtidigt ha en fri andning. Av de 46 personer som tackat ja att delta i studien lottades 24 till träningsgrupp...
personer med stroke, resultaten kompletterade varandra, några bekräftade varandra, men inga resultat var direkt motsägelsefulla. Ett genomgående mönster i alla kategorier var att nästan alla personer var representerade i alla kategorier.

Genom att använda olika datainsamlingsmetoder så har i avhandlingen framkommit olika aspekter på balans. Träning med basal kroppskännedom i 8 veckor gav ingen statistisk säkerställd skillnad gällande balansförmåga mellan grupperna. Personerna med stroke och fysioterapeuterna beskrev att balansen utmanades av basal kroppskännedom och att träningen gav möjligheter till att reflektera över kroppen och dess funktion. För personer med stroke så hade SSST ha god validitet och reliabilitet med en begränsad känslighet vid upprepade måtningar. Personerna med stroke upplevde att balansen var en utmaning men att de lyckades hantera sitt vardagliga liv. Den objektiva och den självskattade balansmätningen kompletterade den subjektiva upplevelsen att leva med balans nedsättning.
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