EFFICACY OF PASSIVE REHABILITATION INTERVENTIONS FOR THE HEMIPLEGIC SHOULDER IN STROKE PATIENTS WITH SEVERE UPPER LIMB IMPAIRMENT

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Efficacy of passive rehabilitation interventions for the hemiplegic shoulder in stroke patients with severe upper limb impairment

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Voor Linde

"Always go with the choice that scares you the most, because that's the one that is going to help you grow"

-Caroline Myss

TABLE OF CONTENTS

General Introduction 1

Stroke and the hemiplegic upper limb

The hemiplegic shoulder

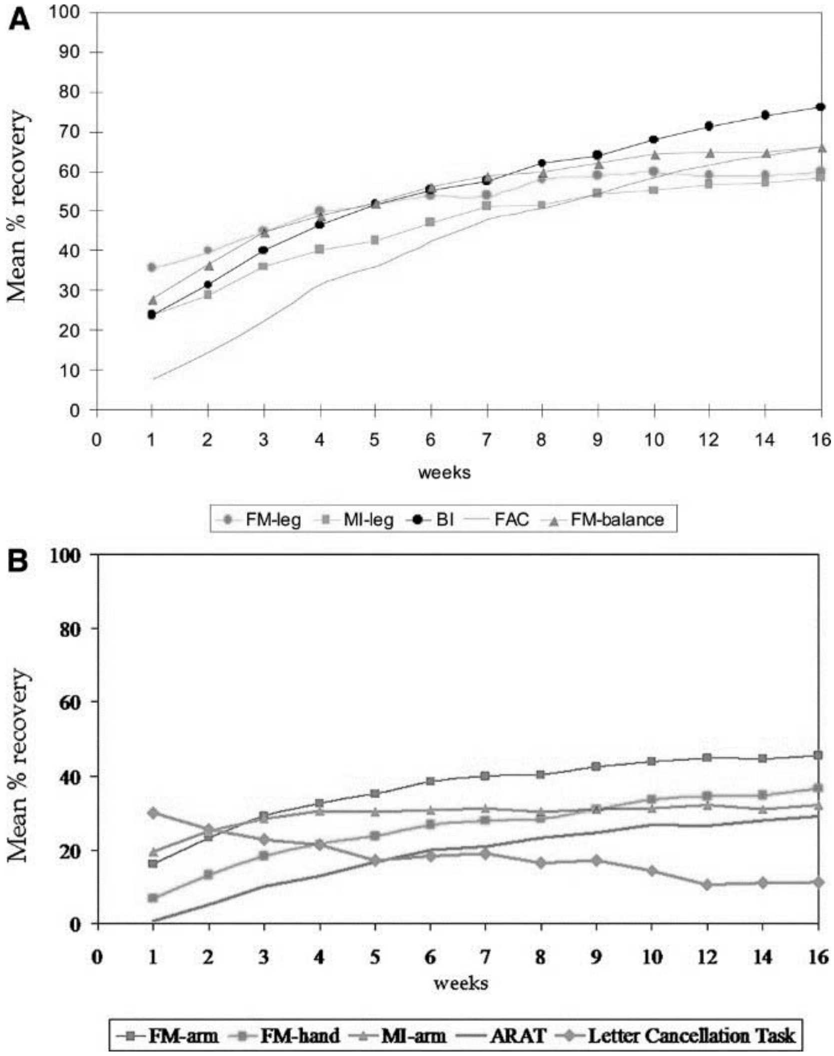
Hemiplegic Shoulder Pain

Objectives and thesis outline

1. Stroke and the hemiplegic upper limb

The World Health Organization defines a stroke as "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 of vascular origin" [1]. Worldwide, stroke is an important cause of death and one of the main reasons of acquired disabilities in adults. In Belgium, each year 200-230 per 100.000 inhabitants suffer a new stroke [2]. Annually 9501 people in Belgium die as a consequence of stroke [3]. Because of the recent developments in medical management of stroke, most people survive the initial phase after stroke [4]. However, stroke survivors are confronted with a quite challenging and long period of functional recovery. They have to deal with and adapt to a wide variety of disabilities which all may have a great impact on their functional performance, independence and quality of life (QoL). These disabilities can include motor impairments (e.g. paresis, spasticity), pain, psychosocial deficits (e.g. cognitive impairments, depression, social isolation), language and/or speech problems [5]. Stroke recovery is difficult to predict and has a heterogeneous character [4, 6]. The most functional recovery occurs in the first 6 months after stroke (subacute phase). In the chronic phase after stroke (> 6 months after stroke onset) most patients' functional abilities stabilize. The eventual (or final) functional outcome depends on different factors such as the initial severity and location of the stroke, as well as the individual ability for neuroplasticity. The spontaneous neurologic recovery displays a nonlinear logarithmic pattern[7] presenting with the most improvement during the first three months [8]. The clinical ascertainment that the lower limb (LL) recovers more rapidly and to a greater extent than the upper limb (UL) could not be confirmed in the study of Kwakkel et al. (2006). Figure 1 displays the linear pattern of functional recovery of the UL, LL and activities of daily living (ADL). Although the mean percentage of functional recovery for the UL is obviously less compared to the mean percentage of functional recovery for the LL, no statistical difference was found [9]. Most patients (64%) regain an independent walking capacity (15/15 mobility item Barthel Index with or without walking aids or orthoses) at 6 months post stroke [10]. However, due to anatomical and physiological characteristics of the brain, the high demands to regain dexterity after stroke and the potential functional substitution by using the other arm in daily activities (learned non-use) the prognosis for the UL is less promising [11, 12]. Only 5-20% of the stroke patients with UL paresis achieve full functional recovery of the UL at 6 months post stroke [13], while 33-60% of the patients do not show any recovery of UL function [14].

Figure 1. Recovery patterns of lower limb, ADL's (A) and upper limb (B) as a function of time.



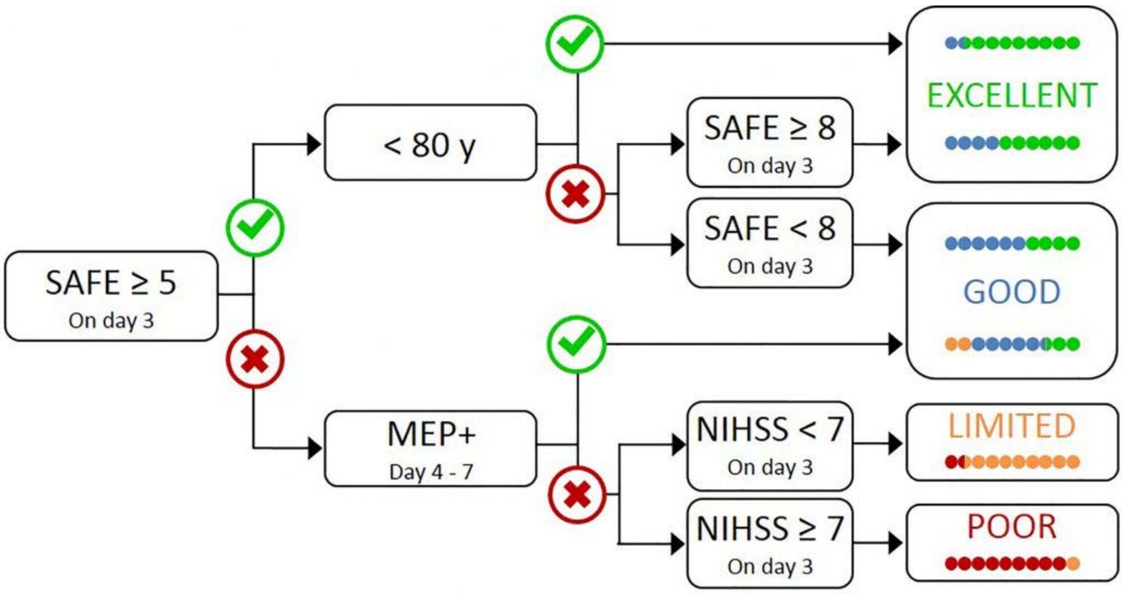
With permission from Kwakkel et al. Stroke 2006;37:2348-53 [9]

A. Mean standardized recovery patterns (percent of maximum attainable recovery) of the lower limb and ADLs as a function of time (n=101)

B. Mean standardized recovery pattern of the upper limb as a function of time (n=101)

According to the prognostic model of Nijland et al. (2010) functional recovery of the UL at 6 months post stroke can be predicted within 72 hours after stroke onset. Patients showing some finger extension (Fugl-Meyer Finger Extension item score ≥ 1) and shoulder abduction (Motricity Index Shoulder Abduction item score ≥ 9) on day 2 after stroke onset have 98% probability of achieving some dexterity (≥ 10/57 on the Action Research Arm Test) at 6 months. Patients who did not show this voluntary motor control only had a probability of 25% on regaining some dexterity [15]. Prabhakaran et al. (2008) suggest that spontaneous biological recovery, which occurs in the first 3 months after stroke, follows a proportional recovery rule. This rule suggests that the amount of spontaneous recovery of the upper limb accounts for approximately 70% of the patients' maximal potential recovery. Based on the FMUE score within the first 72h after stroke a prediction is made of the FMUE score at 3 months post stroke [16]. However, this rule is not applicable for all stroke patients. Patients with severe initial paresis show a smaller change in FMUE score than expected by the proportional recovery rule. These patients were identified by lower upper and lower extremity motor recovery scores (FMUE and FMLL), more neurological deficits (NIHSS) and suffered a more severe stroke (Bamford classification)[17]. It seems that only using clinical measures to predict motor recovery for all patients is inaccurate and that combinations of clinical assessments and biomarkers are necessary[18]. Cathy Stinear and colleagues (2012) developed the Predict Recovery Potential (PREP) algorithm, which combines clinical measures, transcranial magnetic stimulation (TMS) and diffusion weighted MRI in the first 3 days post stroke to predict the UL functional outcome at 3 months post stroke [19]. Because not all clinical settings have access to the equipment to evaluate the biomarkers. Stinear et al. (2017) recently developed a new algorithm that would be more accessible. The PREP2 algorithm (figure 2) predicts the outcome of the UL at 3 months post stroke based on the strength of shoulder abduction and finger extension (SAFE) scored on the Medical Research Council (MRC) grades combined with motor evoked potentials (MEP's) as a biomarker of corticospinal integrity and the NIHSS score as an indication of stroke severity [20]. The complete explanation of this model is however beyond the scope of this dissertation, but the model may indeed render interesting perspectives for future more stable outcome prognosis of the UL.

Figure 2. The PREP2 algorithm.



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The recovery of UL function has a great influence on the patients' QoL [21, 22]. Unfortunately, a very high degree of restored UL function is needed to persuade the patients to finally use their hemiplegic UL in activities of daily living (ADL) on a regular basis. In the study of Fleming et al. (2014) a score of ≥ 54/57 on the Action Research Arm Test (ARAT) was warranted to integrate the hemiplegic UL in daily living [23]. Notwithstanding the value of predictive tools toward gain in function, prediction of recovery of functional movement integrated in their daily living remains a great challenge [24].

Despite this rather negative prognostic context there are some arguments why it is important to implement UL rehabilitation from early after stroke, aiming to increase the probability of UL recovery. First, UL function is quite essential in view of independence in daily living [25]. Second, some patients do regain upper limb function after 6 months despite their initially poor prognosis in restoring capacity [15]. Therefore, Winters et al. (2016) recommend that monitoring of the prognostic factors is preferably extended up to 8 weeks post stroke [26]. Despite the value of these prognostic models there are still some doubts about their predictive accuracy and about generalization to the entire stroke population [25]. Third, initial dose and intensity of UL training often are insufficient to explore the maximal potential of the UL. In the first phase after stroke, training the UL might not be the first priority for therapists nor patients [27]. Therapists are discouraged by the poor UL prognosis [28, 29] and patients are hampered by the effort it takes to perform minimal activities with the hemiplegic arm or by the pain they might develop. Finally, recent findings ascertain improvements in coordination of joint movement and functional task performance, even in severely impaired stroke survivors, in the chronic phase after a stroke [30]. This ascertainment should encourage therapists to keep searching for the most effective strategies to provide therapy with sufficient intensity and dose for a given patient in order to maximize the potential of his or her UL recovery [11, 30]. Therefore, it is essential to understand the impairment-related challenges that the UL can pose after a stroke and how they affect the motor control.

The most common UL impairments after stroke include paresis, loss of fractionated movement, abnormal muscle tone and/or loss of somatosensation on the contralateral side of the brain lesion. These are the result of direct damage to the primary motor cortex, the primary somatosensory cortex, secondary sensorimotor cortical areas, subcortical structures and the corticospinal tract.

Paresis has the biggest contribution to UL dysfunction and can clinically result is a wide variety of symptoms including muscle weakness but also slower, less accurate and less efficient movement patterns [31]. Due to poor and slow progress, it may eventually lead to the development of learned non-use. The increasing immobility, which is the result of learned non-use, possibly renders various secondary complications like pain, contractures or secondary sensory loss [32]. This cascade can further inhibit the recovery of UL dexterity [12].

Loss of fractionated movement or the presence of movement synergies can be defined as a decreased ability to selectively activate muscles and limit independent control of single joints [31, 33]. Together with the appearance of spasticity the presence of these abnormal synergies leads to the development of compensatory movements [31, 32] resulting in a less efficient motor control.

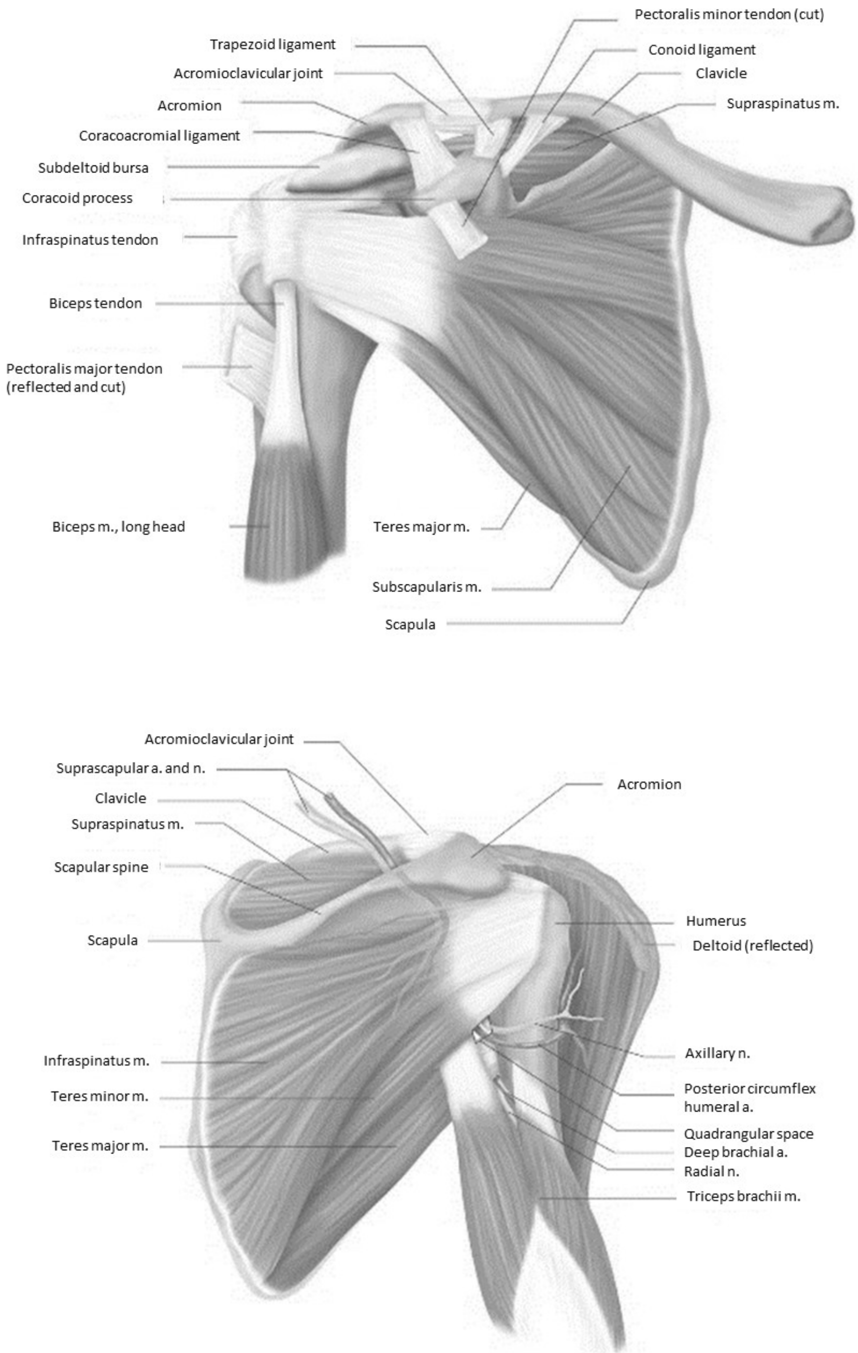
Although in stroke patients weakness and loss of control often are dissociable components, the weakness often predominates during the initial phase after stroke, whereas synergies become more prominent when time proceeds and the initial symmetrical weakness across flexors and extensors of the UL becomes more asymmetrical [34]. Recent studies suggest the contribution of the reticulospinal tract as the main provider of residual motor function in severe UL paresis as in these patients coupling of shoulder abduction and elbow flexion is prominent and power grip of the hand is often preserved [35-37].

All these impairments have a negative influence on the recovery of the UL and therefore hamper regaining shoulder stability after stroke. To understand the reasons why a poorly recovered UL may contribute to the development of hemiplegic shoulder pain (HSP) it is essential to understand the working mechanism of the shoulder joint and the changes related to stroke.

2. The hemiplegic shoulder

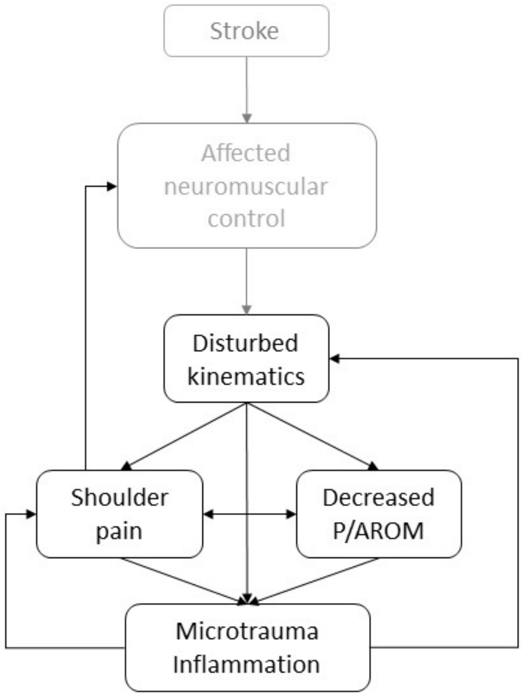
The glenohumeral joint is a ball-and-socket joint and is considered as the most mobile joint of the human body as a result of the relative small area of bony contact and the very loose joint capsule. Joint stability is secured by the surrounding muscles (figure 3) and capsuloligamentous structures. Other articulations forming the shoulder joint are the acromioclavicular joint, the sternoclavicular joint and the movement of the scapula on the thoracic wall. During humeral movements an adaptation of the scapular position is needed to maintain the scapulohumeral control. The rotator cuff muscles work together to contain the glenohumeral joint. As long as the force couple, arisen by the collaboration of subscapularis and infraspinatus muscles, is balanced the glenohumeral head can be centered. The rotator cuff muscles also play an important role in lowering the humeral head away from the acromion (tucking-in mechanism) to prevent impingement of the supraspinatus tendon between the acromion and humeral head. Other mechanisms to minimize the risk on developing impingement are the upward rotation of the scapula to elevate the coracoacromial arch and the rotation of the humerus to move the tubercles away from the coracoacromial arch. Most important muscles to preserve these mechanisms are serratus anterior and trapezius muscles for the scapular rotation, subscapularis muscle for internal rotation of the humerus during flexion of the arm and infraspinatus muscle for external rotation of the humerus during shoulder abduction [38].

Figure 3. Anterior (A) and posterior (B) view of the shoulder joint.



After a stroke many changes occur at the level of the shoulder joint due to impairments caused by the lesion of the central nervous system. These changes occur directly at the level of the shoulder joint itself but may also be influenced by stroke-mediated changes in the scapular position and trunk posture. The changes may occur in the flaccid as well as in the spastic stage after stroke and will disturb the normal alignment and biomechanics of the shoulder complex. Early after stroke, weakness of the shoulder muscles often results in an inferior glenohumeral subluxation [39-41] and the inadequate selective muscle activation affects the scapular and humeral movements [42, 43]. There have been several studies performed investigating the scapular movement during shoulder flexion in stroke patients [44, 45]. Stroke patients show a decrease of active shoulder flexion[44] and if they experience shoulder pain the humeral external rotation during this flexion is also decreased [45]. Concerning the scapular upward rotation movements some authors found an increased upward rotation of the scapula [44, 46-48] while others also found a decrease of upward rotation of the scapula in stroke patients [48]. Probably the differences are dependent on time post stroke, severity of the stroke and possible shoulder pain. Anyway, the disruption of the scapulohumeral rhythm, due to the reduced neural input, decreases the glenohumeral congruence. This results in an impaired length-tension relationship of the rotator cuff muscles inhibiting the external humeral rotation of the humerus during shoulder flexion and abduction [45]. In the subacute phase after stroke, emerging spasticity, may create an internal rotation of the shoulder joint also leading to impaired biomechanics of shoulder movements [49]. The shoulder muscles that are mostly involved in this spastic pattern are the pectoralis, subscapularis, teres major and latissimus dorsi muscles [50]. Additionally, any stroke-induced disturbance in trunk muscles may lead to an altered postural trunk alignment impeding the shoulder complex and therefore eventually creating an anterior glenohumeral subluxation [50]. All these changes generate an increasing risk on impingement that on its turn augments the potential hazard of creating pain. This pain may induce a vicious circle (figure 4) impeding antalgic use/movement creating a new opportunity to start inflammation or soft tissue injuries provoking again pain [49].

Figure 4. Vicious circle of disturbed kinematics and shoulder pain after stroke.



3. Hemiplegic Shoulder Pain

3.1 Epidemiology

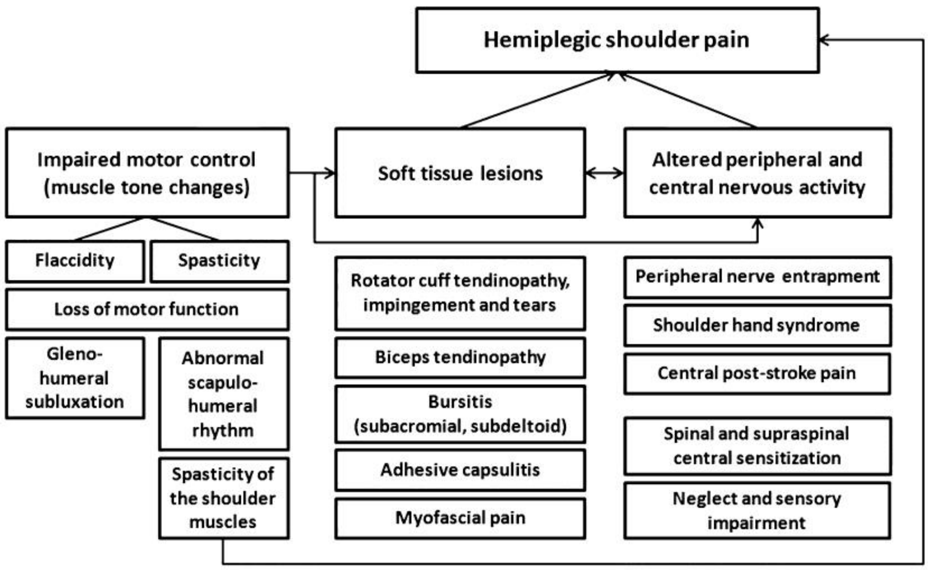
Hemiplegic shoulder pain (HSP) is, together with falls, depression and urinary tract infections, one of the most common complications after stroke [51]. The prevalence data of HSP vary from 5 to 84% depending on the selected study population, the time since stroke and on how HSP was defined and/or measured. The prevalence numbers described in the review of Kalichman et al. (2011) are 22-23% for the total stroke population (all stroke survivors with no subcategories of time since stroke, stroke severity, residency or housing,…) and 54-55% among stroke patients who follow therapy in rehabilitation settings [49, 52, 53].

HSP occurs mostly several weeks or months after stroke onset [54], but some patients experience pain around their hemiplegic shoulder even within the first 2 weeks post stroke [55, 56]. The peak incidence of pain is considered to be around 4 months post stroke [57, 58]. Often shoulder pain is esteemed to be self-limiting. Approximately 80% of the patients who developed shoulder pain in the study of Gamble et al. (2002) experienced a decrease or a resolution of shoulder pain during the study period of 6 months [58]. Although the prognosis of HSP seems to be good, it clearly has a negative effect on the rehabilitation of stroke patients in a crucial phase of recovery. With respect to this effect it should be stated that HSP is associated with reduced functional use of the UL [59], a longer hospital stay [59, 60], a decreased level of outcome [61-64] and a reduced QoL [65, 66]. Unfortunately, despite the progress on evidence-based stroke treatments in general, recent studies fail to show a specific reduction in the frequency of HSP [57, 66].

3.2 Underlying pathologies

Due to the complex anatomy and physiology of the shoulder joint, the causes of HSP are often multifactorial [60]: neurological, biomechanical or often a combination [50]. Regularly different underlying pathologies are present simultaneously, in combination or sequential in which one pathology may trigger another one [53]. Lo et al. (2003) identified in HSP four types of causes (frozen shoulder, rotator cuff tears, subluxation, shoulder-hand syndrome) and 11 possible combinations. In this study 63% of the patients had a single type of shoulder dysfunction, leaving 37% with 2 or more types of shoulder dysfunction present at the time of the investigation [67]. Depending on the time since stroke, different causes of HSP can predominate[68]. In the flaccid phase, early after stroke, weakness of the shoulder muscles undermines the protective stability mechanism of the shoulder joint increasing the risk on glenohumeral subluxation (GHS) and/or traction injuries of soft tissue. Afterwards, when spasticity develops, shortening of the soft tissues around the shoulder joint can cause shoulder pain as a result of altered biomechanics [64]. Figure 5 gives an overview of the possible causes of HSP.

Figure 5. Distribution of the causes of HSP.



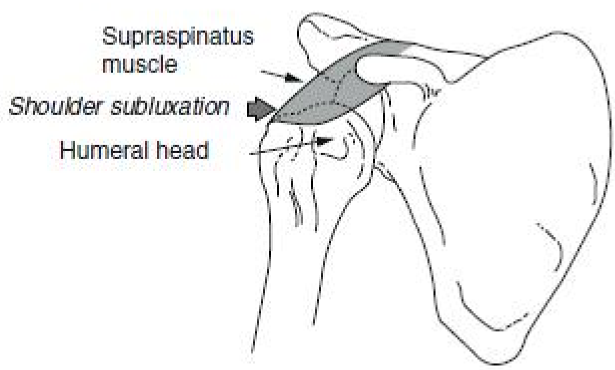
With permission from Kalichman et al. Am J Phys Med Rehabil. (2011) Sep;90(9):768-80 [53]

Glenohumeral Subluxation (GHS)

Due to the paresis of the proximal shoulder muscles (in particular supraspinatus and deltoid muscles) together with the gravitational pull on the paretic arm, mechanical integrity of the shoulder complex is hampered, resulting in a palpable gap between the inferior part of the acromion and the humerus [69, 70] (figure 6). This subluxation mostly develops during the first 3 weeks after stroke [71]. The prevalence of GHS in stroke patients varies from 17-66% [49, 71, 72]. This wide range can be explained by the different methods that are used to measure the GHS, the stroke severity of the included patients and the time-window post stroke assessment took place in[71, 73].

Although the causal relationship between the presence of GHS and HSP could not always be confirmed [60, 70, 74, 75], the increased presence of GHS in HSP-patients compared to patients without HSP has been described by several authors [60, 76-82]. The related pain is speculated to be secondary due to stretch on the capsule and surrounding structures [49, 60, 70] or to ischemia in the tendons of the supraspinatus muscle or long head of the biceps muscle over the sub-luxated joint. These speculations are supported by the fact that shoulder pain often develops later with respect to GHS [70]. When HSP is directly related to the GHS, pain occurs/increases when the hemiplegic arm is pendent and disappears/decreases when the joint congruence is restored [60]. It is known that patients with GHS have an increased risk of developing a shoulder-hand syndrome (SHS) [60] or rotator cuff injuries [68, 83]. Being a potential source of pain and/or invalidation consequences on the long term, prevention and treatment of GHS should be an essential part of the standard treatment protocol for stroke patients.

Figure 6. Inferior subluxation of the shoulder.



Murie-Fernandez et al. Neurologia 2012 May;27(4):234-44 [69]

Frozen Shoulder or Adhesive Capsulitis (AC)

Prolonged immobility after a stroke can lead to the development of a frozen shoulder or adhesive capsulitis (AC). AC is characterized by a very painful, impaired passive range of motion (PROM, especially in abduction and external rotation) of the shoulder [55]. The prevalence of AC among stroke survivors varies between 43-77% , depending on the selected population [63, 67, 72].

The causal relationship between HSP and AC can be bidirectional and become self-supportive. The presence of HSP may trigger the development of AC as a result of relative immobilization, atrophy, disuse and disability. AC – induced by paretic immobilization – can be very painful, again leading to immobilization. Therefore, maintaining a functional shoulder PROM should be one of the priorities of stroke management [55].

Soft-tissue injuries

Although soft tissue injuries also often occur in healthy people, the amount of such injuries in the hemiplegic shoulder is quite bigger compared to the non-hemiplegic shoulder [60, 84, 85] and to shoulders of healthy controls [86]. In stroke patients the movements that normally prevent impingement are impaired [55] increasing the risk of developing soft-tissue injuries after stroke onset [86]. Most often injuries occur at the biceps or supraspinatus tendons and around the bursa (glenohumeral – deltoid). The risk of developing soft tissue injuries is higher in people with low motor recovery [86, 87]. These patients receive more passive exercises and need more external forced manipulations during transfers and positioning, increasing the risk on developing traumatic soft tissue injuries [82, 87]. On the other hand, some authors state that, on the contrary, patients with good motor recovery have a greater risk on developing a traumatic tear of the rotator cuff and explain this by the increased risk on impingement during movements characterized by impaired stroke-mediated biomechanics [88].

Shoulder-hand syndrome (SHS)

Although the pathophysiology is not very clear [89] 23% of the stroke patients often complain of shoulder and wrist pain [90], clinically defined as SHS or complex regional pain syndrome (CRPS) [89, 91, 92]. Due to the paresis after stroke, the unstable shoulder and wrist are more prone to small repetitive trauma that may lead to soft-tissue injuries inducing SHS [91, 93]. Clinical symptoms can be classified in four categories: sensory symptoms (hyperesthesia, allodynia), vasomotor symptoms (temperature asymmetry, skin color changes), edema/sudomotor symptoms (asymmetric sweating changes) and motor/trophic symptoms (decreased PROM, motor dysfunction, trophic changes)[94]. Symptoms mostly appear between 2 weeks and 3 months after stroke onset [92, 95]. Prevention is based on recentralization of the glenohumeral joint and cautious joint mobilization [95]. Kondo et al. (2001) suggest that a passive mobilization with restriction of certain movements could help to prevent the development of SHS. In their protocol passive mobilization of shoulder abduction and flexion beyond 90° was not allowed, shoulder rotations were performed in the adducted position, only one finger joint (proximal or distal) was moved at a time, during finger flexion the wrist was supported in neutral position and during finger extension in flexed position. Mobilization was stopped immediately when patients complained of pain and resumed the day after [89].

Central post stroke shoulder pain

Although it is generally accepted that HSP is mainly caused by musculoskeletal changes, a musculoskeletal problem cannot always be directly correlated with HSP. An additional factor that might contribute to the presence of HSP is neuronal damage, especially in patients with late onset HSP [96, 97]. Several studies showed similarities between central mediated post stroke shoulder pain and HSP certifying the possibility that HSP might be a form of central neuropathic pain [58, 96, 98]. Symptoms of neuropathic origin that appear in patients with HSP are increased heat-pain threshold [96], decreased sensitivity to cold [58] and to light touch [58, 98]. Although this altered sensitivity was most of the times not limited only to the hemiplegic shoulder [97] patients often only complain of pain around the shoulder area [96]. Possible explanations are the extended cortical representation of the UL or the considerable influence of HSP on the patient's life, leading to an increased awareness of shoulder pain compared to other body parts [96]. If current treatment modalities of HSP are not satisfactory, pharmacotherapy for neuropathic pain (antidepressants, anticonvulsants) could be evaluated. However, further research on the effects on pain in HSP patients is necessary [96, 97].

3.3 Contributing factors

Knowledge about the contributing factors is essential to identify patients that are at higher risk of developing HSP. Regarding these factors not many consistent research conclusions can be drawn due to the inclusion of stroke patients in different stages of recovery and the use of different inclusion criteria or HSP-evaluation methods. Most common factors that have been examined are shoulder subluxation, spasticity, PROM limitation, poor UL recovery and impaired sensation [68]. Because the associations between HSP and possible risk factors depend on the time post stroke, Roosink et al. (2011) suggest that some risk factors contribute to the development of HSP while others are more involved in conservation of existing HSP. The contributing factors, most often mentioned in literature, are discussed below.

Age

Age can influence the development of HSP in two ways. Older persons have a higher risk of developing shoulder pain, independent of the stroke [40, 99]. They suffer from age-related changes and often have more comorbidities than younger people. As such, older stroke patients often have a lower functional level post stroke leading to an increased need of support generating an augmented risk of traumata during manipulative assistance they need when performing transfers and ADL [53, 60]. On the other hand, younger stroke patients may also have an increased risk on developing HSP based on the fact that they are more active under stroke-induced altered biomechanics and therefore apt of a greater chance on soft tissue injuries due to impingement [78, 81].

Side of hemiparesis and neglect

There are studies that show no correlation between HSP and the side of the hemiparesis [54, 60, 78] as well as studies that state that patients with a left hemiplegia have a higher risk of developing HSP [52, 72, 100, 101]. A possible reason for this side-preference is that more patients with a left-sided hemiparesis develop neglect increasing the risk on traumata [72, 73] and increasing the duration of immobilization due to the developed non-use [101]. However, attention should also be paid to patients with a right-sided hemiparesis, who often are not able to report shoulder pain due to language and/or speech problems [100].

Poor motor recovery

Low motor recovery of the UL increases the risk of developing HSP [60, 78, 81, 82]. Aside from the distinct muscle weakness, people with low motor recovery sustain also increased periods of immobility and require more help during transfers increasing the risk of manipulation-induced soft tissue injuries [102]. In the study of Aras et al. (2004) shoulder pain was significantly more present in patients with a lower Brunnstrom stage of recovery ($p = 0.004$) in the (sub)acute phase after stroke and significantly related to the flaccid stage after stroke ($p = 0.01$) [60]. Kim et al. (2013) also retrieved that an impaired UL motor function at the acute stage is an independent risk factor for HSP during the first 6 months after stroke [78]. Previously Lindgren et al. (2007) already described comparable findings [76]. Finally, patients with poor motor recovery of their UL are often confronted with sensory impairments and have an increased risk in developing GHS, two factors that contribute to the development of HSP.

Limited passive range of motion (PROM)

Shoulder pain has been associated with restricted external rotation [61, 73] and abduction of the shoulder both in the acute and chronic stage after stroke [60, 67, 68, 101, 103]. Reduced shoulder PROM is observed within the first weeks after stroke and increases with the time post stroke [104]. Lindgren et al. (2012) identified a significant correlation between restricted passive shoulder abduction and HSP at 16 months post stroke ($p = 0.02$). Although no significant correlation could be detected between limited passive external rotation and shoulder pain, more patients with limited external rotation were in the group with shoulder pain [101]. However, until now, change in passive shoulder movement could not be correlated with change in HSP [105].

Roosink et al. (2011) think it is more likely that restricted PROM is related to poor motor recovery, spasticity, soft-tissue inflammation and/or abnormal use of the UL due to pain related fear of movement and that it therefore is often an impairment expression that it seen as a contributor to the persistence of HSP. The bidirectional relationship between restricted PROM and HSP might be a critical element in a vicious circle leading to chronic shoulder pain [79]. Therefore, it is necessary to maintain the PROM from the shoulder form early after stroke onset.

Sensory impairments

No clear consensus is reached about the correlation between HSP and impaired sensation. Possible reason for this lack are differences regarding the definition, the wide variety of impaired sensations and the different evaluation methods [78]. Some studies mention associations of HSP with sensory impairments [56, 58, 76, 79, 100]: light-touch sensory abnormality [56, 58, 76], reduced temperature sensation [56, 58, 79] and impaired proprioception [79]. A possible explanation for these relationships is given by the higher risk on repetitive micro traumata of soft tissues around the shoulder joint due to the sensory disturbances whether or not combined with an altered perception of injuries [79].

4. Prevention and management of HSP

4.1 Management

The presence of HSP has a great influence on the life of the stroke patients and on their rehabilitation process. Patients with HSP experience a decreased QoL [65, 106] and potentially a longer stay in hospital compared to stroke patients without HSP [60]. A long period of shoulder pain might inhibit rehabilitation of the UL function, as patients in pain avoid painful exercises and thereby risk to create a longer period of immobility and developing contractures possibly leading to persisting arm dysfunction and learned non-use [68, 76]. Because of the complexity of the shoulder joint and the associated multifactorial causes, management of HSP is fairly complex demanding for a multidisciplinary approach. Although an optimal treatment approach has not yet been established [69] focus is mainly directed towards neuromuscular electrical stimulation (NMES), transcutaneous electrical nerve stimulation (TENS), intra-articular steroid injections, botulinum toxin injections, analgesic pharmacotherapy and physiotherapy[50]. NMES is often applied to the supraspinatus muscle or posterior deltoid muscle and might have a positive effect on shoulder subluxation when applied additional to physiotherapy [107]. However, NMES does not seem to improve shoulder pain [107, 108] and the dose and intensity of NMES in the studies that report positive effects is fairly high [109]. Based on the gait control theory of pain it seems that high intensity TENS, that activates the muscles aiming to maintain the muscle bulk, may reduce HSP [110]. Intra-articular steroid injections in the glenohumeral joint itself or in the subacromial bursa are used in case of inflammatory pain often due to rotator cuff injuries, biceps tendinosis, bursitis or adhesive capsulitis [111]. Chae et al. (2009) reported a reduce in pain and an increased ROM for two to four weeks when injections are accompanied with appropriate ROM-exercises[112]. However, caution is needed with repeated injections since atrophy of the joint capsule and weakening of soft tissue around the shoulder has been noticed [49]. In case of neurologic underlying pathologies botulinum toxin injections could be used either to reduce pain by inhibiting neurotransmitter release by sensory neurons or reduce overactivity of certain muscles aiming to recover the muscular imbalance due to hypertonicity. Muscles that are often injected with botulinum toxin referred to HSP are the subscapularis, infraspinatus and pectoralis muscles [113]. Pharmacologic treatment depends on whether the nature of the underlying pathology is more neurologic or mechanical. In case of underlying neurological pathologies antispasmodics are used to inhibit spasticity, tricyclic antidepressants and Selective serotonin reuptake inhibitors are used in case of centrally mediated pain and gabapentinoids in case of peripherally mediated pain[50]. In case of mechanical pain non-steroidal anti-inflammatory drugs are used if not contra-indicated. Physiotherapy, related to the management of HSP, aims on reducing the consequences of the paresis and improving the biomechanics of shoulder movements. Passive ROM exercises, within the pain free ROM, can be initiated as soon as possible if the medical condition of the patient is stable with caution to prevent impingement [50]. Because the management of HSP is rather complex and generally unsatisfactory [59] and because of the considerable role of physiotherapists (together with the entire multidisciplinary rehabilitation team) in the prevention of HSP, we further focus in this part on the preventative strategies which need to be a crucial point of the rehabilitation program starting at the first day after stroke.

4.2 Prevention

The hypothesis of a vicious cycle including shoulder pain and limited PROM emphases the importance of preventing the risk of repetitive micro trauma and preserving the optimal joint congruence and movement abilities. The education of patients, caregivers and family is the corner stone in the prevention of HSP [79]. Other key elements in this prevention are proper handling and positioning of the patient with respect to the shoulder joint, supporting the hemiplegic shoulder in case of painful subluxation and maintaining the shoulder PROM.

Regarding positioning and handling of the hemiplegic arm there is no consensus on which position or which technique is the best [69]. The aim is to strive for symmetric positioning of the scapula [50] and to inform as many people as possible who are taking care of the patient. This is especially the case in patients who require assistance with transfers as these patients are more likely to develop shoulder pain [102]. For all patients, but especially for those who require most assistance, prevention and management of HSP needs a 24h-multidisciplinary approach to succeed. In the context of this doctoral thesis we will restrict this introduction to the support of the hemiplegic shoulder (4.2.1) and to passive mobilization of the shoulder joint (4.2.2) as preventative measures for HSP.

4.2.1 Supporting the hemiplegic shoulder

Due to the paresis after stroke, often proximal shoulder muscles are no longer capable of preserving joint congruence against gravity when the hemiplegic arm is not supported. Gravity pulls the arm downward and, without the counteractivity of the supraspinatus and deltoid muscles, an inferior GHS occurs as a result of stretch on the joint capsule. This subluxation can be quite pronounced in patients with severe UL impairment increasing the risk on developing HSP or other secondary problems (e.g. shoulder-hand syndrome). Also, these patients have a higher chance on developing trauma of the hemiplegic arm because they cannot control the swinging of the arm during daily activities. Therefore, in patients with severe UL impairment, supportive devices (e.g. arm slings, lap-tray) are used to improve the anatomic alignment of the shoulder joint aiming to prevent or treat GHS and/or avoid any other trauma [49, 103, 114-116]. Despite the assumed rationale, insufficient evidence is available regarding the effectiveness in prevention or treatment of GHS and shoulder pain by means of an arm sling [115, 117]. Nevertheless, they are often used in clinical settings to support the patients arm during standing or walking. However, incorrect use of these arm sling can result in the development of soft-tissue contractures inducing and/or preserving pain. Apart from the lacking evidence regarding the effectiveness of slings as such, also evidence regarding the best or better type of sling is currently missing [50]. Besides the pain issue, clinically the use of arm slings often is controversial based on the fact that slings may encourage learned non-use, facilitate synergic flexion patterns of the UL [71], disturb the body schema and limit sensory input [49, 69]. For that matter, wheelchair attachments have been proven to be more effective compared to arm slings [114]. But, when walking or standing no alternative is available. Due to its clinical importance and in order to optimize the clinical decision making regarding the use arm slings more evidence concerning the effects is needed.

4.2.2 Passive mobilization of the shoulder joint

Preserving a functional active range of motion (AROM) is necessary for many activities in daily life. Even in stroke patients who, due to the severity of their paresis, are not capable of preserving a functional AROM, conserving a functional PROM is important for hygienic reasons, dressing and positioning in bed or in the wheelchair. Taking into account the fact that a restricted PROM is a risk factor on developing HSP. PROM exercises, early after stroke, should be an essential component in rehabilitation after stroke [50]. Unfortunately, studies investigating the effectiveness of stretch programs to maintain shoulder PROM refute this effectiveness [118, 119] and comparative studies concerning the best or better techniques for passive mobilization are lacking. Moreover, inappropriate stretching and passive mobilization techniques often result in rotator cuff injuries [120] exacerbating the situation. In any case, if pain, consistent with impingement, appears during passive mobilization the amplitude of the movement should be decreased [50]. Also special attention should be paid to avoid overstretch of the spastic biceps and subscapularis muscles [68], two structures very often showing abnormalities during sonographic examination in stroke patients [60, 68, 84, 87].

Since active therapy is preferred above passive techniques [69] but not all patients are able to perform adequate active exercises to preserve their ROM, it is necessary to have more insight in the most effective mobilization technique. It is, however, also important to take safety into account during the search for effectivity and look for the technique with the lowest risk on creating soft-tissue injuries.

Key messages

- Post stroke UL prognosis is less promising compared to the prognosis of the lower limb or walking capacity.
- Due to the key role of the UL in daily activities UL impairment has a negative effect on independency, self-governance and QoL.
- Therapists keep searching for the most effective therapeutic strategies to maximize the potential of UL recovery and minimize secondary complications like HSP.
- HSP is one of the most common complications after stroke with a peak incidence in the most crucial phase of recovery (4 months post stroke).
- HSP has a negative influence on functional use of the UL, on the length of the hospital stay, on the rehabilitation outcome and on QoL.
- Underlying pathologies are often multifactorial and therefore, management is often complex and unsatisfactory.
- Prevention of HSP aims to preserve optimal joint congruence and movement abilities and to decrease the risk on creating repetitive microtraumata.
- A multidisciplinary 24h approach is essential in the prevention and management of HSP.
- Despite the frequent clinical use of arm slings, insufficient evidence is available regarding the effectiveness in prevention or treatment of GHS and shoulder pain.
- Conserving a functional active and passive ROM is essential for hygienic reasons, performing daily activities and positioning in bed or in the wheelchair.
- Evidence regarding the effectiveness of mobilization techniques for the hemiplegic shoulder who have the lowest risk on creating soft-tissue injuries is lacking.

5. Objectives and thesis outline

HSP is a common post-stroke complication interfering on the rehabilitation of stroke patients as a barrier for appropriate recovery progress. Patients with HSP often hardly tolerate passive or active shoulder movements, resulting in immobility, atrophy and learned disuse and therefore a less effective motor rehabilitation achievement. A longer period of HSP also has a negative effect on the patients QoL, the duration of the hospital stay and the functional outcome for the patient.

First, we wanted to look – besides the evidence-based practice – for a practice-based motivation for this doctoral thesis by describing the current practices regarding UL rehabilitation after stroke by physiotherapists as well as occupational therapists working in Flanders (Belgium) and by gaining insight into the stroke survivors view (subacute and chronic) about their UL rehabilitation (chapter 2). Based on this information three other aims were deduced. The second aim was to examine the immediate and long-term effects of arm slings on shoulder subluxation and shoulder pain in stroke patients (chapter 3). The third aim was to investigate the immediate effect of arm slings on posture, balance and gait in subacute stroke patients (chapter 4). The fourth aim was to compare the effect of different mobilization techniques for the hemiplegic shoulder on shoulder PROM and shoulder pain (chapter 5).

Chapter 2 – 5 correspond to the individual manuscripts that are published or under revision for publication.

Chapter 2. To fulfill the first aim we conducted a survey among physiotherapist and occupational therapist specialized in stroke rehabilitation. The survey consisted out of 30 questions enquiring personal information and UL specific topics divided in 3 sections: 1) Passive mobilization, 2) Active exercises and 3) Immobilization. The survey for stroke survivors consisted of seven sections: 1) Personal information 2) Motor recovery of the UL and expectations on UL recovery; 3) Comfort, pain and QoL; 4) Immobilization; 5) Physiotherapy; 6) Occupational therapy; 7) Nursing (only for patients less than 6 months after stroke). Both patients in subacute and chronic phase after stroke were allowed to participate.

Chapter 3 reports on the second aim regarding the immediate and long-term effect of arm slings on shoulder subluxation and shoulder pain in subacute stroke patients. A randomized controlled trial was conducted among 28 subacute stroke patients with severe UL impairments. Patients were randomly allocated into three different groups: a control group without a sling, a group wearing the Actimove® Sling (BSN medical SA-NV, Leuven, Belgium) and a third group who wore the Shoulderlift (V!GO, Belgium). The patients could wear their supportive devices for 6 weeks. Before and after this period the glenohumeral subluxation and shoulder pain were assessed. Our first hypothesis was that patients who could wear an arm sling would show a reduction in glenohumeral subluxation over time. Secondly, we suspected that wearing an arm sling would result in an immediate reduction of the subluxation and that the reduction was greater when wearing the Actimove® sling compared to the Shoulderlift. A final hypothesis was that wearing an arm sling would decrease HSP.

Chapter 4 covers aim 3 and investigates the immediate effect of arm slings on balance, gait and posture in subacute stroke patients by means of a controlled design. Nine stroke patients (< 9 months post stroke) and nine healthy controls performed specific balance test and gait analyses in the same three different conditions as used in chapter 3: 1) wearing the Actimove® sling, 2) wearing the Shoulderlift and 3) not wearing an arm sling. Based on available literature our hypothesis was that wearing an arm sling would improve balance, increase gait speed and gait symmetry.

Chapter 5 describes the results of the research concerning our 4th aim and encompasses the effect of different mobilization techniques for the hemiplegic shoulder on shoulder PROM and shoulder pain. Eleven stroke patients (< 6 months post stroke) were included in this multiple treatment design. Our hypothesis was that by applying the combined soft-tissue mobilization technique 1) shoulder PROM would improve better compared to the other two techniques and 2) HSP would a decrease.

Finally **Chapter 6** discusses the findings of the presented studies, the strengths and limitations of this doctoral thesis, clinical recommendations and future perspectives.

Table 1 provides an overview of the methodological aspects of the different studies.

Table 1: Overview of methodological aspects of the different studies

Chapter and design	Aim	Population	Intervention	Primary outcome	Secondary outcome
Chapter 2A Survey among therapists	To explore current daily practices in upper limb rehabilitation	N = 80 in total N = 49 physiotherapists N = 31 occupational therapists	Subjects: Passive mobilization Active exercises Immobilization		
Chapter 2B Survey among stroke survivors	To gain insight into the stroke survivors view on their upper limb rehabilitation	N = 102 subacute < 6 m post stroke N = 118 chronic > 6 m post stroke	Subjects: Personal information Motor recovery and expectations of UL Comfort, pain and quality of life Immobilization Physiotherapy Occupational therapy (Nursing)		
Chapter 3 Randomized controlled trial	To examine the immediate and long-term effects of arm slings on shoulder subluxation and shoulder pain	N = 28 9.39 ± 4.40 weeks post stroke FMUE = 8.64 ± 6.44 FMUE_SE = 7.32 ± 3.75	6 weeks – 3 groups ▪ Actimove sling ▪ Shoulderlift ▪ No sling	AHD (subluxation) AHD (correction with sling) Shoulder pain (VAS)	Passive ROM Spasticity (MAS) Trunk stability (TIS) Motor deficits UL (FMUE)
Chapter 4 Case control study	To investigate the immediate effects of arm slings on balance, gait and posture	N = 10 stroke patients 185 ± 83 d post stroke FMUE = 22.22 ± 15.21 N = 9 healthy controls	Balance test and gait assessment in 3 conditions ▪ Actimove sling ▪ Shoulderlift ▪ No sling	Balance: CoP excursion, CoP velocity, weight distribution Gait: gait speed, cadence, stride length, step width, stance time, double support time Trunk excursion	Balance (BBS) Motor deficits UL (FMUE)

Chapter 5 Randomized multiple treatment trial	To compare the effect of different mobilization techniques for the hemiplegic shoulder on passive ROM and shoulder pain	N = 11 52.82 ± 19.37 days post stroke FMUE = 10.45 ± 10.71 FMUE_SE = 7.45 ± 5.66	3 * 4 weeks Different mobilization techniques in randomized order ▪ Combined soft-tissue mobilization in scapular plane ▪ Scapular mobilization ▪ Angular mobilization in frontal plane	PROM shoulder	Shoulder pain (VAS) Spasticity (MAS) Trunk stability (TIS) Motor deficits UL (FMUE)

m = months; d = days; FMUE = Fugl-Meyer upper extremity part, FMUE_SE = Shoulder elbow part of the FMUE; AHD = acromio humeral distance; VAS = Visual Analogue Scale; CoP = centre of pressure; PROM = passive range of motion, MAS = Modified Ashworth Scale; TIS = trunk impairment scale; BBS = Berg Balance Scale

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Chapter 2

Current practices of upper limb rehabilitation after stroke in Flanders

A. Survey among physiotherapists and occupational therapists

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B. Survey to question the stroke survivors view on upper limb rehabilitation

To gain insight in the current daily practice in UL rehabilitation after stroke and to understand the patient needs for that matter we conducted a two-way survey among therapists, working in stroke rehabilitation in Flanders (Belgium), and among stroke survivors in view of the description of their needs for that matter and the understanding of their opinions on UL rehabilitation.

The amount of information gained from both surveys was that extensive that gathering it in one comprehensive paper within the word-restrictions that journals handle, it wat opted to write this information up in a subdivided chapter 2. The first part (A) of this chapter describes and discusses the results conducted among therapists who work with stroke patients. This paper has been submitted to the International Journal of Rehabilitation Research. The second part (B) addresses the methods and results of the surveys conducted among stroke survivors. To avoid redundancy and overlap it was opted to skip a contextual introduction of the second part of the two-way survey and only to provide this part with an own method and materials, results and discussion section.

To aggregate the main findings of both parts, a finalizing joint keynote box was entered at the end of this chapter 2.

A. Current practices of upper limb rehabilitation after stroke in Flanders: a survey among physiotherapists and occupational therapists

ABSTRACT

The aim of this study was to explore the current daily practices in upper limb rehabilitation after stroke in Flanders (Belgium). An online survey was conducted among 80 physiotherapists and occupational therapists working in 12 different rehabilitation settings in Flanders. Questions covered three major topics concerning upper limb rehabilitation after stroke: 1) passive mobilization, 2) active exercises and 3) immobilization of the hemiplegic arm. Descriptive analysis was used to explore the responses (SPSS 23.0). Most therapists (92.5%) indicate that passive mobilization of the upper limb is part of their standard range of motion-protocol. Most of the times passive mobilization is performed three to four times a week taking up 11 to 20 minutes. Most therapists (78.8%) consider active arm-oriented therapy as essential. Considering patients with minor recovery of the upper limb, 67.5% of the therapists do include active exercises in their upper limb therapy program. However, 28.8% limit these active approach to the first three months after stroke onset. The use of a general upper limb clinical algorithm is scarce (27.5%) and 52% of the therapists provide an arm sling in the minority of their patients with upper limb impairment (<25%). This survey provides valuable insights into the current practices of upper limb rehabilitation after stroke in Flanders, which can be used as a basis for recommendations and further research.

Key words: Stroke Rehabilitation - Upper Extremity - Surveys and Questionnaires - Physical Therapists - Occupational Therapists

INTRODUCTION

Stroke is one of the leading causes of acquired disabilities worldwide confronting patients with often a quite challenging and long period of functional recovery [1]. Within the variety of potential disorders movement impairments are initially often appreciated as most invalidating for patient and proxies. Regaining walking capacity and arm function are therefore the most important motivations for rehabilitation. Most patients (64%) regain an independent walking capacity (with or without walking aids) at 6 months post stroke [2]. On the other hand, functional recovery of the upper limb is less promising. Only 5-20% [3] of the stroke patients demonstrate full recovery of the upper limb, while 30-66% [4, 5] remain without function (≤ 10/57 Action Research Arm Test) [6]. The recovery and therefore the rehabilitation of the upper limb tends to be more complex than the lower limb and this is due to various reasons: 1) most strokes occur in the middle cerebral artery territory, resulting in neural damage of the primary motor and sensory areas for the upper extremity and in damage of the corticospinal tract, which is responsible for the fine motor skills of the hand [7, 8], 2) functional use of the upper limb demands a high level of coordination and fine motor skills [9] and 3) patients opt to choose the possibility to enter the help of their non-hemiplegic arm to perform daily activities rendering a learned non-use of the hemiplegic upper limb [10, 11]. Although functional recovery of the upper limb is quite essential in view of independency in daily living [12], the early training of the affected arm may be jeopardized as first priority for patients and therapists due to given arguments [13]. However, current evidence emphases the necessity of providing early upper limb therapy with sufficient dose and intensity to maximize the potential recovery while the amount of therapy-time spent on the upper limb during this crucial phase of rehabilitation is estimated as insufficient [14-16]. Unfortunately there are several additional issues that may jeopardize the implementation of such evidence based recommendation for a high demanding rehabilitation. As the increasing number of stroke patients is creating greater demands on rehabilitation services the time available for upper limb training decreases [13]. Moreover, as upper limb prognosis is rather poor this decreasing availability of time could discourage therapists to search for extra treatment time and options [6, 17]. In combination with the fact that patients could be hindered to use and train the re-acquired movements due to pain in the hemiplegic arm or because using the arm requires too much effort, this situation renders less eagerness in patients to invest in upper limb therapy. Notwithstanding all these deranging and demotivating factors for restoring a proper arm function the importance of such function implies a permanent challenge to look for the most effective and efficient strategies to maximize upper limb recovery [13, 18]. The first step to actually face up to this challenge in practice exists in exploring actual daily rehabilitative practice.

To our knowledge there are no studies available providing such information in Flanders (Belgium). Therefore, we conducted a survey among physiotherapists (PT's) and occupational therapists (OT's), working in Flanders (Belgium), to describe the current practices regarding upper limb therapy after stroke.

METHODS

The survey was send to 12 rehabilitation centers or rehabilitation wards in hospitals, situated in Flanders (the Northern Dutch speaking part of Belgium), where they provide multidisciplinary therapy for stroke survivors. This study was approved by the Medical Ethics Committee of the Ghent University Hospital after approval of the local ethics committees of the participating centers and published in a public repository (NCT03252899). All recruited participants agreed and signed an informed consent prior to the study.

The survey was provided online (https://docs.google.com/forms). Both OT's and PT's were invited to participate, regardless of number of years working at the given setting. The survey consisted out of 30 questions enquiring personal information and upper limb specific topics: 1) Passive mobilization, 2) Active exercises and 3) Immobilization. The survey took approximately 20 to 30 minutes to complete.

Data analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences, version 23 (SPSS 23.0). Descriptive analysis was used to explore the responses. To compare the results of PT's to the results of OT's a Chi-square test was used.

RESULTS

A total of 80 therapists, of whom 49 (61.3%) PT's and 31 (38.8%) OT's, participated in the survey. Based on the information about the overall number of therapists working at the given settings, this resulted in a response ratio of 56%. Most therapists were active in a hospital setting (92.5%). Characteristics of the study population are summarized in table I.

Table I. Characteristics of the study population.

Age	%	Experience	%	Work setting	%
< 30 y	31.3	< 5 y	31.3	Acute hospital ward – neurology	11.5
31-40 y	35.0	5-10 y	17.5	Acute hospital ward – generic locomotor	10.3
41-50 y	27.5	11-15 y	21.3	Rehabilitation setting inpatients	5.1
51-60 y	6.3	16-20 y	12.5	Rehabilitation setting outpatients	15.4
61-65 y	0.0	>21 y	17.5	Rehabilitation setting in and outpatients	55.1
				Others	2.6

Y=years

Passive mobilization

Most (92.5%, n=74 with 49 PT's and 25 OT's; p=0.597) therapists perform a passive mobilization of the upper limb regularly (minimal once a week). For 83.8% of all confirmations, this passive mobilization is seen as a part of the standard range of motion (ROM)-protocol for stroke patients at their department. Potential reasons not to perform passive mobilization are that 1) there is no limitation of passive ROM (51.6%); 2) there is no spasticity or hypertonia (18.8%) present; 3) pain is elicited by passive mobilization (29.7%); 4) the potential to perform active movements with the arm is assessed negligible (4.7%) ; 5) there were other reasons (28.1%) like patients that have sufficient recovery to perform active exercises, immobilization was prescribed by the doctor,…. Modalities of passive mobilization are presented in table II. If we compare the results of the PT's to the results of the OT's we notice that OT's perform a passive mobilization of the UL more frequently (p=0.043). Considering the other modalities of passive mobilization and the indications not to perform this mobilization no significant differences could be detected except for the use of transversal muscular stretch as technique to perform shoulder mobilization. An overview of the differences between PT's and OT's are provided in table III.

Table II: Modalities of passive mobilization of the upper limb.

Frequency	%	Duration	%	Techn shoulder mob	%
1-2x/wk	5.4	< 10 min	38.7	Scapular mob	83.8
3-4x/wk	48.6	11-20 min	56.0	Glenohumeral mob	82.4
5-6x/wk	33.8	21-30 min	5.3	Active ass mob	82.2
7x/wk	2.7	> 30 min	0.0	Transversal stretch	45.9
More times/d	9.5			Capsular stretch	27.4

Wk = week; min = minutes; d=day; mob = mobilization; Techn shoulder mob = Techniques used for shoulder mobilization; Act ass mob = active assisted mobilization; Transversal stretch = transversal muscle stretch; capsular stretch = stretch of the joint capsule.

Table III. Differences between physiotherapists and occupational therapists regarding passive mobilization.

	PT	%	OT	%	
Mobilization frequency					
1-2x/wk		4.1		8.0	
3-4x/wk		59.2		28.0	
5-6x/wk		30.6		40.0	
7x/wk		0.0		8.0	
More times/d		6.1		16.0	
Mobilization technique	**PT**	**%**	**OT**	**%**	**P**
Scapular mob		89.8		75.0	0.097
Glenohumeral mob		87.8		70.8	0.076
Act ass mob		75.5		87.5	0.234
Transversal stretch		57.1		20.8	**0.003***
Capsular stretch		34.7		16.7	0.110

Wk = week; min = minutes; d=day; mob = mobilization; Techn shoulder mob = Techniques used for shoulder mobilization; Act ass mob = active assisted mobilization; Transversal stretch = transversal muscle stretch; capsular stretch = stretch of the joint capsule; ***p<0.05**

Active exercises

More than 3/4th (78.8%; PT's 85.7%, OT's 67.7%) of the therapists start active exercises as soon as possible when patients are medically stable. Even when the upper limb is profoundly affected (no selective movements possible), 67.5% of the therapists include active exercises in their upper limb therapy, while 28.8% only include active exercises when patients are less than three months post stroke. Only the minority (3.8%) does not give active exercises to patients with minor recovery of the upper limb, because there isn't enough time within therapy hours to spend on upper limb treatment apart from other therapy goals or therapists find it difficult to provide exercises to these patients due to the restricted capacities to move their hemiplegic upper limb.

Only 27.5% of the therapists use a clinical algorithm (set of rules for solving a problem in a limited amount of steps [19]) for therapeutic decision making regarding upper limb treatment at their department.

Immobilization

Most therapists (52.5%) recommend an arm sling in <25% of stroke patients with upper limb impairment. Followed by 40% who recommend an arm sling to 26-75% of the stroke patients. Only 7.5% recommend an arm sling in most (>75%) stroke patients. No significant differences were detected between PT's and OT's. More information considering the type of slings used is presented in figure 1. Mostly (62.5%) patients are advised to wear the arm sling only during certain activities. Sometimes patients are recommended to wear the sling during several hours a day (21.3%) or in 27.5% even permanently (nights not included). Only occasionally the patients have to wear their sling constantly, including the night (5%). Indications to use a sling in order to prevent or treat complications of the hemiplegic arm are summarized in table IV. When therapists indicated “others” they added that the arm sling was only used when patients mentioned shoulder pain during standing and walking. Therapists also mentioned that they preferred the use of a lap board, that general positioning is more important than the use of an arm sling and that it is very important to instruct the patient and his family. Mostly therapists (75%) state that the use of the sling is reduced over time. It seems that particularly the PT’s show this tendency when compared to OT’s (PT’s 83.7%, OT’s 61.3%; **p=0.024***). This decision can be based on several reasons: decreased pain and/or subluxation, increased recovery and/or shoulder stability, more active use of the arm in daily life or sufficient patient-attention for the upper limb. The mentioned (dis)advantages of using a sling are illustrated in figure 2. No significant differences could be detected between PT’s and OT’s.

Figure 1. Type of slings used as indicated by therapists.

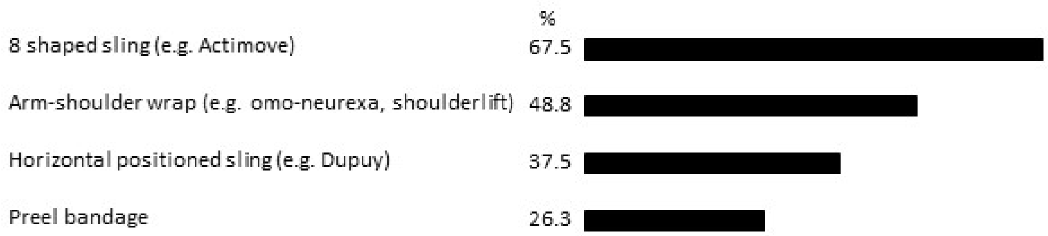


Table IV. Preventive and therapeutic indications for the use of an arm sling in stroke patients.

	Preventive %	Therapeutic %
Glenohumeral subluxation	68.8	76.3
Hemiplegic shoulder pain	60.0	80.0
Shoulder hand syndrome	38.8	50.0
Neglect	26.3	32.5
Severe cognitive impairments	42.5	42.5
Others	15.0	10.0

Figure 2. Advantages (a) and disadvantages (b) for the patients when using an arm sling mentioned by the therapists.

DISCUSSION

Providing the most effective and efficient rehabilitation strategies to explore the full potential of upper limb recovery after stroke is a big challenge for therapists. While the importance of intensive rehabilitation is evident, a consensus on the practical approach is often lacking and therefore the rehabilitation community is looking for guidelines for this matter. Despite the apparent importance of Evidence Based Medicine (www.cebam.be), scientific evidence concerning the topics of this survey is often lacking. Therefore, in view of generating appropriate recommendations, exploration of daily practice is mandatory as starting point. Subsequently, we conducted a survey among therapists regarding upper limb therapy after stroke in order to describe regular daily practices. To our knowledge this is the first study that describes the current practices regarding upper limb rehabilitation after stroke by therapists in Flanders (Belgium). Both experienced OT's and PT's in stroke rehabilitation were questioned concerning three major subjects: 1) passive mobilization, 2) active exercises and 3) immobilization.

Passive interventions are frequently applied in stroke patients, especially when recovery of active movement is absent. Those interventions have the advantage that they can be applied even in absence of any voluntary motor activities [20]. However, previous studies have indicated that there is insufficient evidence and limited clinical advantage for the patients from these passive initiatives [21]. Most responding therapists (83.8%) considered passive mobilization of the upper limb to be an intrinsic part of the standard ROM-protocol notwithstanding the lack of clear evidence. The most referred indications are prevention of immobility and soft-tissue contractures [22] and reduction of pain [23]. Despite the high frequency of the common execution of passive mobilization in a ROM-protocol there are several reasons mentioned by respondents to abolish this passive part of the protocol. Besides, so far no studies have compared different mobilization techniques for the hemiplegic arm in stroke patients. Taking into account all these elements this may imply that the application of passive mobilization in the used ROM-protocol is to be considered as a recommendation rather than an obligatory protocolled standard. According to the results of our survey most of the times passive mobilization is performed three to four times a week taking up 11 to 20 minutes per session. As available reimbursed treatment time is limited the efficiency of the integration of passive mobilization as a standard therapeutic guideline can be questioned. Since active exercises are still preferable above passive therapy modalities, which are not likely to cause meaningful changes in motor recovery [24, 25], and available treatment time might be restricted by legislation and/or practical organisation, the proportion of passive mobilization to the total amount of therapy time might not result in the most desirable outcome. Moreover, about half of the patients (52%) in a general stroke population develop contractures with an increased risk for patients suffering a severe stroke [26]. Passive mobilization is done by the PT’s, but quite a huge amount is also performed by OT’s during their therapy session. Surprisingly, in our study population OT’s indicated to perform passive mobilization even more frequently compared to the PT’s. These findings seems remarkable as these techniques are not considered to be a standard part of the basic OT-education in Flanders. It is not known whether these OT’s took additional courses to master these techniques as this should be recommended for safety and efficacy reasons for this vulnerable and complex to treat extremity. Also, regarding the mobilization technique used, differences could be observed between PT’s and OT’. OT’s seem to be less familiar with the capsular stretch ($p=0.110$) and transversal muscular stretch ($p=0.003$) compared to PT’s. Whereas PT’s mostly use scapular mobilization and glenohumeral mobilization, OT’s mostly use active assisted mobilization. Maybe, because they are more familiar with activation of the UL rather than performing more specific joint-directed interventions.

Considering active exercises for the upper limb after stroke, most therapists start with active exercises as soon as possible (78.8%). From this survey it can be retained that even when dealing with a profoundly affected arm (no movement in the paretic arm or movement is not functionally useful [27]) a lot of Flemish therapists invest in active exercises (67.5%) and give adequate arm-oriented therapy. In contrast, a recent study of de Jong et al. (2016) indicated that patients with a profoundly affected arm receive little arm-oriented therapy and that therapists spend most time on impairment level [20]. A possible reason for this therapeutic choice is that patients often don't have "enough (active) movement to work with". This reason was also indicated by Barker et al. (2007) to be the second most important factor from the stroke survivors perspective that finally contributes to poor upper limb recovery. Patients point out that they experience their insufficient abilities as the greatest barrier for their therapists to explore the full potential for upper limb recovery [18]. Therapists tend to shift to more passive strategies in severe arm paresis instead of exploring active strategies [18]. This was confirmed in our own survey as the frequency of active exercises has to be put in a time-perspective because 28.8% of the responders restrict active exercises to the first three months after stroke. This may indicate that these therapists appreciate the importance of active arm-oriented therapy but opt to retain it to the early (most potential) phase of recovery. However, actual research indicates that there is increasing evidence that upper limb function may still improve even long after 6 months post stroke [28]. Therefore, precautions for this time frame should be taken into consideration. The use of a clinical algorithm could guide the therapist through assessment and treatment guidelines for upper limb training to tailor an evidence based approach at the individual's level of functioning [19, 29]. So far, such an algorithm lacks validation and is therefore not widely spread with a scarce use of it in our study population (27.5%).

Arm slings are often used in clinical practice aiming to support the hemiplegic arm in order to prevent or reduce shoulder subluxation and pain [30]. Based on our results we carefully interpret that, for therapist working in Flanders, the decision of immobilizing the upper limb by means of an arm sling seems to be preceded by appropriate clinical reasoning. More than half of the therapists (52%) only provide an arm sling in the minority of their patients (< 25% of the patients with upper limb impairment). This is approximately the same percentage as described by Li et al. (2013). In their study OT's indicated that reducing the stress from gravitational pull during walking or standing, protecting the upper limb during transfers, reducing shoulder pain and maintaining or correcting glenohumeral alignment were the main reasons for using an arm sling [31]. These findings could be confirmed by the results of this survey as the most common reasons to use a sling were to prevent glenohumeral subluxation or to reduce shoulder pain. Notwithstanding the theoretical background for such indications, studies investigating the effect of arm slings on shoulder subluxation and pain still cannot provide sufficient evidence [32, 33]. For the given purposes wheelchair attachments appear to provide the best correction of glenohumeral subluxation [32]. In our survey, therapists also mentioned the advantage of using a lapboard instead of an arm sling. Therapists (75%) do tend to reduce the use of arm slings over time, especially PT's (83.7%) contribute to this finding.

Notwithstanding the enclosure of 12 rehabilitation settings, not all similar settings in Flanders were included. This was not possible due to organizational reasons. However, we tried to include settings from which localization was spread over whole the Northern part of Belgium. Also, private practitioners in Flanders were not included. Quite a huge amount of (chronic) stroke patients are treated by a private practitioner in Flanders. It was however not feasible to conduct a survey amongst those private practicing physiotherapists, since there is not yet a list available of these specialized therapists. More specific questions with respect to treatment content were not formulated. In view of response rates it was opted to select the major topics enabling the survey to be completed in an acceptable time frame.

CONCLUSION

- Although in literature there is no clear evidence for the effectiveness of passive mobilization of the upper limb in stroke patients, 83.8% of the responding therapists confirm that passive mobilization is part of their standard treatment ROM-protocol. However, therapists did report several indications to refute passive mobilization as part of this protocol. Therefore, we suggest to consider passive mobilization as a recommended part rather than an obligatory part of the upper limb ROM-protocol.
- Even though sufficient evidence regarding these outcomes is still lacking, preventing glenohumeral subluxation or reducing shoulder pain are the main reasons for therapist to use an arm sling. Therapists, PT's more than OT's, in Flanders do tend to reduce the use of arm slings over time.
- Active arm-oriented therapy, early after stroke, is considered essential but often seems to be limited in time (< 3 months after stroke), especially in case of poor upper limb recovery.
- According to actual insights the implementation of an upper limb clinical algorithm among therapists working in Flanders is scarce. More research is however necessary to validate such a clinical algorithm.

B. Survey to question the stroke survivors view on upper limb rehabilitation

MATERIALS AND METHODS

The surveys were send to 12 rehabilitation centers or rehabilitation wards in hospitals, situated in Flanders (the Northern Dutch speaking part of Belgium), where they provide multidisciplinary therapy for stroke survivors. This study was approved by the Medical Ethics Committee of the Ghent University Hospital after approval of the local ethics committees of the participating centers and hospitals and published in a public repository (Clinical Trials Registry: NCT03252899). All recruited participants agreed and signed an informed consent prior to the study.

There were two survey versions available on paper for stroke survivors (for patients less than 6 months and more than 6 months after stroke onset). The survey for chronic stroke patients was also provided online. This was not the case for the subacute patients since they often need more help due to language or cognitive problems and as an inpatient access to a computer and the internet is not always available. Both inpatients and outpatients with UL impairment after stroke could participate if they were not hampered by severe aphasia or severe cognitive problems. The survey was divided in seven sections: 1) Personal information 2) Motor recovery of the UL and expectations on UL recovery; 3) Comfort, pain and quality of life (QoL); 4) Immobilization; 5) Physiotherapy; 6) Occupational therapy; 7) Nursing (only for patients less than 6 months after stroke). The length to complete the survey was also organized to be achieved in 20 to 30 minutes.

Data analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences, version 23 (SPSS 23.0). Descriptive analysis was used to express the percentage of responders to the questions. A Fisher's Exact test was used to investigate the differences between chronic and subacute stroke patients. Normal distribution was examined using a Shapiro Wilk test. Based on the result that variables were not normally distributed, a non-parametric Spearman correlation coefficient test was used to examine correlations between the variables. Probability values lower than 0.05 were considered statistically significant in all tests.

RESULTS

Personal information and motor recovery

A total of 220 patients (n= 102 patients in the subacute phase (<6 months) and n=118 patients in the chronic phase after stroke (>6 months)) completed the survey. Demographic variables for all patients are summarized in table IV. Patients were asked to specify whether they were able to perform active, voluntary movements in the shoulder, elbow, wrist and hand as an estimation for the recovery of their UL (table V). To illustrate the functional capacities of the patients, they had to indicate if they could drink from a glass of water, comb their hair and write their name using the hemiplegic arm (table V). Finally patients were asked what their expectations were towards the further recovery of their UL. One out of five patients (20.5%) expects full recovery, almost half of them (44.5%) expects partial restoration, 28.2% expects no further changes and 6.8% fears deterioration in function. The differences for that matter between patients in subacute and chronic phase after stroke are illustrated in figure 3. Only a negligible correlation could be defined between the amount of motor recovery and the expectations of the patients (table VI).

Table IV. Demographic variables of the patients who responded to the survey (%).

		Subacute %	Chronic %
Gender	**Female**	38.2	42.4
	Male	61.8	57.6
Age			
	< 30 y	0.0	1.7
	31-40 y	1.0	7.6
	41-50 y	9.8	13.6
	51-60 y	17.6	25.4
	61-65 y	6.9	18.6
	> 65y	62.7	32.2
Time post stroke			
	< 1 month	13.7	
	1-3 months	36.3	
	3-6 months	48.0	
	6-9 months		9.3
	9 months – 1 y		12.7
	1-5 y		50.8
	5-10 y		16.1
	> 10 y		11.0

y = year(s); Gender 2 missing in subacute group; Age 2 missing in subacute group; 1 missing in chronic group; Time post stroke 2 missing in subacute group

Table V. Distribution of analytic and functional recovery of the upper limb for stroke survivors who responded to the survey.

Active voluntary movement	%	Functional movements	%
Active movement of shoulder and elbow	68.6	0 out of 3 functional movements	54.1
Active movement of shoulder or elbow	10.9	1 out of 3 functional movements	7.7
No active movement of shoulder or elbow	20.5	2 out of 3 functional movements	16.8
Active movement of wrist and hand	60.5	3 out of 3 functional movements	21.4
Active movement of wrist or hand	6.3		
No active movement of wrist or hand	33.2		

Functional movements: (drink glass water/comb hair/write name)

Figure 3. Expectations for upper limb recovery.

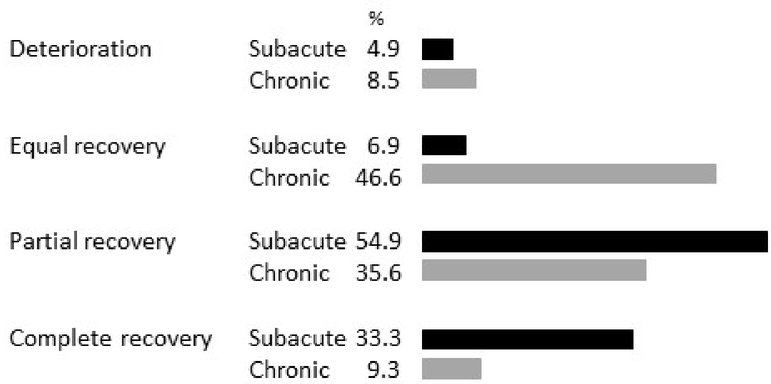


Table VI. Spearman correlations between motor recovery and expectations for upper limb recovery for all patients.

		Expectation
Proximal activity	Spearman Correlation	0.158
	Sig. (2-tailed)	**0.019***
Distal activity	Spearman Correlation	0.239
	Sig. (2-tailed)	**0.000****
Functional activity	Spearman Correlation	0.265
	Sig. (2-tailed)	**0.000****

*p<0.05
**p<0.001

Comfort, pain and QoL

Patients were asked to score the ‘comfort’ of their UL when lying in bed, sitting in a chair and while walking or standing by means of a Visual Analogue Scale (VAS) from 0 (least comfortable) to 10 (most comfortable). There were no remarkable differences between subacute and chronic stroke patients. For the comfort when lying in bed patients indicated a mean of 6.4 (± 2.5), sitting in a chair scored a mean of 7 (± 2.4) and during standing/walking patients scored 6.6 (± 2.5). On this last item 6 subacute patients did not designate a score, all other items had no missing values.

Of all responding patients 37.7% acknowledged that they felt pain situated at the hemiplegic UL. In relation to the time post stroke, significantly (p=0.038) more subacute patients reported UL pain (45.1%) compared to chronic stroke patients (31.4%). More detailed information about the localization and timing of UL pain in relation to the time since stroke is presented in figure 4. The given percentages are relative to the patients who reported the presence of pain situated at the hemiplegic UL.

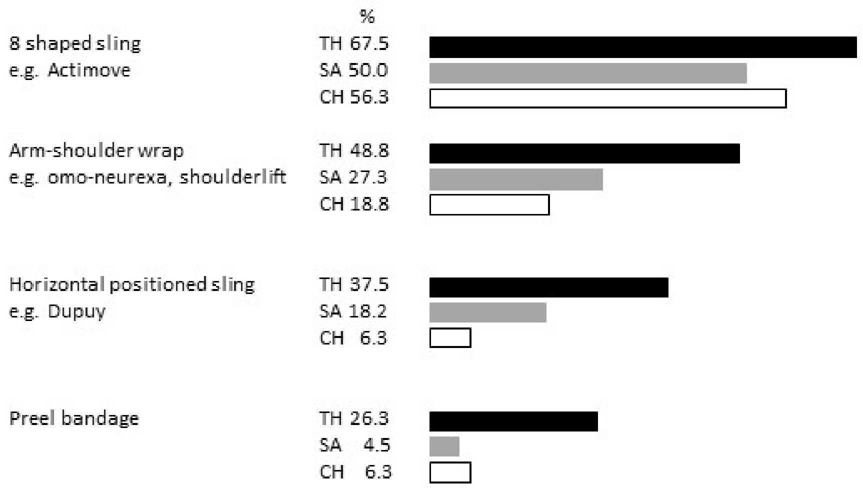
Figure 4. Overview of localization and timing of upper limb pain for patients who reported upper limb pain in both groups.

Most patients believe their QoL is reduced by the incomplete recovery of their UL after stroke (subacute phase 83.1% (2 missing); chronic phase 79.4% (5 missing)). Various reasons were mentioned for this decreased QoL: difficulties performing activities of daily living, personal care, or doing the housekeeping, not being able to resume work activities, hobby's, driving the car or participating in other social activities, …

Immobilization

Only 21.6% of the subacute patients and 13.6% of the chronic patients wear an arm sling at time of the survey. Generally, the subacute patients wear the arm sling between 1 and 3 hours (40.9%) or more than 6 hours a day (40.9%). Only 18.2% use the arm sling for 3-6 hours a day. The amount of time during the day that the chronic stroke patients wear the arm sling was similar to that from the subacute patients (37.5% 1-3 hours; 25% 3-6 hours; 37.5% more than 6 hours a day). The types of slings used are presented in figure 5. Advantages of wearing an arm sling mentioned by the patients are 1) it supports and/or protects the shoulder or arm, 2) it reduces shoulder pain, 3) it is comfortable to wear a sling, 4) I don't have to pay attention to my arm because it is in a save position. Possible disadvantages mentioned by the participants are 1) pain in the neck, 2) it feels tight, 3) it restricts the freedom to move, 4) it is stigmatizing, 5) it feels not comfortable, 6) the sling is not easy to apply yourself. In the chronic patients 51% did were a sling in an earlier phase after stroke. Most important reasons for not wearing the sling anymore at the time of completing this survey are that the use of the sling was not needed anymore due to recovery or pain reduction. Other patients ceased the use of the arm sling because it hampered the possibility to move the UL or they were advised by their PT or doctor to decrease the use of the arm sling.

Figure 5. Type of slings used as indicated by therapists, subacute stroke patients and chronic stroke patients.



Note: TH = therapists, SA = subacute stroke patients, CH = chronic stroke patients

Therapy

Most patients state that they perform active UL exercises every physiotherapy (52%) or occupational therapy (62%) session (figure 6). Patients state that PT's (85.9%) as well as OT's (88%) pay sufficient attention to the UL during therapy hours. Patients in the subacute phase are satisfied with the attention given to the UL during nursing (92.6%). Mobilization of the UL usually happens 5-6 times a week in subacute stroke patients (50%), whilst the frequency in chronic stroke patients seems to lower. An overview of the mobilization frequencies for both groups is presented in figure 7. The time needed for the mobilization is presented in figure 8. Patients in subacute phase were asked if the mobilization was performed by the PT or OT. In 44 patients (43.1%) mobilization of the UL is performed by the PT and in 42 patients (41.2%) by both the PT and OT. Only 4 patients (3.9%) answered that mobilization is performed only by the OT and 12 patients (11.8%) did not answer this question.

Figure 6. Frequency of active upper limb exercises during physiotherapy and occupational therapy.

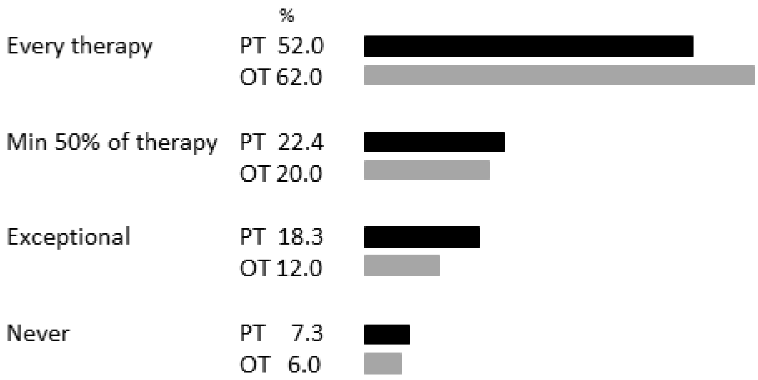


Figure 7. Mobilization frequencies.

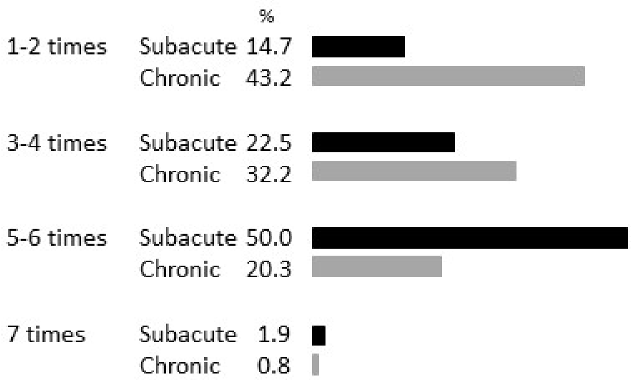
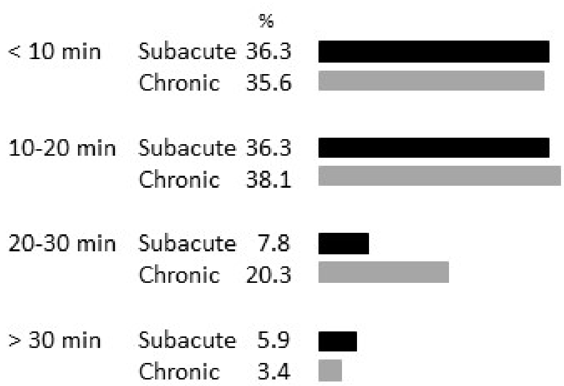


Figure 8. Time needed to perform a mobilization of the upper limb.



DISCUSSION

UL recovery is a big challenge for stroke patients and therapists. To explore the full potential of UL recovery, therapy needs to be active and provided with sufficient intensity and dose. These kind of interventions are very demanding for the patients. So far, no studies have been conducted to explore the stroke survivors needs and questions their view on UL rehabilitation in Flanders.

Our review questioned patients in the subacute and chronic phase after stroke about their view on UL rehabilitation. Patient expectations regarding UL recovery vary. Stroke patients in the subacute phase expect the UL to recover partially (54.9%) or completely (33.3%) while patients in the chronic phase after stroke consent that UL function will not change anymore in the future (46.6%) or that further recovery will only be partial (35.6%). It is not surprising that expectations change over time when someone has suffered a stroke. In the subacute phase the believe in full recovery possibly can be seen as a coping mechanism to deal with the loss [34] or the consequence of unrealistic illness beliefs or hopes. We expected a correlation between the level of recovery and the expectations. These correlations were however negligible. Therefore, other factors, explaining these expectations are to be plausible. In the study of Wiles et al. (2002) it is mentioned that patients expectations can be influenced by the information received (or not) from the health professionals. When a patient does not receive the appropriate information considering the restricted chances on recovery the uninformed patient may be seduced to hope for full recovery and with lack of opposing information he may assume that his therapists share the same opinion [34]. Not being appropriately informed in the chronic phase, can be appraised as if the possibility on further recovery is no longer existing. Coaching in time emphasizes the importance of always providing information: up-to-date, evidence based and correctly timed in view of stage of recovery. For example, recent findings suggest that increase in UL function may continue over 6 months post stroke or longer [28]. This change in evidence can imply a motivated and justified change in expectations, and therefore behavior, for the future amongst chronic stroke patients when appropriately informed by their therapists.

The presence of pain in the hemiplegic arm is a well-known complication after stroke. In our study 37.7% of the patients felt pain in the UL, mostly present at the shoulder (90.4% of the patients that reported pain) and occurring during activities (78.3%). Hemiplegic shoulder pain is a common complication after stroke often leading to a longer hospitalization period, a negative treatment outcome and a decreased QoL [35-38]. However, the patients in this survey did not mention pain as a reason as such for their decreased QoL. They rather referred to the inability to perform activities from daily life. This referral indicates the importance of appropriate attention for the best possible performance of these activities during treatment as inabilities in daily functioning seems to jeopardize the QoL impressively.

Most participating patients did not wear a sling at the moment of the survey (82.7%). This ascertainment is in accordance with the answer from the therapists who reported that most of the time they only recommend a sling in less than 25% of the patients with UL impairment. Physical therapy and occupational therapy are essential key elements of rehabilitation programs for stroke patients. Despite the clear differences in the roles of PT's and OT's, therapy content is overlapping [20]. In the present study, most patients confirmed that they perform active exercises with their UL in every session physiotherapy and occupational therapy. These results indicate that therapists do pay attention to the upper limb during therapy sessions. However, we didn't question the therapy content, how it was related to other therapy forms (proportional to e.g. passive interventions), if there was appropriate communication between therapists with respect to this UL treatment and how much time was actually spent on active exercises. It is known that therapists, especially in patients with a profoundly affected arm, do tend to provide more passive interventions, because the patients are often appraised as not having enough potential to perform active exercises [13]. As therapists do not want to discourage the patients and try to maintain hope on further spontaneous recovery together with the idea that PM will not harm they opt for passive interventions [20]. In this survey patients indicate that mobilization of the UL happens usually 5-6 times per week in the subacute phase after stroke. This frequency usually diminishes in chronic phase after stroke. This mobilization was often provide by the PT, but many patients also reported both the PT as the OT performed this passive intervention. This mixed service might reflect the evolution towards a more interprofessional rehabilitation approach for stroke patients in general [39, 40].

Limitations

Notwithstanding the patient diversity (regarding time post stroke, recovery, age) in this survey stroke patients not treated by a multidisciplinary team were not included. Quite a huge amount of (chronic) stroke patients are treated by a private practitioner in Flanders. It was however not feasible to conduct a survey amongst those private practicing physiotherapists, since there is not yet a list available of therapists who commonly treat stroke patients and/or are specialized in stroke rehabilitation.

As the total of potential responding stroke survivors is not known via the given settings, no information can be offered of the maximal response ratio and thus the overall representativeness of this sample.

As self-reporting in stroke survivors is often discussed in literature, it should be stated that it cannot be excluded that stroke survivors have been influenced by their cognitive abilities like impaired memory and/or interpretation difficulties regarding the posed questions. Also more specific questions with respect to treatment content were not formulated. In view of response rates it was opted to select the major topics enabling the survey to be completed in an acceptable time frame.

CONCLUSION

- Expectations regarding UL recovery vary and are, somehow, depended on the time since stroke.
- Reduction of QoL in this study population was more affected by the inability to perform activities of daily living due to UL impairment compared to the presence of pain in the hemiplegic UL.
- Patients confirmed the share of UL therapy during physiotherapy or occupational therapy sessions. However, more information is needed on therapy content and how active exercises are related to more passive therapy forms.

Key messages from this chapter

- Passive mobilization of the UL is reported as a frequent intervention in stroke patients and is seen as an intrinsic part of a ROM-protocol. As there seems to be a huge amount of reasons to deviate from this protocol the passive mobilization should be seen rather as a recommendation than an obligation.
- Slings are mainly used in view of preventing glenohumeral subluxation or reducing shoulder pain.
- The use of these arm slings is acceptable in absolute prevalence data and reduces further in time of recovery. The most frequent types of slings used are the 8 shaped slings followed by the arm shoulder wraps.
- Active arm-oriented therapy is considered essential but often seems to be limited to the first three months after stroke, especially in case of poor upper limb recovery.
- The implementation of an upper limb clinical algorithm among therapists working in Flanders is scarce.
- Patients in the chronic phase after stroke expect less recovery compared to the subacute patients.
- UL-induced reduction in QoL in this population was more based on the inability to perform activities of daily living due to impairments than to the presence of pain in the hemiplegic UL.

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Chapter 3

A randomized controlled trial on the immediate and long-term effects of arm slings on shoulder subluxation in stroke patients

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ABSTRACT

Background: Arm slings are often used in clinical practice to support the hemiplegic arm aiming to prevent or treat glenohumeral subluxation. Evidence supporting the corrective effect of slings on subluxation is scarce and long-term studies are lacking.

Aim: To determine both the immediate and long-term effect on acromiohumeral distance using the Actimove® sling (BSN medical SA-NV, Leuven, Belgium) and Shoulderlift (V!GO, Belgium) and to determine the effect of slings on pain and passive range of motion of the shoulder in stroke patients with glenohumeral subluxation.

Design: Randomized Control Trial

Setting: Hospital inpatients.

Population: Stroke patients.

Methods: 28 stroke patients, with severe upper limb impairments, were randomly allocated to 3 groups (Actimove, Shoulderlift, No sling). Patients wore their supportive device for 6 weeks and no sling in the control group. Immediate and post-interventional effect on acromiohumeral distance was measured using sonography. Pain (VAS), ROM (goniometry), spasticity (Modified Ashworth Scale), Fugl-Meyer Assessment and trunk stability (TIS) were also assessed before and after the intervention.

Results: The level of immediate correction of both slings was different at baseline and after 6 weeks (0 weeks: Shoulderlift 63%, Actimove 36%; 6 weeks: Shoulderlift 28%, Actimove 24%). Comparing the level of subluxation over time shows a distinct decrease in subluxation but only for the control group (-37.59% or 3.30 mm). Subluxation remained the same in the Actimove group (- 2.77 % or 0.27mm) but increased in the Shoulderlift group (+ 12.44% or 1.03 mm). After 6 weeks, the Actimove group reported more pain at rest ($p = 0.036$). ROM for abduction and external rotation decreased in 2 groups and remained un-altered in the Shoulderlift group.

Conclusion: Results of immediate correction varied. Subluxation seemed to reduce in patients that did not wear a sling.

Clinical rehabilitation impact: The (assumed) presence of subluxation may not benefit from wearing an arm sling which may itself inhibit active correction. If a sling is indicated the Shoulderlift may be preferable to the Actimove sling.

Key words: Stroke - Orthotic devices - Shoulder dislocation - Shoulder pain

INTRODUCTION

Hemiplegic shoulder pain (HSP) is one of the most common and functionally incapacitating complications after stroke. Incidence varies from 5% to 84% with an average incidence of 55% [1-3]. The presence of HSP often leads to a decreased quality of life, longer hospitalization and potentially, it may undermine the crucial early phase in the rehabilitation process and therefore have a negative impact on long-term treatment outcome [4-7].

Due to the complex shoulder anatomy and biomechanics, the eventual cause of HSP is considered multifactorial [4], although glenohumeral subluxation (GHS) is often identified as a possible and major cause. Notwithstanding the presence of GHS in 17-66% of stroke patients [2, 8, 9] and the suspected relationship with HSP, the correlation cannot always be identified[8-11]. However, a higher prevalence of GHS in patients with HSP is often reported [4, 12-17]. Despite the ongoing debate on the causal relationship between GHS and HSP, the presence of a subluxation is commonly accepted to be associated with poor upper limb function [18, 19] and also as an important risk factor for developing a shoulder-hand syndrome [20] or other complications (limited range of motion, plexus brachialis injuries, adhesive changes and subacromial impingement) [9, 19]. In view of the potential risk for dysfunction, the relationship with HSP and its role in these complications, the search for appropriate preventative and corrective measures for GHS remains a permanent clinical and scientific challenge.

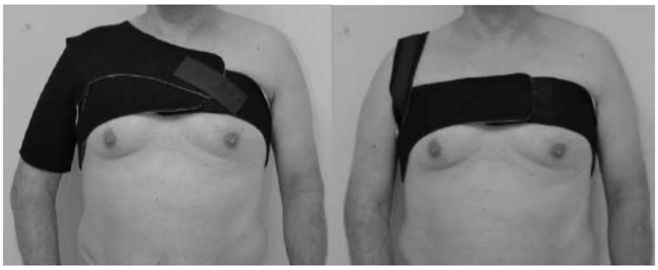
Despite insufficient evidence supporting the beneficial effect of shoulder slings in the prevention of subluxation [21], decrease of pain or increase of function (Cochrane Review, 2005) and the lack of long-term studies on the effect of such arm slings, these slings are often used in clinical practice. They aim to support the arm by functioning to counteract the downward pull of gravity on the humerus of the paralyzed arm and thereby prevent or treat a subluxation and/or avoid (further) trauma [2, 8, 22-24]. Aside from the more obvious aims for the upper limb, some authors also propose effects of these slings on parameters of balance [25] and gait [26-28]. Unfortunately, they may also encourage learned non-use and facilitate unwanted synergic flexion patterns of the arm [29]. They may also cause disturbance in the body schematic with an arm in flexion or a limitation of sensory input and they may create the potential for the onset of contractures over time [2, 30].

Although the use of an arm sling in stroke patients seems to be a logical and sensible common therapeutic intervention, scientific indications are available that individual reconsideration of its use in clinical practice is warranted. The type of sling, its introduction and method of application - in view of the possible negative implications for the patient - should be assessed. As no standard guidelines are available, therapists often have to rely on their own subjective judgment and previous experience (if any) on how best to approach the selection, introduction and application of a sling with a particular patient. Data on the corrective impact of a sling on GHS would therefore be invaluable and benefit therapeutic advancement.

This study will compare 2 different types of slings. The Actimove® sling (BSN medical SA-NV, Leuven, Belgium) supports the forearm of the patient, thus indirectly attempting to immobilize and support the shoulder. The Shoulderlift brace (V!GO, Belgium) is an extension of the Pellenberg retraction-elevation bandage supporting the shoulder joint directly, i.e. proximally allowing the arm to move freely. Assessing the sling correction of GHS can be performed by radiographic evaluation of the acromiohumeral distance (AHD) in a reliable and valid way [22, 31]. However, ultrasonographic evaluation of the GHS is also a reliable method that can be used to measure GHS in stroke patients [32, 33] and will therefore be used in this study. It is less costly, is without radiation exposure and is often more clinically accessible and is safe in application [34]. Kumar et al. described this method as also reliable and valid, when performed by a trained physiotherapist [33].

Figure 1. Actimove sling.

Figure 2. Shoulderlift with and without shoulder part.



The aims of this study are therefore two-fold:

1. To determine the immediate and long-term effect on acromiohumeral distance (AHD) using the Actimove® sling (BSN medical) and Shoulderlift (V!GO) by ultrasonography.
2. To investigate the effect of wearing a sling on hemiplegic shoulder pain and passive range of motion of the shoulder.

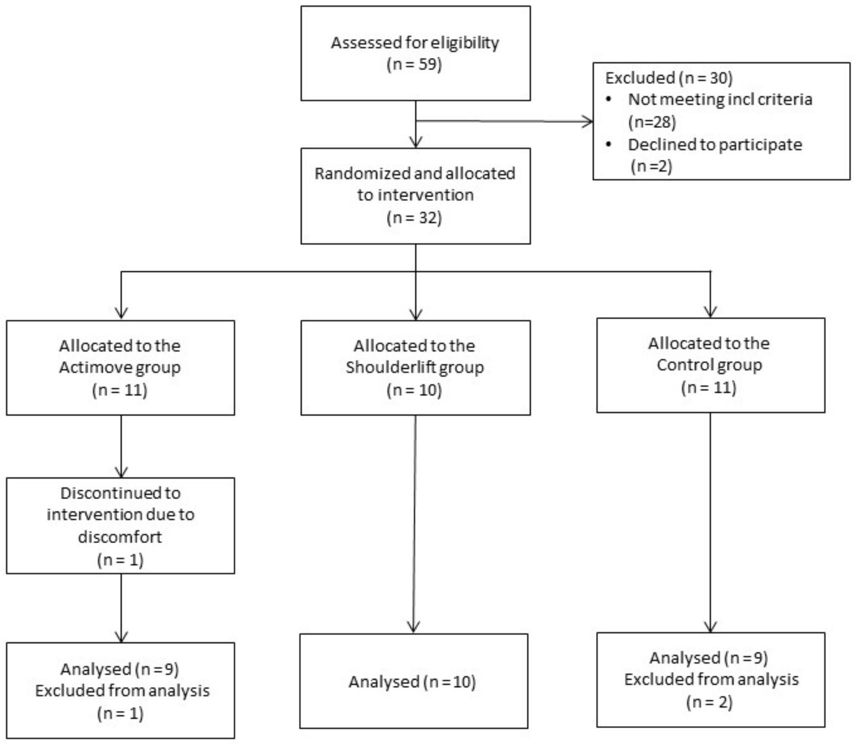
MATERIALS AND METHODS

Participants

Twenty-eight stroke patients were recruited from 3 different rehabilitation centers in Belgium. Only adult stroke patients after a first stroke with a unilateral upper limb hemiparesis were eligible to participate. All had to be able to sit upright in a chair with a back support but no arm support for at least 30 minutes. Patients with a score of ≥ 3 on the muscle testing Medical Research Council Scale for the supraspinatus or deltoid muscles, other neurological conditions, former shoulder problems on the hemiplegic side or severe cognitive impairments were excluded.

Patients were randomly allocated into three different groups: a control group without a sling (with proper positioning of the arm during the day and on request of the patient a supportive device during gait), a group wearing the Actimove® Sling (BSN medical SA-NV, Leuven, Belgium) and a third group wearing the Shoulderlift (V!GO, Belgium). Randomization was performed by extracting a number 1, 2 or 3 (that corresponded to the 3 groups) for each patient. To assure the blinding procedure envelopes were prepared before the intervention. An independent person, who was not informed about the meaning of the numbers, was asked to draw the envelopes. Devices were fitted by trained physiotherapists, nursing staff or family members. Participants wore their device for a period of 6 weeks during the active time of the day, but not when lying in bed and not during formal therapy sessions. Therapy compliance was not systematically assessed, however all team members were informed about the procedure and controlled the patient’s compliance. All patients, independent of the assigned study group, received an equal standard rehabilitation program. Related to the severely impaired upper limb the therapy program focused on avoiding complications (e.g. spasticity, contractures, pain) and active exercises adjusted to the level of impairment. Furthermore patients were involved in physiotherapy focusing on balance (sitting and standing) and gait. Physiotherapeutic interventions were based on a mix of different approaches (e.g. Bobath concept, Motor Learning Program, PNF). All patients received occupational therapy and if needed speech therapy and/or cognitive training. All recruited patients agreed to participate in the study and signed an informed consent form prior to their participation. The study received approval from the Medical Ethics Committee of the Ghent University Hospital (Prof. Dr. D. Matthys; EC/2013/991; 19/11/2013) and was registered on ClinicalTrials.gov (Identifier: NCT02102269).

Figure 3. Flowchart of sample.



Procedure

All measurements, primary (AHD and pain) and secondary (passive range of motion, spasticity, Trunk Impairment Scale, Fugl-Meyer assessment upper limb), were performed at onset of the study and after 6 weeks of treatment. Baseline demographic data (age, sex, time after stroke, type of stroke, side of paresis) are presented in table I.

Sonographic examination of the AHD

Patients were seated in a chair, with a back support but without arm supports and with their feet positioned flat on the floor. The humerus was in the neutral position with respect to flexion-extension and ab- and adduction with the elbow flexed to 90° and in neutral forearm rotation. If necessary, the arms were supported with a cushion, but support was not allowed at the elbow to eliminate the influence on the shoulder joint. Depending on the measurement the shoulder was positioned in neutral or internal rotation (figure 4).

Sonographic measurements were performed by the same, trained, physiotherapist using a Colormaster 128 EXT-IZ (Telemed UAB, Vilnius, Lithuania). The ultrasound transducer was placed over the lateral border of the acromion along the longitudinal axis of the humerus to determine the AHD.

The distance between the lateral border of the acromion and the humeral head was defined in two different ways: the shortest distance to the humeral head [35] and the distance to the nearest margin of the superior border of the greater tubercle [36].

AHD was measured in the non-hemiplegic shoulder and in the hemiplegic shoulder. The level of subluxation (dAHD1) was defined by subtracting the AHD of the non-affected side from the AHD of the affected side. AHD was re-measured immediately after applying the supportive device. The level of correction (dAHD2) was calculated by subtraction of AHD without and with the supportive device. To compare both slings, only the measurements in internal rotation were used since, when wearing the Actimove sling, positioning in the neutral position was impossible. When applying the Shoulderlift brace sonographic examination could only be performed when patients wore the Pellenberg retraction elevation bandage. Wearing the shoulder section as well would make it impossible to position the transducer over the acromion.

Figure 4. Standardized position of sonographic examination.

Pain

Pain intensity was assessed using a visual analogue scale. Patients were asked to score the intensity of their shoulder pain during the last 72 hours at rest, during activities and at night on a scale from 0 to 10 [37]. To examine other dimensions of pain such as frequency and appreciation of comfort of the position of the arm in different situations, a questionnaire was used. Since not all questions of the Shoulder Rating Questionnaire are suitable for stroke patients, only specific questions about the intensity were used from this Shoulder Rating Questionnaire [38]. Patients had 5 options to answer questions about the frequency and intensity of possible shoulder pain and to evaluate comfort of the arm in different positions. The total available score of the questionnaire was 35.

Secondary outcome measures

Passive range of motion (ROM) of the shoulder and elbow were measured using a manual goniometer with the patients in the supine position. The degrees of pain free ROM were noted for shoulder flexion, abduction, external rotation and elbow extension. Spasticity in the upper limb was evaluated using the Modified Ashworth Scale (MAS) again with patients in the supine position. Trunk control was evaluated using the Trunk Impairment Scale (TIS). This test contains 3 subscales (static, dynamic sitting balance and trunk coordination) and the score ranges from 0 to 23 [39]. The Fugl-Meyer assessment was used to quantify motor deficits of the upper limb [40, 41]. Both the total score of the upper limb section and the shoulder elbow score were used in statistical analysis.

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences, version 23 (SPSS 23.0). Normal distribution was examined using a Shapiro Wilk test. A one-way ANOVA was used to compare the mean level of subluxation between groups at onset and after the intervention. To compare the mean level of subluxation between onset and the end of the intervention for all groups a general linear model with repeated measures analysis was performed. An independent samples t-test was used to compare the mean level of correction between groups at the onset and after the intervention period. Depending on normality a Kruskal Wallis test or a one-way ANOVA was used to compare the means of the demographic data and clinical measurements between groups at the start and end of the intervention. To compare the means of the clinical measurements between onset and after the intervention for the different groups a Wilcoxon Signed Ranks test was used. Correlations between the variables were analyzed using a Spearman correlation coefficient test. Probability values lower than 0.05 were considered statistically significant in all tests.

RESULTS

Demographic data

Of the 59 patients screened for eligibility, 32 were included in the study. One patient decided to end her participation prematurely since she found wearing the Actimove sling to be uncomfortable. Three other patients were excluded, two of them because there was no subluxation present at the start of the intervention and one because the patient was not compliant with the protocol. Demographic data and baseline variables are summarized in table I.

Table I. Demographic data and baseline variables (mean ± standard deviations).

	Shoulderlift	Actimove	No sling	P
N	10	9	9	
Age (y)	47 ± 14	62 ± 12	56 ± 9	**0.033***[a]
Sex (m/f)	6/4	6/3	5/4	
Time Post Stroke (w)	10.30 ± 3.74	9.44 ± 5.39	8.44 ± 4.22	0.498‡
Type Stroke (isch/hem)	6/4	7/2	6/3	
Side Paresis (l/r)	5/5	4/5	5/4	
FMUE (/66)	8.70 ± 7.85	7.13 ± 4.05 (1 missing)	8.33 ± 6.58	0.941‡
FMUE_SE (/36)	7.20 ± 3.62	6.63 ± 3.20 (1 missing)	6.89 ± 4.40	0.947‡
TIS	14.78 ± 4.24	10.50 ± 6.74 (1 missing)	11.33 ± 6.23	0.279‡
Pain Questionnaire (/35)	26 ± 2.55	25 ± 4.24	25.88 ± 10.76	0.321‡

FMUE = Fugl-Meyer Assessment Upper Extremity; FMUE_SE = Fugl-Meyer Assessment Upper Extremity_Shoulder Elbow part; TIS = Trunk Impairment Scale; [a]One way ANOVA; ‡ Kruskal Wallis test
*** p < 0.05**

Groups were comparable for the variables time post stroke, arm function, trunk control and pain. A significant difference was detected for age (p = 0.033) with the Shoulderlift group being younger compared to the control and the Actimove group. However, no correlation could be detected between age and hemiplegic shoulder pain.

Effect on acromiohumeral distance

At the onset there was no significant difference between groups for the level of subluxation and for immediate correction on applying the sling. The Shoulderlift tended to correct the level of subluxation by 63% while the Actimove sling corrected it by 36%. After a period of 6 weeks there was no significant difference between groups, neither for the level of subluxation nor for correction after applying a sling. Correction at this post-treatment period was reduced to 28% for the Shoulderlift group and to 24% for the Actimove group.

Table II. Subluxation (dAHD1) and correction (dAHD2) at onset (0w) and after 6 weeks in mm (mean ± standard deviations).

	Shoulderlift	Actimove	No sling	P
dAHD1 (0w, neutral position)	8.54 ± 4.80	9.14 ± 4.02	8.73 ± 4.65	0.961
dAHD1 (0w, internal rotation)	8.28 ± 4.99	9.73 ± 3.53	8.78 ± 5.12	0.810
dAHD2 (0w, internal rotation)	5.21 ± 2.35	3.49 ± 2.35		0.154
dAHD1 (6w, neutral position)	9.99 ± 5.92	8.66 ± 7.00	5.89 ± 5.19	0.368
dAHD1 (6w, internal rotation)	9.31 ± 5.70	9.46 ± 5.43	5.48 ± 3.09	0.203
dAHD2 (6w, internal rotation)	2.57 ± 2.08	2.31 ± 2.94		0.844

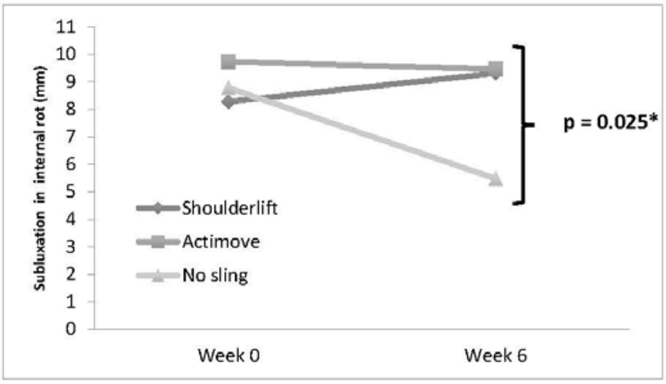
dAHD1 = AHD affected side – AHD non-affected side = level of subluxation
dAHD2 = AHD affected side – AHD affected side with sling = correction

A general linear model with repeated measures, performed to determine the time*group interaction effect, resulted in a significant difference for the subluxation measured in internal rotation (figure 5a; p = 0.025). In the Shoulderlift group dAHD1 increased during the period of 6 weeks, implying an increment in subluxation of 12.44% (1.03 mm). Acromiohumeral distance in the Actimove group remained relatively the same over time showing only a small reduction in subluxation of 2.77% (0.27 mm) after 6 weeks. In the control group a clearly larger decrease of acromiohumeral distance was noted implying a reduction in subluxation of 37.59% (3.30 mm).

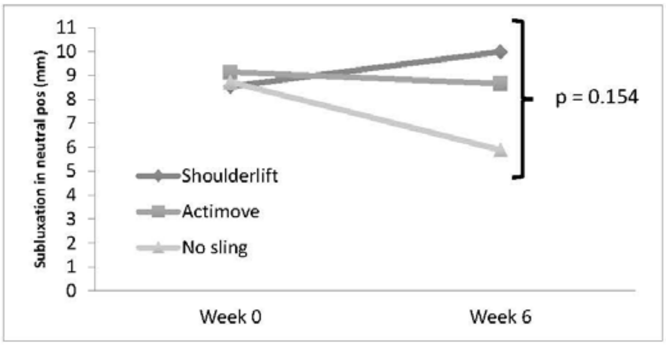
For the measurements in the neutral position the same result was obtained but the level of significance was not reached (figure 5b; p = 0.154).

Figure 5. Evolution of the level of subluxation (mm) over 6 weeks in internal rotation (5a) and neutral position (5b).

5a



5b



Clinical measurements and correlations

An overview of all clinical measurements at the onset and after 6 weeks is provided in Table III.

At the start of the study there was no statistical difference between groups for all pain variables. After 6 weeks the patients in the Actimove group reported more pain at rest (p = 0.036) compared to the other two groups. When evaluating the pain scores over the period of 6 weeks no significant changes could be detected. According to the questionnaire, patients reported most pain during exercise, tranfers and daily care in all groups. Pain and the level of subluxation in all 3 groups was not correlated. Spasticity in the upper limb was low before and after 6 weeks. No relevant differences could be detected between groups at both times and no significant evolution was detected over a period of 6 weeks. Besides no relevant correlations could be detected between spasticity and shoulder pain nor for the level of subluxation. At onset all groups were comparable for ROM. No statistical significant changes could be detected in ROM (all directions) between onset and 6 weeks for all groups. It was noted that, in contrast with the Shoulderlift group, ROM of abduction and external rotation decreased in the Actimove and control group. Only the ROM of shoulder abduction correlated significantly with pain intensity (VAS) during activities measured at the end of the intervention (Table IV). Upper limb function (FMUE) at the start was comparable for all groups.

Patients in the Shoulderlift and control group increased their score significantly (p < .05). Upper limb function scores and level of subluxation were not correlated.

Table III. Overview clinical measurements (mean ± standard deviations).

	Shoulderlift	Actimove	No sling	P
VAS rest 0 w	1.14 ± 1.86	0	0.22 ± 0.67	0.082
VAS rest 6 w	0.71 ± 1.89	2.63 ± 3.16	0	**0.036***
VAS activity 0 w	4.86 ± 2.27	5.75 ± 2.12	2.78 ± 2.59	0.050
VAS activity 6 w	2.29 ± 2.63	4.38 ± 2.39	2.44 ± 2.01	0.157
VAS night 0 w	0.71 ± 1.89	1.88 ± 2.95	1.56 ± 3.00	0.639
VAS night 6 w	2.00 ± 2.65	1.88 ± 3.04	0	0.104
Questionnaire 0 w	26.00 ± 2.55	25.00 ± 4.24	25.88 ± 10.76	0.321
Questionnaire 6 w	26.33 ± 3.39	24.33 ± 5.51	28.63 ± 2.26	0.389
ROM flexion 0 w	110.5 ± 24.99	106.11 ± 35.34	128.33 ± 28.06	0.273
ROM flexion 6 w	104.5 ± 23.51	92.78 ± 25.63	113.33 ± 24.49	0.320
ROM abduction 0 w	92.5 ± 13.18	83.89 ± 15.37	97.78 ± 21.08	0.398
ROM abduction 6 w	93.00 ± 12.52	78.33 ± 23.45	89.44 ± 13.33	0.219
ROM ext rot 0 w	25.50 ± 28.72	14.44 ± 17.04	25.56 ± 16.48	0.393
ROM ext rot 6 w	24.50 ± 28.13	2.22 ± 14.17	13.89 ± 13.64	0.108
TIS tot 0 w	14.78 ± 4.24	10.50 ± 6.74	11.33 ± 6.23	0.279
TIS tot 6 w	16.78 ± 2.86	13.13 ± 6.40	14.44 ± 5.83	0.330
FMUE 0 w	8.70 ± 7.85	7.13 ± 4.05	8.33 ± 6.58	0.941
FMUE 6 w	12.30 ± 10.55	8.38 ± 5.21	12.78 ± 12.28	0.828
FMUE_SE 0 w	7.20 ± 3.62	6.63 ± 3.20	6.89 ± 4.40	0.947
FMUE_SE 6 w	9.20 ± 5.12	7.63 ± 4.21	9.56 ± 7.33	0.837

VAS = Visual Analogue Scale, ROM = Range of Motion, TIS = Trunk Impairment Scale, FMUE = Fugl-Meyer Assessment Upper Extremity, FMUE_SE = Fugl-Meyer Assessment Upper Extremity_Shoulder Elbow part
*** p < 0.05**

Table IV. Correlations between pain intensity during activities and limited passive range of motion for shoulder abduction at 6 weeks per group.

	Shoulderlift	Actimove	No sling
Correlation coefficient	-0.797	-0.755	-0.687
P	**0.032***	**0.030***	**0.041***

Spearman correlation coefficient
*** p < 0.05**

DISCUSSION

Arm slings are often used to support the hemiplegic arm in an attempt to counteract the downward pull of gravity on the humerus in order to reduce or prevent a possible subluxation. Due to the lack of long-term studies investigating the effect of arm slings on subluxation we have attempted to address this by examining the immediate and long-term effect on acromiohumeral distance using the Actimove® sling (BSN medical SA-NV, Leuven, Belgium) and Shoulderlift (V!GO, Belgium).

Effect on acromiohumeral distance

In clinical practice the hemiplegic arm can be supported in various ways. Wheelchair attachments appear to provide the best correction for GHS with a mean correction of 15mm [23, 42]. However, using wheelchair attachments is no longer useful when patients become ambulatory. Also, side effects such as inadequate stimulation to perform transfers independently, skin problems due to friction or even overcorrection of subluxation have been reported [22, 43]. Moreover in the case of patients with severe neglect or cognitive impairments the hemiplegic arm can fall off the lapboard due to visual and/or sensory inattention. Often ambulatory patients with hypotonia and severe paresis or HSP are prescribed an arm sling [42]. However, there is insufficient evidence regarding the preventive [21] and corrective function of these slings [23]. There are some observational studies that have measured the immediate effect of shoulder devices on subluxation [8, 22]. The average amount of subluxation was 12mm, measured from X-rays. Overall immediate reduction was 8mm. When comparing different slings a mean correction of 13mm was noted for the slings that support the arm in flexion compared to 4mm for the slings that do so in extension [23, 42].

The present study compared the immediate and long-term effects of two different arm slings on the GHS in hemiplegic patients. The characteristics of the Shoulderlift stimulate the use of the hemiplegic arm when function recovers and allows the patient to counterbalance weight-shift in ambulation [24]. The Actimove sling on the other hand supports the arm via an immobilizing approach. Due to the low number of patients in each arm our results should be interpreted with caution. Nevertheless, they indicate a different corrective function for the two slings at the times of measurement of AHD. An immediate correction of 63% (5.21mm) was noted for the Shoulderlift and 36% (3.49 mm) for the Actimove sling. So in contrast to the literature [21, 23], our extension sling appears to establish a better correction than the flexion sling. When repeating the measurement 6 weeks later, the Shoulderlift only corrects 28% (2.57mm) and the Actimove sling 24% (2.31mm). This reduction might be explained technically in that the materials, from which the slings are manufactured, lose their (elastic) quality overtime and thereby potentially, their corrective properties.

Surprisingly our results indicate that not wearing a sling reduces the subluxation (subtracting the AHD of the non-affected side from the AHD of the affected side) over time in comparison to patients who did wear an arm sling. The level of subluxation remained approximately equal when wearing the Actimove sling and even increased when wearing the Shoulderlift. A possible explanation for this is that patients without a supportive sling are more attentive to the position of their arm during daily activities and are actively engaged in muscle activity to preserve glenohumeral congruence. Meanwhile, patients who wear a sling describe a secure feeling as their arm is supported and cared for (passively). They do not have to look actively after their arm and muscular activity is not required [25]. EMG recordings of the shoulder muscles is mandatory to confirm our hypothesis. Improvement of upper limb function during the period of intervention also provided an indication of the differences we observed, but no correlation could be detected between upper limb functional changes and the level of subluxation. This result did not support our hypothesis that the improvement of upper limb function might explain the reduction of subluxation in the control group. Active control (to take care of a paralyzed limb) might therefore be the most acceptable explanation given this result. Thus, the presence of subluxation might not always be an absolute indication to use an arm sling. Informing the patient, the carers and family members on how to position and handle the hemiplegic arm might be more important together with early active strengthening exercises for stabilizing the shoulder muscles. We are aware of the fact that this is not a potential acceptable assumption, but mere hypothetical. Therefore, this assumption has to be seen rather as a question for further research, rather than actual evidence assumption.

Effect on clinical measurements

Regarding HSP the present study showed no correlation between the pain variables and the level of subluxation. After 6 weeks, patients in the Actimove group reported more pain during activity than the patients in the Shoulderlift or control group, although this was not significant. Possibly this minor difference could be explained by the limited pain free passive range of motion of external shoulder rotation in the Actimove group. The interrelationship of limited passive shoulder abduction, external rotation and HSP has been described elsewhere [4, 17, 19, 44-46]. Roosink et al. (2011) describes a bi-directional relationship between restricted passive range of motion and persistent shoulder pain beginning from 3 months post stroke. Restricted joint motion could be a critical element to address in order to break the vicious circle of post stroke shoulder pain [28]. In contrast to the Shoulderlift and control group, patients in the Actimove group had the most restricted range of motion for external rotation and shoulder abduction after 6 weeks. Since the arm in this sling is positioned in internal rotation against the body during most of the day, this almost permanent fixed position may possibly lead to muscle and/or capsule tightening and even contractures [23]. This could also be an explanation for the increased pain during activities since too much internal rotation in the shoulder is known to increase the risk of impingement during active and passive movements of the arm [47, 48]. Only in the Shoulderlift group the passive range of motion of shoulder abduction and external rotation could be preserved suggesting that this sling may be the better option for patients who do need to wear a sling. Patients not wearing a sling should be discouraged from holding their arm against their abdomen whilst walking to prevent the decrease of external rotation. A possible compensation is to position the arm in their pocket during walking [25]. The correlation between less external rotation and increased pain during activities was confirmed in our results.

Limitations of the study

To our knowledge this is the first study that investigates the immediate and long-term effect of arm slings using sonography. However, due to the small sample size our results should be interpreted with caution. Post hoc power analysis for the change in AHD distance over 6 weeks, showed a medium effect size (f = 0.47) with a power of 67%. With containment of the given size effect obtaining a power of 80% would warrant a total sample of 39 patients implying that we would have had to add 3 or 4 patients per group. Sonography is a reliable and valid method to measure the AHD [35, 36] even in stroke patients [32, 33], but it did present some difficulties. For example, patients with severe limitation of external rotation in the shoulder could not be positioned in the neutral rotation. The greater tubercle of the humerus was not always visible on the sonographic image. Particularly when performing the measurement in internal rotation and maintaining the position of the transducer along the longitudinal axis of the humerus, the tubercle could not be seen. When dealing with a large person or a severe subluxation the transducer was too small to cover the subluxed distance and this resulted in some missing data.

An immediate correction of a sling can be influenced by various elements (sling as such, brand new material, increased attention to the limb,…). Repeating the measurement a few hours after application, to determine the intrinsic corrective character and 'settling' of the sling was lacking in this study. This should be investigated in future studies.

Also, limitations in the use of a visual analogue scale for pain in stroke patients should be taken into consideration. Not all patients were able to score their pain due to language problems or cognitive impairments. Furthermore, in stroke patients, self-reported pain often underestimates the extent of pain found during physical examination of the shoulder [49].

CONCLUSIONS

- The present findings indicate that not wearing a sling is related to AHD reduction, whereas wearing the sling does not seem to prevent pain and shoulder subluxation. Therefore, prescribing a sling might not be the preferred treatment approach since it may actually inhibit active correction.
- The Shoulderlift tends to provide better initial correction than the Actimove sling. However, both slings seem to lose their corrective functioning ability over time.
- Due to the small sample size our results should be interpreted with caution and further research is necessary to confirm our findings.

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Chapter 4

Immediate effects of arm slings on posture, balance and gait in subacute stroke patients: a case control study

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ABSTRACT

Background: The decision of providing stroke patients an arm sling in view of prevention of shoulder subluxation or reduction of pain remains a clinical challenge. Apart from the presumed obvious aims some authors described an additional potential positive effect of using an arm sling, on balance and gait.

Aim: To measure the immediate effect of wearing an arm sling on balance and gait in subacute stroke patients.

Methods:

Setting: Hospital in- and outpatients.

Participants: ten stroke patients (> 18y, first stroke, < 9 months ago) and nine healthy controls, matched for age and gender. Patients had to be medically stable, able to stand independently, able to walk 20 meters and to understand simple commands.

Ethical approval: Belgium registration B670201525435

Interventions: Participants performed static and dynamic balance tests on the DynStable® (Motekforce Link) and walked on the GAITRite® in different conditions: 1) with restriction of the arm (Actimove sling®), 2) without restriction of the arm (Shoulderlift brace) and 3) not wearing an arm sling) in a randomized order.

Findings: No significant differences were found for the balance tests, gait parameters and trunk excursion between the different conditions for both groups.

Conclusion: Based on our results, the impact of using arm slings on posture, balance and gait should be questioned.

Key words: Stroke - Postural balance - Gait disorders, Neurologic - Orthotic devices - Upper extremity

INTRODUCTION

Stroke is one of the main causes of acquired disability [1, 2]. Approximately 80% of stroke patients show motor impairments of the upper limb [3]. Stroke patients with severe upper limb impairments are often prescribed an arm sling in order to prevent or reduce shoulder subluxation and pain [4]. Interestingly, however, the beneficial effect of arm slings in subacute stroke patients is still under debate [5, 6]. In clinical practice this debate is further impeded by the fact that therapists may be discouraged to use these slings due to their potential negative effects (e.g. encouragement of the learned non-use phenomenon) [4, 7] or encouraged by potential positive effects (e.g. protection of the hemiplegic arm) [8, 9]. Therefore, the decision of prescribing an arm sling to stroke patients remains a clinical dilemma. This is complicated further by the limited and contradicting evidence regarding the potential effect of an arm sling on the impaired balance and asymmetrical gait after stroke [9-11]. According to Acar and Karatas (2010) [9] patient's balance improved when using a sling, by limiting the uncontrolled swinging of the arm [9] typically observed in stroke patients. Furthermore, patients could become more aware of their body posture as the arm sling may serve as a feedback mechanism [9, 10, 12]. In contrast, the beneficial effect of arm slings on balance was recently refuted by Sohn et al., who was unable to find improvements in patient's balance while wearing an arm sling [13]. Concerning walking, evidence shows that wearing an arm sling could increase stability and efficiency [10, 11, 14]. Two previous studies demonstrated a more symmetrical gait pattern when wearing a sling [10, 11] and an increased walking speed [10].
Since a decreased postural control and a less stable walking pattern after stroke may jeopardize the activity and participation level of an individual rendering the patient more prone to falls and increased disability, the potential effect of these slings for this matter proposes an additional therapeutic consideration that needs further substantiation. Hence, this study tried to further unravel these clinical dilemma by investigating the immediate effect of two conceptual different arm slings: 1) the Actimove sling® (BSN Medical SA-NV, Leuven, Belgium), 2) the Shoulderlift (V!GO, Belgium) on balance and gait in subacute stroke patients by means of a controlled design. The Actimove sling® supports the forearm of the patient in order to (indirectly) immobilize and support the shoulder joint. The Shoulderlift is an extension of the Pellenberg retraction-elevation bandage supporting the shoulder joint proximally allowing the arm to move freely.

The first hypothesis was that wearing an arm sling would have a positive effect on balance and gait, assuming a greater effect of the Actimove sling® compared to the Shoulderlift based on a greater controlling influence on an uncontrolled arm swing in post-stroke patients. A second hypothesis was that in the healthy control group the impact of wearing a sling on balance and gait was different in comparison with the impaired condition caused by a stroke.

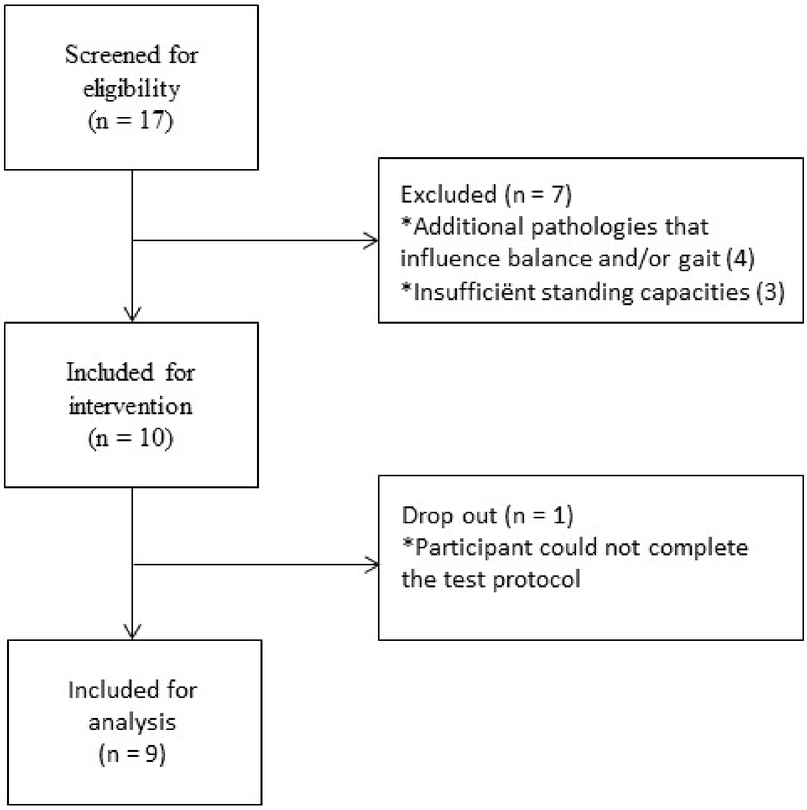
MATERIAL AND METHODS

Participants

Ten stroke patients and 9 healthy controls were enrolled. Stroke patients were recruited from the Rehabilitation Centre of the Ghent University hospital if they were older than 18 years with a first time stroke of no longer than 9 months before inclusion. Patients had to be medically stable, able to stand independently without assistive devices for at least 3 minutes, able to walk 20 meters (walking aids were allowed) and able to understand simple questions and commands. The score for the supraspinatus and deltoid muscles needed to be less than 3 on the Medical Research Council (MRC) scale. If scores were higher than 3, wearing a sling would not be necessary because of sufficient proximal muscle control. Pushers, patients with dizziness and other pathologies or neurologic comorbidities (e.g. Parkinson Disease, Multiple Sclerosis, etc.) that are known to influence balance and gait were excluded. Healthy controls, matched for age and gender, were recruited through social networks and media. Participation of healthy controls was allowed in the absence of severe vision problems (use of glasses was allowed), dizziness or recent illness that could disturb balance and walking, symptoms suggestive for vestibular, neurological or psychological disorders. Participants were excluded when they used medication that influenced the central nervous system or balance and when a history of 2 or more falls without apparent reason during the last 6 months was present.

This study was approved by the Medical Ethics Committee of the Ghent University Hospital (Belgium registration B670201525435). All recruited participants agreed and signed an informed consent prior to the study.

Figure 1. **Flowchart of the stroke patients inclusion process.**



Design

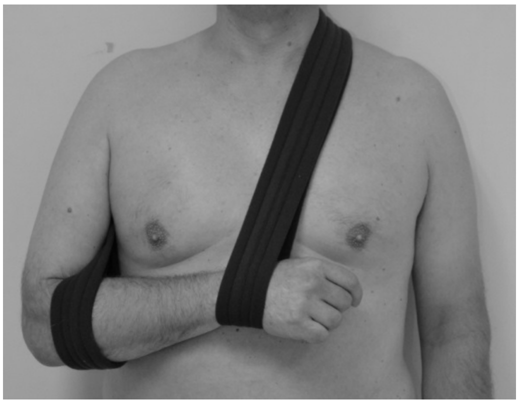
A cross-over design was used because a blinded protocol was impossible regarding the nature of this intervention. Healthy controls were included in an attempt to assess the impact of a sling on balance and gait behavior in comparison with the impaired condition caused by a stroke.

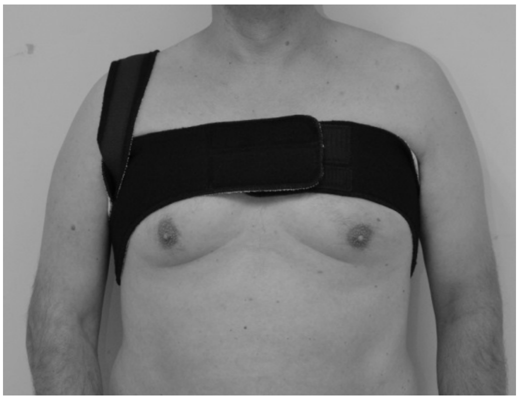
Procedures

Generic baseline measurements included Berg Balance Scale [15] for evaluation of functional balance and Fugl-Meyer assessment [16, 17] to quantify motor deficits of the upper and lower limb.

All specific balance and gait analyses were performed in three different conditions: 1) wearing a sling with restriction of the arm (Actimove sling®), 2) wearing a sling without restriction of the arm (Shoulderlift brace) and 3) not wearing an arm sling. All three conditions were applied in random order based on a computer-generated sequence.

Figure 2. Actimove sling (a) and Shoulderlift (b).





Balance

Balance tests were performed on a platform designed for assessment and training of static balance by using a force-plate and a Virtual Realty Environment. The DynSTABLE (Motekforce Link) offers real-time integration of a translational balance platform (100*100cm), two force plates (50*100cm), a motion capture system (6*Optitrack Flex 3) and virtual reality environment. The force-plate, mounted on a translational platform, records the excursion of the centre of pressure (CoP). The platform can translate ±10cm in every direction. Calibration was performed every test day. The testing protocol included: postural stability tests (eyes open (EO), eyes closed (EC), tandem stance (TS) and unipedal stance (US)) and time to stability test. All participants wore a safety harness.

Details of the performed tests and measured variables are presented in table I.

Table I. Description of the static balance tests performed on the DynSTABLE.

Test	Modalities	Outcome
Postural Stability – EO	3 x 30 sec – eyes open – feet at shoulder width	CoP excursion(COP, COPML, COPAP, Area COP, velocity COP) and weight distribution.
Postural Stability – EC	1 x 30 sec – eyes closed – feet at shoulder width	
Postural Stability – TS	1 x 10 sec – eyes open – semi tandem stance	
Postural Stability – US	1 x 10 sec – eyes open – unipedal stance on preferred leg	
Time to stability	Participants stood still with their feet at shoulder width while the platform moved unexpectedly to the left or right in a randomized way.	The average time needed for the participant to recover balance after an unexpected perturbation was measured.

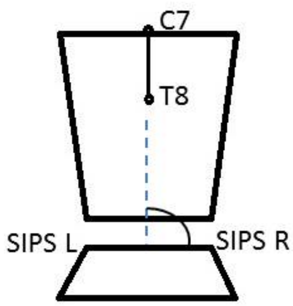
EO = eyes open; EC = eyes closed; TS = tandem stance; US = unipedal stance; CoP = Centre of Pressure; CoPAP = maximal deviation of CoP in anterior posterior direction; CoPML = maximal deviation of CoP in medio-lateral direction.

Posture and Gait

The GAITRite (CIR Systems, Inc.) is a walkway designed to assess spatiotemporal parameters during gait (www.gaitrite.com). The walkway is 90cm x 700cm x 3.2mm and consists of sensors. The spatial resolution is 1.27cm and the sample rate 120 Hz. All participants had to walk the GAITRite nine times: three times for every sling condition. They were instructed to walk at their self-selected speed. The use of ankle foot orthoses and/or walking aids was allowed. The following variables were measured: velocity, cadence, stride length, step width, stance time, double support time.

Every walk of the participants was recorded with a webcam (Logitech HD Pro Webcam C910) to evaluate the excursion of the trunk during walking. To enable this, trunk assessment markers were placed on anatomic landmarks: cervical vertebra 7 (C7), thoracic vertebra 8 (T8) and bilateral on the posterior superior iliac spine (SIPS) (figure 2). The used resolution was 800X600, the frame rate 30 Hz and the camera settings were adjusted according to the incoming light.

Figure 3. Model to calculate trunk excursion.



SIPS L = Spina iliaca posterior superior left;

SIPS R = Spina iliaca posterior superior right;

C7 = cervical vertebra 7;

T8 = thoracic vertebra 8.

The videos were processed using the MaxTRAQ software from Innovision Systems, Inc (www.innovision-systems.com/Products/MaxTraq.html). This software digitizes kinematic variables out of standard video files. The angles between C7/T8 and SIPS left/SIPS right were measured at the time of heel strike, toe off and during midstance. Three consecutive foot-steps were used to collect these data. Angles > 90° indicated that participants moved their trunk to the hemiplegic/non-dominant side, angles < 90° implied they moved their trunk to the non-hemiplegic/dominant side.

Statistical analysis

In order to compare the stroke patients and the healthy controls, the non-dominant side of the controls was compared with the hemiplegic side of the stroke patients.

Data analysis was performed using Statistical Package for the Social Sciences (SPSS) for Windows, version 24. Data are presented as means ± standard deviation. Statistical significance was accepted at a p-level < .05. Due to the small sample size, non-parametric tests were used. The Friedman test was used to compare the different conditions within one group. If a significant difference was detected pairwise comparison was justified. To compare the different variables between groups a Mann-Witney U test was used.

RESULTS

Demographic data and baseline measurements

From the 17 stroke patients that were initially screened for eligibility, only 10 could be included. The most common reasons for excluding patients were; insufficient standing balance to complete the protocol or the presence of pathologies of the lower limbs that influence balance or gait. During the testing, one patient decided to interrupt the intervention because she was not able to complete the protocol. Accordingly, the data of 9 stroke patients and 9 healthy controls is shown in the present work. Demographic data and variables are summarized in table II.

Table II. Demographic data and baseline variables (mean ± standard deviation).

	Stroke group	Control group	P
Age (y)	50.67 ± 7.11	50.56 ± 6.98	.93¥
Gender (Male/Female)	7/2	7/2	
Height (cm)	175.67 ± 10.89	177.11 ± 11.91	.72¥
Weight (kg)	87.17 ± 15.85	80.06 ± 14.55	.31¥
Time post stroke (days)	185 ± 83		
Hemiplegic side (L/R)	3/6		
Type stroke (Isch/hem)	3/6		
BBS (max 56)	42.22 ± 11.41	55.33 ± 0.71	**.003¥,***
FM UL (max 66)	22.22 ± 15.21		
FM LL (max 34)	19.78 ± 7.36		
Walking aids (Y/N)	5/4		
Tripod	3		
One point walking cane	1		
Ankle Foot Orthoses (Y/N)	6/3		

Isch = ischemic stroke; hem = haemorrhagic stroke; BBS = Berg Balance Scale; FM UL = Fugl-Meyer Assessment Upper Limb; FM LL = Fugl-Meyer Assessment Lower Limb; Y = yes; N = no
¥ Mann-Witney U test
***p<.05**

Balance

Postural stability tests

No significant differences were found for the outcome parameters of the CoP excursion between the different conditions for both groups (table III). When the two groups were compared, significant differences could be detected for the eyes open and eyes closed conditions, indicating that the healthy controls performed better on these postural stability tests. An overview of the p-values comparing the different conditions between groups can be found in appendix 1.

Weight distribution was registered during the EO and EC condition of the postural stability test. For stroke patients it was expressed in % weight on their hemiplegic or non-hemiplegic leg. For healthy controls the non-dominant side was compared with the hemiplegic side, the dominant side with the non-hemiplegic side. No significant differences could be detected for weight distribution when comparing the different conditions in each group (table III). Weight distribution was more symmetrical for the healthy controls compared to the stroke patients (appendix 2).

Time to stability

The time needed to regain stability after an unexpected perturbation is summarized in table III. No significant differences were detected between the three different conditions in both groups or between groups

Table III. Outcome parameters of CoP excursion during balance tests performed on the DynSTABLE.

		Stroke group				Control group			
		AM	SH	WS	P	AM	SH	WS	P
CoP (cm)	EC	114.11	118.69	108.95	.46	45.45	42.69	39.52	.64
		±57.16	±62.44	±58.81		±27.78	±14.38	±13.82	
	EO	69.76	70.39	65.20	.72	33.17	24.71	26.82	.12
		±36.73	±43.51	±35.13		±22.40	±6.69	±8.43	
	TS	62.94	61.25	55.65	.88	43.64	41.01	33.31	.46
		±41.69	±53.94	±30.23		±16.72	±16.23	±12.77	
	US*	79.57	77.89	72.41	.47	56.56	49.30	44.86	.61
		±41.67	±15.00	±17.88		±32.23	±21.24	±24.72	
Area of CoP (cm2)	EC	19.20	15.46	13.93	.90	1.51	1.82	1.54	.26
		±20.95	±15.46	±9.77		±0.75	±1.20	±0.64	
	EO	7.65	7.74	5.44	.90	1.52	0.74	0.92	.24
		±7.74	±8.49	±2.45		±1.53	±0.28	±0.37	
	TS	14.08	15.10	11.29	>.99	6.30	5.64	3.80	.37
		±8.73	±12.26	±3.78		±3.80	±3.95	±2.11	
	US*	19.37	15.48	19.30	.78	11.51	8.83	9.77	.85
		±5.74	±2.47	±12.61		±7.81	±7.05	±8.32	
V CoP (cm/s)	EC	3.81	3.96	3.64	.46	1.52	1.42	1.32	.64
		±1.91	±2.08	±1.96		±0.93	±0.48	±0.46	
	EO	2.33	2.35	2.18	.72	1.41	0.82	0.89	.12
		±1.23	±1.45	±1.17		±1.25	±0.22	±0.28	
	TS	6.30	6.14	5.57	.88	4.37	4.11	3.34	.46
		±4.17	±5.41	±3.03		±1.67	±1.63	±1.28	
	US*	7.97	7.81	7.25	.47	5.67	4.94	4.49	.61
		±4.18	±1.49	±1.79		±3.23	±2.13	±2.47	
WD EC (%)	H/ ND	33.33	33.56	30.56	.30	48.52	48.11	47.44	.54
		±11.26	±10.69	±14.35		±5.87	±3.82	±4.72	
	NH/ D	66.67	66.44	69.44	.30	51.48	51.89	52.56	.54
		±11.26	±10.69	±14.35		±5.87	±3.82	±4.72	
WD EO (%)	H/ ND	31.67	31.22	32.78	.97	48.12	48.75	47.54	.49
		±12.50	±12.39	±11.49		±4.48	±4.79	±4.27	
	NH/ D	68.33	68.78	67.22	.97	51.88	51.25	52.46	.49
		±12.50	±12.39	±11.49		±4.48	±4.79	±4.27	
TTS** (s)	H/ ND	2.61	2.66	2.61	.90	2.69	2.67	2.21	.37
		±1.05	±0.79	±0.81		±0.44	±1.21	±0.46	
	NH/ D	2.23	2.80	2.61	.46	2.62	2.40	2.18	.26
		±0.80	±1.46	±0.86		±0.44	±0.89	±0.50	

EO = eyes open; EC = eyes closed; TS = tandem stance; US = unipedal stance; CoP = Centre of Pressure; CoPAP = maximal deviation of CoP in anterior posterior direction; CoPML = maximal deviation of CoP in medio-lateral direction; V CoP = velocity of CoP excursion; NH = non hemiplegic; H = hemiplegic; ND = non dominant; D = dominant; FR = functional reach; AM = actimove; SH = shoulderlift; WS = without sling
*Only 4 stroke patients could complete the US test.
** H/ND side = time needed to regain stability when platform moved to the hemiplegic or non-dominant side
NH/D side = time needed to regain stability when platform moved to the non-hemiplegic or dominant side

Posture and Gait

Spatiotemporal parameters

To allow the stroke patients to walk independently the use of walking aids was permitted. Three participants used a tripod, two used a one-point walking stick and four walked without walking aid. Concerning the gait parameters, the GAITRite could not detect statistical significant differences between the different conditions within each group except for the stride length on the non-dominant side of the control group (Table IV). Pairwise comparison revealed a significant higher stride length of the non-dominant side for healthy persons not wearing a sling compared to healthy persons who wore the Actimove sling (p=.029).

Table IV. Overview of spatiotemporal gait parameters for both groups (mean ± SD).

		Stroke group				Control group			
		AM	**SH**	**WS**	**P**	**AM**	**SH**	**WS**	**P**
Velocity (m/s)		0.38 ±0.33	0.36 ±0.31	0.36 ±0.29	.72	1.27 ±0.17	1.26 ±0.16	1.30 ±0.16	.46
Cadence (steps/min)		58.88 ±27.79	57.93 ±26.43	59.46 ±24.89	.46	108.20 ±9.44	107.59 ±6.55	109.21 ±8.54	.64
Stride length (m)	H/ND side	0.81 ±0.38	0.78 ±0.35	0.86 ±0.52	>.99	1.41 ±0.14	1.41 ±0.14	1.43 ±0.14	.03*
	NH/D side	0.70 ±0.29	0.72 ±0.25	0.74 ±0.32	.46	1.41 ±0.13	1.41 ±0.15	1.43 ±0.14	.10
Step width (cm)	H/ND side	16.57 ±4.15	16.97 ±3.95	16.88 ±3.90	.90	9.79 ±2.33	9.70 ±2.50	10.34 ±2.42	.41
	NH/D side	16.05 ±4.47	16.54 ±4.40	15.98 ±4.63	.61	9.60 ±2.34	9.74 ±2.43	10.02 ±2.52	.33
Stance time (s)	H/ND side	2.30 ±1.98	2.20 ±1.73	2.94 ±4.10	.64	0.70 ±0.07	0.70 ±0.06	0.69 ±0.06	.64
	NH/D side	2.64 ±2.25	2.40 ±1.66	3.47 ±4.13	.64	0.70 ±0.07	0.70 ±0.05	0.69 ±0.06	.92
Double support time (s)	H/ND side	2.69 ±3.35	3.45 ±4.62	3.64 ±6.19	.77	0.29 ±0.05	0.29 ±0.05	0.28 ±0.05	.46
	NH/D side	3.87 ±5.77	3.57 ±4.72	5.80 ±9.49	.55	0.29 ±0.05	0.29 ±0.04	0.28 ±0.04	.58

AM = actimove; SH = shoulderlift; WS = without sling; H = hemiplegic; NH = non-hemiplegic; D = dominant; ND = non-dominant.
***p<0.05**

Trunk excursion

No statistical significant differences could be detected between different conditions within each group (table V). When comparing the two groups, in most conditions, there were no significant differences detectable (table VI).

Table V. Angles of trunk excursion at heelstrike (HS), toe-off (TO) and during midstance (MS) for both groups (°; mean ± SD).

		Stroke group				Control group			
		AM	SH	WS	P	AM	SH	WS	P
HS	H/ND side	91.69 ±10.57	89.87 ±7.41	92.21 ±10.19	>.99	96.20 ±5.97	95.10 ±2.55	93.97 ±4.59	.12
	NH/D side	92.98 ±9.80	90.93 ±5.20	94.99 ±12.20	>.99	93.11 ±6.76	95.20 ± 7.55	95.25 ±5.77	.31
TO	H/ND side	94.48 ±19.12	90.77 ±9.53	93.50 ±21.17	.31	90.85 ±3.64	92.93 ±7.07	93.82 ±5.84	.31
	NH/D side	91.38 ±9.64	89.31 ±5.33	91.63 ±10.83	.85	95.30 ±6.67	98.36 ±5.96	96.92 ±5.77	.51
MS	H/ND side	93.54 ±9.90	94.87 ±9.45	93.86 ±12.27	.87	94.83 ±5.55	96.06 ±4.79	96.12 ±4.66	.51
	NH/D side	93.57 ±14.07	90.78 ±9.89	98.14 ±15.55	.37	92.75 ±4.19	100.44 ±16.05	94.71 ±4.85	.22

AM = actimove; SH = shoulderlift; WS = without sling; H = hemiplegic; NH = non-hemiplegic; D = dominant; ND = non-dominant.

Table VI. Comparing trunk excursion between groups (p values).

		AM	SH	WS
HS	H/ND side	.17	.18	.28
	NH/D side	.49	.48	.48
TO	H/ND side	.73	.75	.48
	NH/D side	.11	**.04***	.06
MS	H/ND side	.36	.57	.30
	NH/D side	.56	.28	.90

NH = non hemiplegic; H = hemiplegic; ND = non dominant; D = dominant; AM = actimove; SH = shoulderlift; WS = without sling; HS = heelstrike; TO = toe-off
***p < .05**

DISCUSSION

Balance and gait training after stroke are vital components in rehabilitation, mainly because stability and locomotion are strong predictors of independence in daily living [18]. In the present work, we used a controlled design to investigate the potential effect of two conceptual different arm slings: 1) the Actimove sling and 2) the Shoulderlift versus not wearing a sling, on balance and gait in patients with stroke. In our selected population sample, we found no differences between either wearing slings or not nor between the two types of slings on postural stability tests, trunk excursion and spatiotemporal gait parameters. This may suggest, that the use of an arm sling does not seems to influence balance or gait in stroke patients with given characteristics. Hence, we propose that in this defined population the prescription of arm slings should not be inspired by an assumed beneficial effect on balance or gait. To consider this proposition for the group of stroke patients in general further research is mandatory.

To the best of our knowledge, we are the first case control study that has tested the effect of two different arm slings in subacute stroke patients on balance and gait in combination with the trunk excursion, which could have clinical implications, as arm slings are frequently considered as an adjuvant therapy for patients with stroke [4].

Balance

Considering the *postural stability tests* our results suggest that static balance is not influenced by the use of an arm sling. Our results confirm the findings of Sohn et al. [13], who also did not find significant differences in comparing CoP excursion with and without sling. In the study of Sohn and colleagues [13], stroke patients were recruited earlier after stroke (mean of 9 weeks) than in the present study (mean of 6 months), and different types of slings were used (Bobath axillary support and simple arm sling in study of Sohn et al. vs Actimove sling and Shoulderlift in present study). Moreover, the patients included in their study suffered a mild to moderate stroke when looking at upper limb recovery (Mean FM UL score Sohn et al. 38/66, vs present study 22/66) but scored very close to our patients on the Berg Balance Scale (Sohn et al. 46.4/56; present study 42.2/56) [13]. Despite these methodological differences we found similar results, reaffirming the absence of immediate positive effects of wearing slings on balance and gait.

In contradiction, Acar and Karatas (2010) [9] reported a decrease of the postural sway when wearing an arm sling. Many factors might contribute to this conflicting evidence. For example, they recruited patients with an average time post stroke of 3 months. This shorter time post-stroke in comparison to our study (average of 6 months), might have influenced the patient's swinging of the upper limb during the balance tests. Since uncontrolled arm movements mostly occur in the early phase after stroke when the upper extremity is more or less flaccid [19], it could be argued that the difference in the time post stroke could have explained the divergent results.

Also, in the study of Acar and colleagues [9], patients had a median Brunnstrom stage for the upper extremity of 3 and a mean Berg Balance score of 29.8/56 representing more difficulties with balance compared to our study population (average score BBS 42.2/56). Since the upper limb recovery is not expressed in a score on the Fugl-Meyer assessment, comparison with our study population is difficult. Another important factor that could have played an important role in the effect of arm slings is the type of sling tested. Since Acar and colleagues did not provide specific details about the arm sling they used we cannot make a comparison with the arm slings we used.

When looking at the results from the postural control test within the control group, similar to the stroke patients, they did not show statistical differences between the use of any arm sling compared to no sling. In general, healthy controls do have a better postural stability than stroke patients, which is not surprising. In fact, it has been described that the postural sway of stroke patients is twice of that of their healthy peers [20].

Posture and Gait

Spatiotemporal gait parameters Similar to the balance tests, we found no sling-based differences in spatiotemporal gait parameters. These results are not in line with previous findings showing that the use of an arm sling could increase walking stability and efficiency. More specifically, it has been documented that patients with subacute stroke have a more symmetrical *gait* pattern with better loading on the hemiplegic leg [10, 11] and an increased walking speed [10] when wearing an arm sling. There are several explanations for these divergent results.

First, in healthy subjects, arm swing amplitude increases with gait speed and is reduced by cognitive loading [21]. Stroke patients often walk very slow and need sufficient attention to accomplish gait. The combination of slow walking (0.36-0.38 m/s in this study compared to 0.62 m/s in the study of Hesse et al.) and high cognitive loading during walking without a sling implied a very small amplitude of arm swing in our trial, possibly mimicking the suppression of the arm-induced CoP excursion by means of the sling. Second, high cognitive loading also increases muscle tone, resulting in less uncontrolled arm swing in stroke patients who walk very slow. Since this spontaneous restricted arm movement could mimic the suppression of the arm-induced CoP excursion by means of a sling, different walking conditions may have become very similar regarding integration of arm movement.

Third, gait speed in stroke patients is also influenced by the use and the type of walking aids [22, 23]. Patients in the study of Yavuzer and Ergin (2002) [10] had better walking capacities and therefore were able to walk independently and performed their gait analysis barefoot, while our patients had to walk under supervision and were allowed to use walking aids and ankle-foot orthoses. This may explain why the patients in the study of Yavuzer and Ergin (2002) [10] showed an improved gait when wearing an arm sling and our patients did not.

Trunk excursion From a clinical point of view, we would expect that wearing an arm sling would emphasize the trunk asymmetry in stroke patients. For that reason, we registered the trunk excursion during gait. Since no statistical differences could be detected between the different conditions in the stroke group, it is most likely that the trunk excursion, measured during walking, is not the result of wearing the arm sling.

Clinical impact

Notwithstanding the exploratory merits of this study and the sincere aspiration to optimize rehabilitation, this study might offer some novel insights into the clinical limitations of prescribing arm slings in patients with subacute stroke. Since, no effect could be detected, the impact of using arm slings on posture, balance and gait can be questioned and should be addressed with appropriate consideration.

Limitations of our study

The main limitation of this study is that we only tested the immediate effects of the use of an arm sling and did not include longer wearing time trials that could have revealed the long term effects of wearing an arm sling on balance and gait. Also, due to the small sample size and specific inclusion criteria in the present work, our results must be interpreted in view of the given description and can therefore not be generalized to all stroke patients. Additionally, in future studies we would recommend the inclusion of an adaptation period, allowing patients to become familiar with each arm sling, to avoid confounding factors such as patient's discomfort that could have negatively influenced our test results.

Furthermore, since the effect of wearing an arm sling on balance might be elicited by reducing the CoP excursion induced by an uncontrolled swinging of the arm, the inclusion of a more dynamic balance test is advisable.

CONCLUSION

Based on the results of the present study, we can state that in a stroke population matching the described characteristics balance and gait are not prone to be immediately influenced by the use of an arm sling. The results of our study indicate that further research into the assumed sling benefits is warranted. Despite the frequently use of arm slings in the treatment of patients with stroke, we argue that their assumed positive effect on balance and gait not always seems to be an additional indication to prescribe an arm sling. Nonetheless, further research is warranted to study the long term effects of using an arm sling on balance and gait.

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APPENDICES

Appendix 1. Comparing CoP outcome parameters between groups (p values).

		P CoP	P CoPML	P CoPAP	P area of CoP	P velocity of CoP
AM	**EC**	**.005***	**.001***	**.007***	**<.001***	**.005***
	EO	**.004***	**.005***	**.005***	**.002***	**.02***
	TS	.29	.39	.21	**.009***	.29
SH	**EC**	**.001***	**<.001***	**.007***	**<.001***	**.001***
	EO	**.001***	**.001***	**.004***	**<.001***	**.001***
	TS	.34	.63	.25	.102	.34
WS	**EC**	**.001***	**<.001***	**.005***	**<.001***	**.001***
	EO	**.002***	**.001***	**.004***	**.001***	**.002***
	TS	.15	.21	.08	**.001***	.15

EO = eyes open; EC = eyes closed; TS = tandem stance; CoP = Centre of Pressure; CoPAP = maximal deviation of CoP in anterior posterior direction; CoPML = maximal deviation of CoP in medio-lateral direction; AM = actimove; SH = shoulderlift; WS = without sling
***p<.05**

Appendix 2. Comparing weight distribution between groups (p values).

Condition	EC/EO	Side	P
AM	**EC**	H/ND side	**.003***
		NH/D side	**.003***
	EO	H/ND side	**.005***
		NH/D side	**.005***
SH	**EC**	H/ND side	**.003***
		NH/D side	**.003***
	EO	H/ND side	**.001***
		NH/D side	**.001***
WS	**EC**	H/ND side	**.009***
		NH/D side	**.009***
	EO	H/ND side	**.004***
		NH/D side	**.004***

EO = eyes open; EC = eyes closed; NH = non hemiplegic; H = hemiplegic; ND = non dominant; D = dominant; AM = actimove; SH = shoulderlift; WS = without sling
***p<.05**

Chapter 5

Mobilization techniques of the hemiplegic shoulder in subacute stroke patients with poor arm recovery: a randomized multiple treatment trial

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ABSTRACT

Background: Performing a careful and effective mobilization of the hemiplegic shoulder in subacute stroke patients in view of a functional range of motion remains a clinical challenge. So far however no studies compared different mobilization techniques for the hemiplegic shoulder.

Objectives: Comparison of different mobilization techniques for the hemiplegic shoulder for the primary outcome of shoulder passive range of motion (PROM).

Methods: 11 subacute (first) stroke patients with upper limb impairment, were recruited in the Rehabilitation Center of the Ghent University Hospital. Three different mobilization techniques for the hemiplegic shoulder were applied in randomized order: (1) a combined soft-tissue mobilization in the scapular plane, (2) a scapular mobilization without glenohumeral movement and (3) an angular mobilization in the frontal plane. All techniques were applied for four weeks. Primary (PROM shoulder) and secondary (Shoulder pain, Fugl-Meyer assessment upper extremity part, Trunk Impairment Scale, Modified Ashworth Scale for spasticity) outcome measures were assessed before intervention (0 weeks) and after 4, 8 and 12 weeks. Trial registration: NCT 03211364.

Results: After technique 1 (combined) patients showed an increased PROM for external shoulder rotation (+ 6.82°; p=0.006) compared to the other 2 techniques (scapular mobilization -7.27°; angular mobilization -5.45°). Although no other significant differences could be detected for other outcome measures patients did not show a decrease of PROM for shoulder abduction after technique 1 (+ 0.45°; p=0.057) compared to technique 2 (-8.18°) and 3 (-6.82°).

Conclusions: Using the combined soft-tissue mobilization in subacute stroke patients with poor arm recovery resulted in an increased PROM for external shoulder rotation compared to a decrease after the other two interventions.

Key words: Stroke – Cerebrovascular accident – Hemiplegia – Shoulder joint – Hemiplegic shoulder pain – Passive mobilization – Range of motion

INTRODUCTION

Stroke opposes rehabilitation therapists with a wide variety of challenges including restitution, substitution or compensation of functional abilities as well as the prevention and treatment of several complications. The often poor prognosis of upper limb (UL) recovery post stroke and the potential of mobility related complications is one of the reasons why, in people with severe arm paresis, therapists are inclined to apply more passive therapeutic interventions instead of active arm-oriented therapy modalities [1, 2]. The emerging relative immobility of a poor recuperating UL tends to result in increasing weakness, sensory loss, loss of cortical representation and development of learned non-use and contractures [3, 4]. Hence, 60% of all stroke patients have been reported with muscle contractures [5] leading to fixation of joints in unnatural and functional jeopardizing positions [6]. These contractures already start to develop in the first weeks after stroke and increase over time [7]. Except for the pain they can cause, they can also hamper daily personal care and impede active functional movement capabilities [8]. Due to the altered muscle activation patterns after stroke the upper limb post-stroke posture usually includes internal rotation and adduction of the shoulder [9]. The limited external rotation [10, 11] and/or abduction [12-15] is a well-known risk factor combination in the development of hemiplegic shoulder pain (HSP). This risk profile implies that maintaining an appropriate passive range of motion (PROM) of the shoulder joint should be seen as a priority from early after stroke onset in order to prevent the development of HSP [16]. However, the question arises which is the most efficient, most effective and the safest way to preserve PROM of the shoulder. Current stroke rehabilitation guidelines prefer active exercise and task-specific training of the upper limb above passive therapy modalities [9]. Nevertheless for a substantial amount of patients, therapists have to rely on more passive interventions (e.g. stretching, passive mobilization) to avoid complications (e.g. contractures) due to the slow and difficult recuperation. Notwithstanding the motivation for a shift to more passive interventions a recent review on the effectiveness of stretching indicates that there is no clinical important effect on joint mobility in stroke patients [17]. Studies on passive mobilization of the UL after stroke are scarce. In view of the prevention of the development of soft tissue contractures [18] and HSP [16] the need for early passive mobilization is generally accepted. However, the risk on generating impingement [19], soft tissue injuries [20, 21] and even HSP [22] is considered to be substantial when passive mobilization is not performed in the most qualitative way, i.e. safe and effective. Increases in the amount of abnormal findings during sonographic examination in stroke patients with HSP in their chronic stage compared to the sonograms of in their acute stage indicate that these injuries might be the result of inadequate therapeutic interventions and inappropriate handling [14]. Although no causal relationship is actually underpinned, this assumption might be withheld from the study of Hardwick et al. (2011) revealing altered scapular and humeral movement patterns during ROM exercises increase the risk on developing HSP [23].

Turner-Stokes and Jackson (2002) previously formulated recommendations considering passive mobilization of the hemiplegic shoulder [19]: 1) reduce muscle tone [24] and relocate the humeral head [25] before starting the passive mobilization if necessary, 2) ensure appropriate rotation of the scapula and humerus to avoid impingement and/or rotator cuff injuries [19] and 3) avoid overstretch of the biceps long head tendon and subscapularis tendon [14]. Irrespective of these recommendations there are, to our knowledge, no studies comparing different mobilization techniques for the hemiplegic shoulder. Due to the clinical importance and the lack of comparative assays we conducted a randomized multiple treatment trial comparing different mobilization techniques. The primary goal was to investigate whether there were different effects on shoulder PROM in stroke patients depending on the performed mobilization technique.

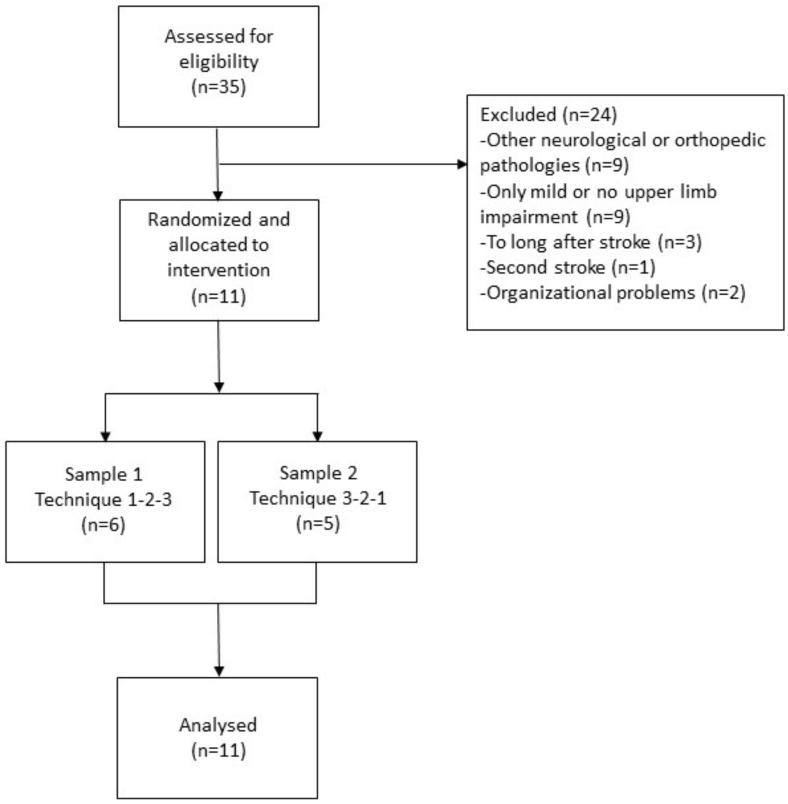
MATERIAL AND METHODS

Participants

Eleven participants (> 18 years) were recruited from the Rehabilitation Center of the Ghent University Hospital after adopting the exclusion criteria to the eligible 35 patients. Patients who were maximal six months after a first stroke that resulted in upper limb impairment were eligible to participate. Patients were excluded if they had shoulder pain prior to their stroke, when orthopedic surgery was performed at the hemiplegic shoulder before the stroke occurred or when active ROM was sufficient to maintain PROM by active exercise. Also patients with additional orthopedic or neurologic problems that could interfere with shoulder mobility or pain were not allowed to participate.

This study was approved by the Medical Ethics Committee of the Ghent University Hospital (Belgium registration) and registered in a public repository (NCT 03211364). All recruited participants agreed and signed an informed consent prior to the study.

Figure 1: Flowchart of sample.



Design

A multiple treatment design was chosen in order to compare the different mobilization techniques within the same patients [26]. Mobilization was performed by physiotherapists who were trained in neurological rehabilitation. Prior to the study these therapists attended two specific training sessions to instruct and secure alignment regarding the different techniques. Also instruction videos were available at any time during the study.

Procedure

Patients were randomly allocated to one of the two samples. Randomization happened based on a computer generated sequence (www.randomizer.org). The first sample (sample 1) received their mobilization in following order: technique 1-2-3. In the second sample (sample 2) the reverse order was applied (technique 3-2-1). Each technique was carried out for four weeks, resulting in a total intervention time of 12 weeks. Patients received their mobilization during five days a week. The time spent on mobilization of the shoulder joint was 10 to 20 minutes within a maximum of 30 minutes to be spent on the mobilization of the whole upper limb. During the intervention period no intra-articular injections of the shoulder joint nor injections of shoulder muscles using botulinum toxin were allowed.

Intervention techniques

The first technique (technique 1) was the combined soft tissue mobilization of the shoulder joint in the scapular plane. In this technique glenohumeral movements were preceded by transversal stretch of hypertonic muscles (mm pectorals, m. biceps, m. latissimus dorsi/teres major) to reduce the muscle tension in order to achieve capsular stretch. Besides, during this technique, the humeral head was positioned more posterior in the glenoid fossa aiming to improve joint congruence and the humerus was positioned in relative external rotation. To obtain this position the physiotherapist placed the elbow anterior to the shoulder during the time of mobilization. The second technique (technique 2) was a scapular mobilization (all directions). As this technique 2 did not included glenohumeral movements it was considered as control intervention and therefore organized in between the other two techniques for both samples. This approach was seen as most appropriate from an ethical point of view instead of offering “no” treatment. The third technique (technique 3) was the angular glenohumeral mobilization in all directions of the shoulder joint with shoulder abduction and rotations in the frontal plane. This technique is considered as the usual care angular mobilization. Technique 1 and 3 were performed with the patients lying in supine, technique 2 with the patients in side-lying. The therapists were instructed to stay below the threshold when observing sharp pain in/around the shoulder joint during mobilization, stretch pain was allowed and the goal was to reach the maximal PROM.

Outcome measures

The primary outcome measure was the PROM of the shoulder, measured using a manual goniometer with the patients lying in supine. The maximal degrees of PROM were noted for flexion, abduction, external and internal rotation of the shoulder joint. Measurements were performed by a physiotherapist specifically trained to guarantee standardization of the given measurement procedures. If assistance was needed a second physiotherapist helped to position the arm. A manual goniometer to measure PROM is a reliable method in healthy persons [27] and stroke patients [28].

The secondary outcome measures consisted of shoulder pain (VAS), the Trunk Impairment Scale (TIS), the upper extremity part of the Fugl-Meyer Assessment (FMUE) and the Modified Ashworth Scale (MAS). Pain intensity was measured using a visual analogue scale (VAS). Patients were asked to rate their shoulder pain during rest, during activities and during the night on a scale from 0 to 10 [29]. Additionally, after every period of four weeks mobilization in a given technique patients were asked if they felt pain during the mobilization. If they confirmed, they were asked to score the intensity (VAS) and to identify the type of pain (sharp or stretch). The TIS is a reliable method to examine the trunk stability with a score ranging from 0 to 23 [30]. Trunk stability was measured to evaluate the natural progress of recovery after stroke. The FMUE was used to quantify the motor deficits of the

upper limb [31, 32]. The total score of the UL section is 66 and 36 for the shoulder-elbow part (FMUE_SE). The spasticity of the shoulder muscles and elbow flexors was measured using the Modified Ashworth Scale, with the patients lying in supine.
All outcome measurements were taken at baseline and after 4, 8 and 12 weeks of treatment.

Data analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences, version 24 (SPSS 24.0). To compare the outcome measures after each intervention period the differences were calculated between the beginning and the end of the intervention period. Grouped data are presented as means ± standard deviation for each technique. Statistical significance was accepted at a p-level < .05. Due to the small sample size, non-parametric tests were used. To compare the different variables between the two samples a Mann-Witney U test was used. The Friedman test was used to compare the different techniques. If a significant difference was detected, an automatic pairwise post-hoc analyses function of the Friedman test was used to calculate adjusted probabilities (Bonferroni correction).

RESULTS

11 participants were recruited and underwent all three mobilization techniques. Mean time post stroke for the entire study population was 52.82 (± 19.37) days and the mean FMUE_SE score was 7.45 (±5.66). PROM of the shoulder at the start of the intervention was 120° (± 29.07) flexion, 91.36° (±11.64) abduction and 27.27° (± 23.17) external rotation. Pain intensity score at the start of the intervention was 4.18 (± 3.13) during activities and 1.18 (± 2.64) during the night. Patients had no pain at rest before starting the intervention. All participants were randomly assigned to sample 1 (n=6) or sample 2 (n=5). The two samples were comparable for both the demographic data and baseline variables (table I).

Table I. Demographic data and baseline variables (average ± SD) at the start of the intervention (week 0).

	Sample 1 Technique 1-2-3	Sample 2 Technique 3-2-1	P
Age (y)	50.5 (±10.6)	55.8 (±4.7)	0.537
Number of patients included	6	5	
Gender (M/F)	4/2	4/1	
Side hemiparesis (L/R)	4/2	1/4	
Type stroke (I/H)	4/2	4/1	
Time post stroke (d)	58 (±22.33)	46.6 (±15.04)	0.329
PROM flexion at 0 weeks (°)	124.17 (±31.69)	115 (±28.28)	0.537
PROM abduction at 0 weeks (°)	94.17 (±9.17)	88 (±14.41)	0.429
PROM external rotation at 0 weeks (°)	26.67 (±28.58)	28 (±17.89)	0.931
VAS activities at 0 weeks	4 (±3.29)	4.40 (±3.29)	0.931
VAS night at 0 weeks	0	2.60 (±3.58)	0.329
TIS at 0 weeks (max 23)	8.5 (±6.19)	12.40 (±4.16)	0.429
FMUE at 0 weeks (max 66)	10.83 (±10.38)	10 (±12.31)	0.931
FMUE_SE at 0 weeks (max 36)	7.33 (±5.05)	7.60 (±6.95)	0.931

y = year; M = male; F = female; L= left; R = right; I = ischemic; H = hemorrhagic; d = days; PROM = passive range of motion; TIS = trunk impairment scale; FMUE = Fugl-Meyer Assessment upper extremity; FMUE_SE = shoulder elbow part of the Fugl-Meyer Assessment

When comparing the average change in primary outcome parameters between the three different techniques (table II) a significant difference could be detected for the PROM for external rotation of the shoulder (p=0.006). After the combined soft tissue mobilization an average increase of 6.82° (±9.20°) was noted while after the two other techniques PROM external rotation decreased. Pairwise comparison for this variable is presented in table III. No significant differences could be detected for the other primary outcome measures nor for the secondary outcome measures (table II and IV).

Table II. Baseline value (average ±SD) and average (±SD) change in primary and secondary outcome parameters for each intervention.

	Week 0	Technique 1	Technique 2	Technique 3	P
PROM flexion (°)	120 (±29.07)	-0.45 (±9.86)	-5.91 (±22.00)	-9.55 (±25.64)	0.663
PROM abduction	91.36 (±11.64)	0.45 (±5.22)	-8.18 (±12.30)	-6.82 (±13.09)	0.057
PROM external rotation	27.27 (±23.17)	6.82 (±9.20)	-7.27 (±10.81)	-5.45 (±11.72)	**0.006***
VAS rest	0	0.73 (±2.01)	0.18 (±0.75)	0 (±0.89)	0.819
VAS activities	4.18 (±3.13)	-1.18 (±2.23)	1 (±3.55)	-0.64 (±2.62)	0.539
VAS night	1.18 (±2.64)	0.18 (±0.60)	0 (±0)	-0.73 (±1.85)	0.156
MAS shoulder retroflexors	0.36 (±0.51)	1.36 (±0.32)	-0.23 (±0.82)	0.32 (±0.56)	0.250
MAS shoulder adductors	0.32 (±0.56)	-0.23 (±0.41)	-0.09 (±0.30)	0.00 (±0.45)	0.424
MAS shoulder internal rotators	1 (±0.87)	-0.14 (±0.74)	0.09 (±0.66)	0.09 (±0.30)	0.519
MAS elbow flexors	1.14 (±0.64)	0.00 (±0.39)	-0.05 (±0.47)	0.00 (±0.67)	0.908
TIS	10.27 (±5.50)	2.64 (±4.72)	1.27 (±1.42)	1.36 (±1.57)	0.562
FMUE	10.45 (±10.71)	1.82 (±4.4)	1.45 (±1.64)	1.64 (±2.06)	0.916

PROM = passive range of motion; VAS = Visual analogue Scale; MAS = Modified Ashworth Scale; TIS = trunk impairment scale; FMUE = Fugl-Meyer assessment upper extremity part; ***p>0.05**

Table III. Pairwise comparison of the average change in PROM for external rotation.

	P
Technique 1 – Technique 2	**0.043***
Technique 3 – Technique 1	**0.023***
Technique 2 – Technique 3	1.000

***p<0.05**

Table IV. Pain during mobilization (VAS; average ±SD).

	Technique 1	Technique 2	Technique 3	P
Sharp pain	1 (±1.95)	0.64 (±1.43)	1.91 (±2.74)	0.350
Stretch pain	3.36 (±3.20)	2.27 (±2.69)	3.27 (±3.20)	0.407

VAS = visual analogue scale

DISCUSSION

Preserving the PROM of the hemiplegic shoulder is a frequent therapeutic aim especially in those stroke patients confronted with a poor recovery of the upper limb. As a limited shoulder PROM will not only hamper the daily activities of these patients [8] (e.g. dressing, personal care, …) it will also increase the risk on developing a debilitating HSP [12-15]. As such for patients with restricted active movement abilities in the UL after stroke, passive mobilization is often used to preserve a functional PROM. Unfortunately, when passive mobilization is performed with a lack of appropriate caution and apprehensiveness, the risk on soft-tissue injuries increases leading to a higher risk on developing HSP [22]. As to our knowledge no comparative studies regarding different mobilization techniques for the hemiplegic shoulder are available in this relevant clinical domain this multiple treatment trial to investigate the effect of three different mobilization techniques on the PROM of the shoulder joint and on shoulder pain was executed.

After the combined soft tissue mobilization (technique 1) participants had a significant increased (6.82° ± 9.20) passive shoulder external rotation compared to the other two techniques. A decrease or augmented mobility limitation of 7.27° (±10.81) was noted after the scapular mobilization (technique 2) and of 5.45° (±11.72) after the usual care angular glenohumeral mobilization (technique 3). Measuring PROM of the hemiplegic arm has been proven to be reliable in stroke patients [28]. According to the reliability study of de Jong et al. (2012) an ICC of 0.94 (0.91-0.96) was noted for the PROM external rotation with a Standard Error of Measurement (SEM) of 5.9° and a Smallest Detectable Difference (SDD) of 16.3° over a period of 20 weeks. Our study population resembles the study population of de Jong et al. (2012) considering the time post stroke and the UL recovery. However, the maximal time in between measurements in our study was only four weeks, implying that there may be less confounding factors to affect the outcome. Therefore we may consider a mean change of 6.82° (± 9.20) to be a real difference since it is higher than the SEM indicated by de Jong et al. (2012). Moreover, the average difference of 13° between the increase in PROM in external rotation after technique 1 and the decreases after technique 2 and 3 approaches the 16.3° as the SDD over 20 weeks [28]. As to our knowledge there are no standard deviations available for PROM goniometric measurements of the shoulder in stroke patients, a priori power calculations could not be performed. To assess the power and effect size of the difference in PROM for external rotation between the different techniques a power analysis (G*Power) was conducted using the standard deviations of our own study. This analysis showed a large effect size (f = 0.57) with a power of 80% for the given sample size. Our results exceeded the SEM and the SDD indicated by Cools et al (2014). However, this reliability study was conducted in healthy persons. For the shoulder flexion and abduction no significant differences could be detected between the different techniques in our study. Although there was no decrease of PROM shoulder abduction after technique 1 compared to a distinct decrease after the two other techniques (-8.18° after technique 2, -6.82° after technique 3), these differences were not significant.

There were no significant differences detected for shoulder pain between the different techniques. The differences calculated between the shoulder pain before and after the different techniques were overall very low, which means there were no important changes in shoulder pain. Also for the other outcome parameters (spasticity, TIS, FMUE) no significant differences could be detected. So, these variables did not influence the differences in PROM for external rotation.

Finally, patients were also asked if they experienced any pain during the mobilizations besides an eventual feeling of stretch pain. Although the therapists were instructed to stay below the pain threshold when observing sharp pain in or around the shoulder joint during mobilization some patients did report the presence of sharp pain after the intervention. Despite the fact that no significant differences could be detected between the different techniques for both types of pain, patients did experience more stretch pain relative to sharp pain.

The physiotherapist who performed the mobilizations were asked about their opinion and experiences with the given techniques during the study without informing them on the present results. They all agreed that patients needed habituation time when the technique changed. It seemed that they indicated more pain in the first week of a new technique although “pain” was not always the most appropriate lexicon. Sometimes they just experienced an increased sensitivity that accompanied the uncertainty about the new technique. According to their opinion participants had to adjust most during the first week of scapular mobilization. A possible hypothesis was that the patients were not used to mobilizations performed when they were side lying. And the increased sensitivity was most apparent after the period of scapular mobilization when there were no glenohumeral movements performed. During the combined soft tissue mobilization patients mentioned less pain/sensitivity and therapist had the impression that they had more control over the hemiplegic arm leading to the idea that they could achieve more mobility without evoking more pain. However, the morphology (i.e. size of the shoulder with respect to manual handling) of the participant and the degree of increased muscle tone may have influenced the performance of this technique.

Limitations

Some limitations of this study need to be addressed. Due to the small sample size, the results have to be interpreted with appropriate reservation and need to be carefully addressed with respect to generalization to all stroke patients. The patients included in this study were subacute stroke patients with a poor recovery of the upper limb indicated by a mean score on the FMUE_SE of 7.45. However, if patients have a better recovery of their upper limb indicated by a higher score on the FMUE, passive mobilization of the shoulder joint is less important since active task-specific training would be preferred for these patients. Since patients were in the subacute phase after stroke, it is unlikely that their condition already reached a stable state. However, since no difference could be detected in FMUE scores nor in pain scores (VAS), it is unlikely that the change in PROM for external rotation is due to natural improvement. Not including a pure control group can be interpreted as a shortcoming, but not treating stroke patients cannot be considered ethically acceptable. Also, the ROM of our study population was already restricted at the start of the intervention. In the future, studies comparing mobilization techniques starting from the first week after stroke should be conducted. Finally, limitations in the use of a visual analogue scale for pain in stroke patients should be taken into consideration. Due to sensory impairments, self-reported pain is not always considered reliable in stroke patients. Unfortunately, as far as we know, there are no more objective ways available to measure pain in stroke patients.

CONCLUSION

Using the combined soft-tissue mobilization in subacute stroke patients with poor arm recovery results in an increased PROM for external shoulder rotation, whereas after the other two interventions a decrease of PROM for this movement direction was noticed. Since external rotation is an essential biomechanical component in the prevention of hemiplegic shoulder pain, combined soft-tissue mobilization can be recommended for that matter.

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General Discussion 6

Summary of main findings

Strengths and limitations

Clinical recommendations and future perspectives

1. Summary of main findings

Early after stroke onset reduced arm function is reported in 76% of the patients. About 62% of these patients with initial arm paresis (mean FMUE score 7/66; mean ARAT score 0/57 within 14 days after stroke onset) will not recover a minimal dexterity (> 10/57 on the ARAT) at 6 months post stroke [1]. This poor recovery of UL function renders unfavorable perspectives for the future functional independence in ADL situations and of the QoL[2, 3] of these patients. Therefore, scientists and therapists are permanently challenged to search for more effective therapy strategies that fit in accordance with actual recommendations: sufficient high intensity and dose in order to maximize the biological and functional potential for UL recovery [4, 5] and concurrently minimize secondary complications. An interesting starting point to explore needs for that matter and develop warranted strategies encompasses not only the understanding of the available scientific evidence, but also the integration of a daily practice based sounding board. So far, such empirical evidence originating from the clinical working field, where the actual challenge is felt, is scarce and even completely lacking in Flanders. Any knowledge on the insights in current therapeutic strategies regarding UL rehabilitation after stroke in Flanders was unavailable, nor was there any insight in the perception and appreciation of the Flemish stroke survivors regarding their UL status and therapy. So, the first aim of this doctoral thesis was to describe the current practices in UL rehabilitation after stroke in Flanders and to gain insight in the stroke survivors views about their UL status and therapy (chapter 2). For that purpose we conducted a survey among 80 therapists (physiotherapist and occupational therapist) experienced in the field of stroke rehabilitation and 220 stroke survivors (subacute and chronic phase after stroke) in Flanders. The major topics covered in this survey were I) passive mobilization, II) active exercises, III) immobilization, IV) motor recovery and expectations and V) comfort, pain and QoL. Results indicated that passive mobilization of the hemiplegic arm and the use of arm slings are frequently applied strategies in Flemish UL stroke rehabilitation. Despite the frequent clinical use, a lot of scientific questions still arise regarding the effectiveness of and best practices in these interventions. The exploration of these questions rendered into three studies that were adopted in this thesis. The effectiveness of two arm slings was explored in a randomized controlled trial to compare the effect on shoulder subluxation and shoulder pain in subacute stroke patients (chapter 3). Also the immediate effect of both slings on posture, balance and gait was examined to cover all possible beneficial aspects of the use of these same arm slings in subacute stroke survivors (chapter 4). Finally, we compared different techniques for passive mobilization of the hemiplegic shoulder and investigated the effect on the passive range of motion (PROM) of the shoulder as the primary outcome (chapter 5).

In this chapter the main findings of these studies will be summarized and discussed. The strengths and limitations of the used methodologies will be discussed and clinical recommendations for daily stroke rehabilitation will be described.

1.1 The use of arm slings in stroke patients.

The use of arm slings after stroke is a frequently discussed intervention in literature as well as in daily neurorehabilitation practice. Despite the lack of evidence for the beneficial effect of shoulder slings in the prevention of subluxation[6] and decrease of shoulder pain (Cochrane Review, 2005)[7] these effects were proposed as the main reasons to apply an arm sling by the participating therapists in our survey. Therapists mentioned potential benefits for patients, but they also specified possible disadvantages of wearing an arm sling. The most cited sling-related drawbacks were that I) the slings are used in the wrong way by the patient or by others, II) they reduce sensory input , III) the patients pay less active attention to their UL in the presence of a sling, IV) they might have difficulties in employing alternative arm positions deviating from sling-induced positions or V) it is possible that patients may develop contractures in these forced positions. These possible disadvantages have also been described in literature[8-10] and should therefore need to be considered thoroughly in the clinical decision making regarding the use of an arm sling in stroke patients. Since no longitudinal studies were available comparing the effect of arm slings on the shoulder subluxation and shoulder pain in stroke patients, we felt the motivated invitation to conduct a randomized controlled trial to compare the immediate and long-term effect of two arm slings on the AHD, as a measure of subluxation, on shoulder pain and on shoulder PROM.

In this study 28 stroke patients were recruited from three different rehabilitation centers in Flanders. They were randomly allocated to three different groups. In the control group patients were not allowed to wear an arm sling. In this group proper positioning of the arm during the day was assured to prevent the subluxation. The first experimental group wore the Actimove® sling (BSN medical SA-NV, Leuven, Belgium) that supports the forearm and immobilizes the elbow in flexion and shoulder in adduction-internal rotation. The second experimental group wore the Shoulderlift (V!GO, Belgium). This device supports the shoulder joint proximally and stimulates the use of the hemiplegic arm when UL function recovers. Intervention lasted six weeks and outcome measures were assessed at onset and after the intervention period. The effect on GHS was measured by determining the AHD using ultrasonography as a reliable, radiant free, cost effective and clinically accessible method in stroke patients[11, 12 13]. Our results indicated that **not wearing a sling reduces the subluxation over time**. The AHD in patients who did not wear a sling decreased whereas it remained the same in patients who wore the Actimove sling® and even increased slightly in patients who wore the Shoulderlift. A possible explanation for this finding is that patients who don't wear an arm sling are obliged to pay more pro-active attention to their paretic arm inducing muscle activity to preserve glenohumeral congruence. To confirm this hypothetical explanation more research is needed including EMG measurements of activity in the involved muscles. When looking at the implied correction of the arm sling immediately after application we noted that the extension sling (Shoulderlift) appeared to correct better (63% at week 0) than the flexion sling (Actimove®, 36% at week 0). This finding is in contrast to earlier studies [7, 13]. It should, however, be mentioned that the Shoulderlift was not studied in any other study. When repeating the measurements six weeks later, both types of slings showed a decrease in immediate reduction (Shoulderlift 28%; Actimove® 24% at 6 weeks). This might be explained technically by the loss of elasticity of the materials used to manufacture the sling. This finding should encourage therapists, when using an arm sling, to reevaluate the corrective effectiveness on a regular base to ensure that the functional aim of the device is maintained over time. Another finding that should be encompassed in the clinical reasoning regarding the use of arm slings is their possible influence on the PROM of the shoulder. Patients in the Actimove group had a decrease of PROM for shoulder external rotation and abduction over 6 weeks. Since the correlation between a limited passive shoulder abduction, external rotation and the risk on developing HSP has been described[14-19] this may lead to the cautious recommendation to use the Shoulderlift for people in need to wear an arm sling (e.g. patients who should be thoughtful in taking care for their hemiplegic arm due to severe neglect, cognitive problems, …).

Aside from the more obvious reasons to provide an arm sling, some authors also suggest secondary effects on balance and gait. Two studies demonstrated a more symmetrical gait pattern when wearing arm slings [20, 21] and one also ascertained an increased walking speed[20]. Acar et al. (2010) described an improved balance when using a sling and explained it by the sling-induced-limitation of an uncontrolled swinging of the arm[22]. To address these more general aspects regarding the arm slings used in our former study, we conducted a case control study using these same arm slings to investigate a potential effect of the Actimove sling® or the Shoulderlift on balance, gait and posture in subacute stroke patients. Nine stroke patients and nine healthy controls, matched for age and gender, performed static and dynamic balance tests (DynStable®, Motekforce Link) and walked on an electronic walkway (GAITRite®) under three different conditions. The conditions were provided in a random order: 1) with restriction of the arm (Actimove sling®), 2) without restriction of the arm (Shoulderlift) and 3) not wearing a sling. No significant differences were found for the balance tests, gait parameters and posture between the different conditions for both groups. The results of the balance tests confirmed the findings of Sohn et al. (2015), who also did not find differences in CoP excursion with and without sling [23]. The patients included in the given study of Sohn et al. were recruited earlier after stroke, had a better recovery of their UL, used different types of slings, but scored comparable on the BBS[23]. This in contrast to the patients in the study of Acar et al. (2010) in whom the mean Berg Balance scores indicated that they had more difficulties with maintaining balance[22]. This may imply that more impaired balance might be more influenced by external factors such as an arm sling[22]. When comparing the results regarding the gait parameters to other studies the main difference can be found in the gait speed of the included patients. Patients in our study had a very slow walking speed (0.36-0.38 m/s) compared to the patients in the study of Hesse et al. (2013)(0.62 m/s). A slow walking pattern implies a very small amplitude of arm swing[24] possibly mimicking the suppression of the arm-induced CoP excursion by means of a sling. Our results might imply that, for this subacute, slow walking study population with impaired proximal shoulder muscles, balance and gait are not prone to be immediately influenced by the use of an arm sling.

The results of both our studies, dealing with the use of arm slings in subacute stroke patients with severe UL impairment, indicate that therapists should not automatically provide an arm sling to all stroke patients. Seemingly there is no appropriate ground for a generalized application of slings in stroke. According to the results from our survey, we may infer that therapist in Flanders in fact do try to restrict the use of arm slings only to patients who really need them. This motivated need has, according to our opinion, to be restricted to the cases in which patients are not capable of taking care for their hemiplegic UL due to severe neglect, cognitive problems or language problems causing difficulties in understanding information on how to manage and protect their UL on their own (without external help). This recommendation does however not dismiss therapists to first try to sensitize patients by means of a self-management program and does not undermine the importance of a 24h multidisciplinary approach of the rehabilitation team. Also patients who do have shoulder pain can wear a sling on condition that wearing the arm sling reduces the present shoulder pain. Most therapists (52%) reported that they provide an arm sling in less than 25% of their patients and they advise to wear the sling only during certain activities (recommendation in 62.5% in case of use). Most patients who participated in our survey did not wear an arm sling (21.6% of the subacute patients and 13.6% of the chronic patients indicated to wear an arm sling). These results are comparable with those described by Li et al. (2013) who conducted a survey among occupational therapists concerning the clinical reasoning in the use of arm slings [25]. The type of sling most used in daily practice, as indicated by both therapist and patients, is the classical 8-shaped arm sling (e.g. Actimove®) followed by the arm-shoulder wrap (e.g. Shoulderlift). As these were specifically the slings that were investigated in our studies, our results can be seen as clinical applicable in Flanders.

1.2 Passive mobilization of the hemiplegic shoulder.

Most survey responding therapists confirmed that passive mobilization is part of their standard ROM protocol for the UL, performing it on average 3-4 times a week during 11-20 minutes. This passive mobilization is applied more frequently in the subacute phase after stroke compared to the chronic phase. Most referred indications for PM in literature are prevention of immobility and soft-tissue contractures[26] or reduction of shoulder pain[10]. However, notwithstanding these referrals, not much research has been executed to examine the specific effects of PM on the UL after stroke. Moreover the effectiveness may be questioned since it is known that 60% of all stroke patients have been reported with muscle contractures[27] leading to fixed joints in unnatural and functional jeopardizing positions[28] and this notwithstanding regular use of the passive techniques. These contractures already start to develop in the first weeks after stroke and increase over time[29]. The limited PROM of the shoulder, especially for external rotation[30-32] and/or abduction[14, 16, 17, 33], is a well-known contributing factor in the development of HSP. Not only the preservation of the PROM, but also the quality of the techniques used to maintain shoulder mobility is therefore very important. The most used techniques as indicated by the responders in our survey were scapular mobilization, glenohumeral mobilization and active assisted mobilization of the shoulder. It would have been worthwhile to know if therapists do apply specific points of attention in view of ensuring the quality of the techniques used. However, no such questions were posed in our survey. In stroke survivors it is very important to decrease the risk of creating impingement[8], soft tissue injuries[34, 35] and HSP[36]. Some recommendations were formulated earlier by Turner-Stokes and Jackson (2002) in order to prevent the development of HSP: (1) reduce muscle tone[37] and relocate the humeral head[38] before starting the PM if necessary, (2) ensure appropriate rotation of the scapula and humerus to avoid impingement and/or rotator cuff injuries[8] and (3) avoid overstretch of the biceps long head tendon and subscapularis tendon[33]. Irrespective of these recommendations so far no study has compared different mobilization techniques for the hemiplegic shoulder. Taking into account this crucial clinical challenge and the lack of scientific support to recommend any approach, we conducted a randomized multiple treatment trial. We enrolled 11 participants with a subacute stroke, resulting in UL impairment, who underwent three mobilization techniques in a randomized order. The primary outcome measure was the PROM of the shoulder.

The results of this study led to a preference of using the combined soft-tissue mobilization technique for the hemiplegic shoulder joint. This ascertainment is based on the fact that this was the only technique that could increase the PROM for the crucial shoulder external rotation. The conservation of glenohumeral external rotation is essential for two reasons. First of all it is an important mechanism to minimize the risk on developing impingement by moving the tubercles away from the coracoacromial arch. After a stroke, due to the lesion of the central nervous system, altered muscle activation patterns of the UL and trunk and/or changes in muscle tone create an upper-limb posture including internal rotation and shoulder adduction[10]. This position is often referred to as the synergic pattern and leads to an increased risk on developing HSP [30, 31]. Secondly, correct scapula setting provides the optimal length-tension relationship for the rotator cuff muscles to function which allows recruitment of the triceps brachii muscle to facilitate forward reaching [39, 40]. Therefore, preservation of PROM of external shoulder rotation is a prerequisite for efficient shoulder movements during reaching. The mechanism of this combined soft-tissue mobilization aims to anticipate to expected problems during mobilization of the hemiplegic shoulder. Very often capsular stretch is impeded by the stretch of the hypertonic shoulder muscles after stroke. To ensure capsular stretch, transversal stretch of hypertonic shoulder muscles is applied before continuing with the glenohumeral movements. These glenohumeral movements are performed as much as possible in the scapular plane and with the arm in external rotation aiming to ensure the joint congruence. Although no other significant differences could be detected for the other outcomes we do want to point out that concerning the shoulder flexion and abduction the PROM did not decrease over the period of four weeks in patients receiving the combined soft-tissue mobilization technique (flexion -0.45° ±9.86; abduction 0.45° ±5.22) whereas after the other two techniques a clear decrease in joint mobility (scapular mobilization: flexion -5.91° ±22; abduction -8.18 ±12.30 and angular mobilization: flexion - 9.55 ±25.64; abduction -6.82° ±13.09) was noticed.

Although we agree that there are some methodological limitations that should be mentioned regarding this study protocol and more research should be done to answer remaining questions, we do think that these results may help therapists to gain insight in how to provide a safe and effective mobilization of the hemiplegic shoulder. Despite the fact that stroke patients in our study were in the subacute phase after stroke and had severe UL impairment, we do believe that the combined soft tissue mobilization might have the same advantage in chronic stroke patients since the risk factors, such as internal rotation, do not change significantly over time and these chronic stroke patients are still often loaded by hypertonic muscles. Patients with moderate to good UL recovery might also be at risk of creating limited PROM at the shoulder joint. Despite the fact that they have the potential to maintain their shoulder mobility they often do create ROM limitations, especially in the end range, due to not fully using there active potential. However, more research is warranted to confirm these assumptions.

2. Strengths and limitations

The most important strength of this doctoral thesis is that all studies are related to relevant topics very often questioned and discussed in daily practice and that it also tried to engage the opinion of therapists as well as stroke survivors. In the survey, that questioned the daily practices regarding UL rehabilitation, 80 therapists responded resulting in a response ratio of 56%. This emphasizes the interest in UL rehabilitation that exists among the therapists who treat stroke survivors every day. No response ratio could be calculated for the stroke survivors, because the total amount of potential responders was not known via the given settings. The number of stroke survivors who responded to our questionnaire (n=220) was higher than expected. The results of the survey clinically induced the aims in the other studies (chapter 3-5) as key challenges and enigmas in daily rehabilitation practices as a kind of practice based evidence questions. The RCT described in chapter 3 is the first RCT that investigated the immediate and long-term effect of arm slings using sonography. Chapter 4 reports on the first case control study that compares the effect of two different arm slings in subacute stroke patients on balance and gait in combination with trunk excursion. And although the need of safe and efficient mobilization is obvious, so far no studies were performed comparing different mobilization techniques for the hemiplegic shoulder (chapter 5).

Some limitations need to be addressed:

- Sample sizes in all studies were rather small. However post hoc power analysis for the change in AHD distance showed a medium effect size (f=0.47) with a power of 67%. To obtain a power of 80% with the given effect size, only 3 or 4 patients should be added to each intervention group (chapter 3). For the difference in PROM for external rotation between the passive mobilization techniques post hoc analysis showed a large effect size (f=0.57) with a power of 80% for the given sample size (chapter 5). Therefore, notwithstanding the smaller samples, we do believe that our results might offer some novel insights into the clinical aspects of prescribing arm slings and performing mobilizations of the hemiplegic shoulder.
- Generalization of our results to the entire stroke population is not possible. We included patients (chapter 3-5) in the subacute phase after stroke with weakness of their shoulder muscles (< 3 on the Medical Research Council Scale for the supraspinatus and deltoid muscles). This implies that we enrolled patients that were potential candidates to wear an arm sling and for whom passive mobilization is a frequently used therapeutic intervention aiming to preserve passive shoulder ROM. Recruiting stroke patients that represent a wider range of the stroke population was not feasible as such heterogeneity would made it impossible to standardize and homogenize the interventions. Standardized interventions as such would not

meet the needs of all stroke survivors given the heterogeneity of this population. Inclusion criteria in further research should probably also include an evaluation of muscle control additional to assessing muscle strength as both components seem to contribute to the hemiparesis phenotype.

- The use of the visual analogue scale (VAS) to define pain. Due to sensory impairments, language or cognitive problems, self-reported pain is not always considered reliable in stroke patients. Besides, self-reported pain often underestimates the extent of pain found during physical examination of the shoulder[41]. However, physical examinations of the hemiplegic shoulder including dynamic tests are often not possible due to the severe paresis and no other, more objective, pain measurements are available for stroke patients as far as we know.

3. Clinical recommendations and future perspectives

On average 54-55% of the stroke patients who follow therapy in a rehabilitation setting suffer from HSP[8, 42, 43]. The onset of pain can occur even after two weeks post stroke[44, 45] and the peak incidence is considered to be around four months post stroke [32, 46]. Since patients who suffer pain are not encouraged to move actively with the limb in pain, it is obvious that the presence of HSP has a negative effect on the rehabilitation[14, 47] of stroke patients in a crucial phase of recovery and this has a great influence on short and longer term regarding their QoL[48]. The management of HSP implies a multidisciplinary approach since it is fairly difficult due to the complexity of the shoulder joint and the multifactorial character of the underlying pathophysiological mechanisms. Therefore, preventative strategies for HSP are crucial in the rehabilitation program of stroke patients. Since the glenohumeral subluxation and a restricted passive mobility may play an important role in the development of HSP they became the key clinical features to address scientifically in this doctoral thesis.

The key advices from this doctoral thesis can be summarized as follows:

- The participating therapists in our survey indicated the main reasons to use an arm sling are the prevention of glenohumeral subluxation and reduction in shoulder pain. However, the results of the RCT described in chapter 3 revealed that only the patients who did not wear an arm sling had a reduction of their subluxation over the time period of six weeks. As described earlier, we carefully advice, not to provide an arm sling to stroke survivors except when patients are not capable of taking care for their hemiplegic UL due to severe neglect, cognitive problems or language problems causing difficulties in understanding information on how to manage and protect their UL. Also patients who do have shoulder pain can wear a sling on condition that wearing the arm sling reduces the present shoulder pain. However, the time should be limited to decrease the risk on developing disadvantages (contractures, reduced sensory input, impaired body schema, learned non-use, …) that can be caused by the sling. Besides, we want to emphasize the need of a 24h multidisciplinary approach to take care of the hemiplegic shoulder. Possibly, an arm sling can also be used to secure the shoulder during transfers if this is more comfortable to nursing staff or family members to optimize the handling of the hemiplegic UL. As mentioned in the report of the given trial, this security-suggestion was not further addressed in this doctoral thesis and should be subject for further research. A suggestion for an algorithmic framework for the use of an arm sling in stroke patients has been included at the end of the general discussion.

- For subacute stroke patients with lower gait capacities the prescription of an arm sling to improve posture, balance and gait should be addressed with appropriate consideration as no effects could be retained.
- In Flanders passive mobilization is part of the standard ROM treatment protocol for the UL in stroke patients (cfr. survey). Considering safety precautions the technique used during mobilization of the hemiplegic shoulder is of utmost importance. The results of the randomized multiple treatment trial described in chapter 5 indicates that the combined soft-tissue mobilization is the most effective in increasing passive external shoulder rotation in subacute stroke patients, which is a crucial factor in the prevention of HSP. For the shoulder flexion and abduction no significant differences could be detected when comparing the different techniques but the results do suggest that also for these variables the combined soft-tissue mobilization might be the preferred technique. Future research on a bigger sample would be needed to confirm this finding. Our hypothesis is that the PROM for shoulder flexion and abduction would also increase if this technique will be applied for a longer period and/or if it would be applied immediately from stroke onset.
- According to the results of the survey, active arm-oriented therapy early after stroke, is considered essential for the recovery. Based on the same survey, this approach seems often to be limited to the first three months after stroke. Based on the actual scientific evidence in that improvement of UL function may continue even long after six months post stroke [5], therapists should be informed regarding this (too) short time frame period of active therapy

The present work has addressed some questions regarding the effectiveness and best practices for the application of arm slings and passive mobilization of the hemiplegic shoulder in subacute stroke patients. Additional research on a larger scale is undoubtedly needed to confirm findings and unravel remaining issues regarding these interventions in stroke survivors, but nevertheless the results of the conducted research may be inspiring and directive for future clinical practice and scientific investigations.

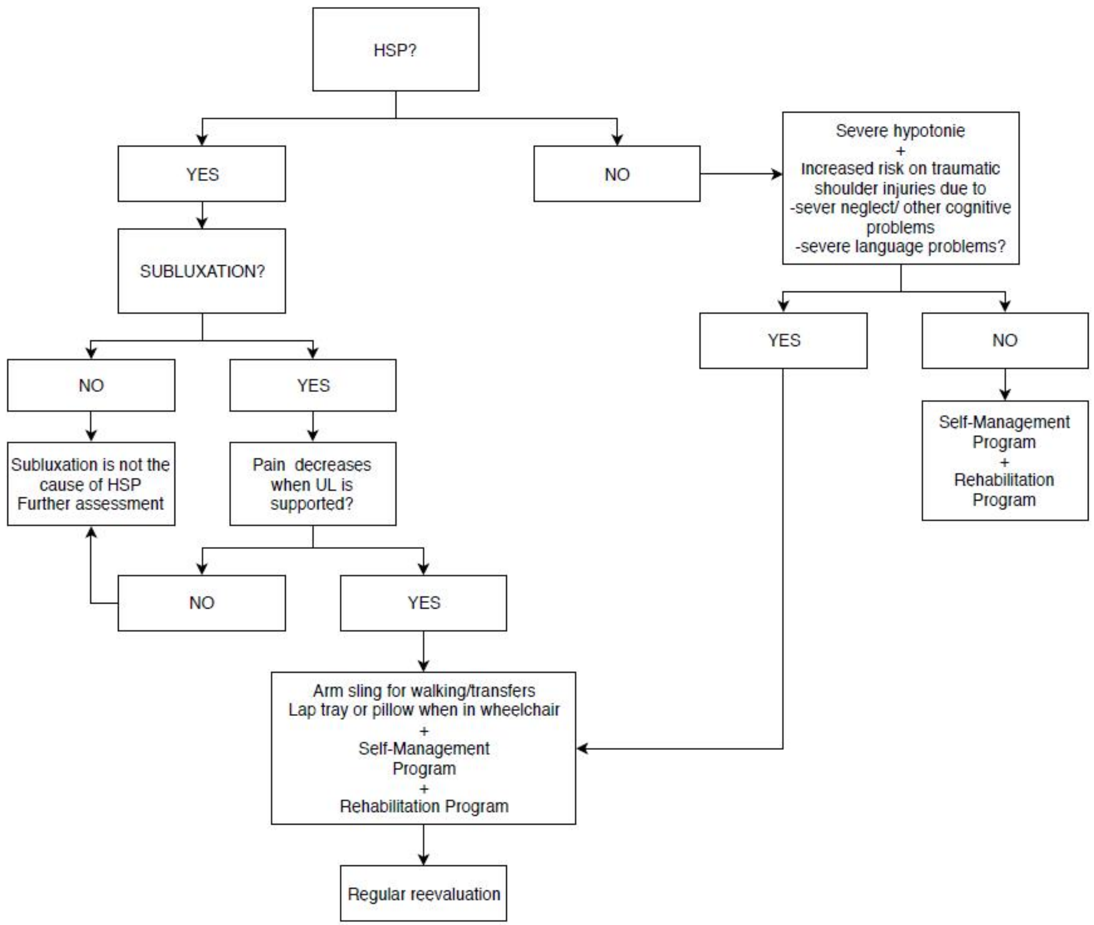
Besides sample size as such to improve power of recommendations, it would also enable us to differentiate the included participants into subgroups taking into account the differences between stroke patients due to the heterogeneity of this pathology. As result of the experience in this PhD-project regarding the difficulties in recruiting stroke patients for rehabilitation research, an initiative could be considered to install a multicenter stroke-rehab-platform in Flanders that could enable, coordinate and stimulate research in acceptable samples.

Considering the evolution in AHD, as a representative method for the glenohumeral subluxation caused by the paresis of proximal shoulder muscles, EMG recordings should be added to confirm the hypothesis that patients who do not wear an arm sling pay unconsciously more attention for their hemiplegic arm resulting in involuntary muscle activity around their shoulder. Such EMG recordings should be measured during transfers and other ADL activities without attracting the patients attention to the method of investigation and thereby the shoulder muscles. This technical achievement is needed to obtain a clear cut insight into the patients spontaneous muscle activity level as we expect that patients without an arm sling would generate more spontaneous muscle activity compared to patients who do wear an arm sling. In the latter case patients might be less attentive to their hemiplegic arm because it is positioned in a safe place.
Since a positive effect of applying NMES on shoulder subluxation has been reported [49, 50] it would be interesting to include this intervention in future research to assess whether the additional application of NMES on stroke patients wearing an arm sling or not would induce a greater decrease in subluxation.

To gain more knowledge in how the PROM of the shoulder joint evolves after a stroke and how the technique of passive mobilization can prevent the deterioration of joint mobility comparative interventions should be conducted starting directly after patients suffered a stroke.

Finally, studies investigating the effect of the use of arm slings or passive mobilization techniques should strive towards longer intervention periods mimicking more the complete rehabilitation phase after a stroke including long-term follow up to assess the development of the hemiplegic shoulder after application of these interventions.

Figure 1: Algorithmic framework for the use of an arm sling in stroke patients.



HSP is defined as pain lasting 72h within the last month since stroke and marked on a pain diagram within a predetermined shoulder area[44, 51].

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Chapter 7

Summary

Reduced arm function is reported in 76% of the patients early after stroke onset. Prognosis of upper limb recovery is usually less favorable compared to average recuperation of the lower limb. Most stroke patients (70%) regain independent walking capacity with or without walking aids, while only 5-20% demonstrate full functional recovery of the upper limb. Given the key role of the upper limb in daily functional activities, the effect of a reduced arm function on independency, self-governance and quality of life of stroke patients is tremendous invalidating. Therapist are therefore continuously in search of more effective and efficient therapy strategies aiming to maximize the potential for upper limb recovery and minimize secondary complications like hemiplegic shoulder pain.

The first aim of this doctoral thesis was to describe the current practices regarding upper limb rehabilitation after stroke in Flanders and to explore the patients' needs for that matter as a starting point for motivated clinical research initiatives. Therefore, we conducted a survey among physiotherapists and occupational therapists, even as among stroke survivors (chapter 2). According to the results of this survey, preventing glenohumeral subluxation and reducing hemiplegic shoulder pain are major challenges. They also embody the most frequent indications to prescribe an arm sling in stroke patients notwithstanding the fact that evidence for the beneficial effect of shoulder slings regarding the given outcomes (preserving congruency in the shoulder and preventing pain) is lacking. Moreover, the use of these arm slings can even provoke disadvantages (e.g. developing contractures, reducing sensory input, encouraging learned non-use…). Combining this (lack of) scientific evidence with the conveyed clinical information from our survey respondents led to the research question covered in chapter 3 of this doctoral thesis.

Chapter 3 reports on the results of a randomized control trial that compared the immediate and long-term effects of two conceptual different arm slings (Actimove®, BSN Medical Leuven Belgium and Shoulderlift, V!GO Belgium) on shoulder subluxation (echographic measurement of subluxation distances), shoulder pain and passive range of motion of the shoulder. In this trial patients were randomly divided into three groups. In two of these groups, patients received an arm sling to support the hemiplegic arm during the day. The third group did not wear an arm sling but was assured of a proper positioning of the arm during the day. Our results revealed that not wearing a sling reduces subluxation over time (group 3), while the subluxation stayed the same in patients wearing the Actimove® sling and even increased slightly in them using the Shoulderlift. A possible explanation could be that patients who do not wear slings are obliged to pay more (pro)active attention to their paretic arm inducing involuntary muscle activity that may preserve glenohumeral congruence. However, more detailed research is needed to confirm this hypothesis. Nevertheless, these results do not imply that there are no indications that justify the use of arm slings in stroke patients at all. Patients who are not capable of taking care for their hemiplegic upper limb due to severe neglect, cognitive problems or language problems causing difficulties in understanding information on how to manage and protect their upper limb could benefit of wearing an arm sling. But also patients who do have shoulder pain can (temporarily) wear a sling on condition that wearing a sling reduces the presence of shoulder pain. This expounded point of view is in line with the views reported in our survey. In case a sling is indicated, there is a slight preference for the Shoulderlift based on the results of this study. This sling displayed a better correction compared to the Actimove sling immediately after application, at the start of the intervention and after 6 weeks. During the period of the intervention, the patients in the Shoulderlift group did not develop a restriction of the passive range of motion for shoulder abduction or external rotation, whereas patients in the Actimove group and in the control group did show a reduced passive range of motion of the shoulder. It should be noted that the restricted passive range of motion on its turn can influence the development of hemiplegic shoulder pain.

Aside from the more 'traditional' and obvious segmental reasons to provide an arm sling, some authors also suggest supposed additional positive effects on balance and gait in stroke patients. To address these clinical relevant suppositions in the same slings as in the previous study a case control study was conducted to compare the effect of these slings on balance and gait in subacute stroke patients. Patients performed balance tests (DynStable®, Motekforce Link) and walked on an electronic walkway (GAITRite®) in three different conditions: 1) with the Actimove sling which restricts the arm against the body, 2) with the Shoulderlift that supports the shoulder proximally but allows movements with the arm and 3) not wearing a sling. No significant differences could be detected between the different conditions for any of the examined parameters. Our results therefore imply that, for the included type of stroke patients, there was no effect of wearing a sling on balance and gait. However, this conclusion is not generalizable, since in this study only subacute patients with a very slow walking speed and impaired proximal shoulder muscles were recruited.

Regarding passive mobilization of the upper limb, about 84% of the Flemish therapists who participated in the survey confirmed that passive mobilization of the arm is part of the standard range of motion-protocol in their hospital or rehabilitation center. Passive mobilization of the hemiplegic arm is performed on average 3-4 times per week with an average duration of 11-20 minutes per session. In literature the most referred indications for passive mobilization are prevention of contractures and reduction of shoulder pain. However, notwithstanding these referrals, no comparative studies have been conducted examining the specific effects of different mobilization techniques on the upper limb after stroke. Chapter 5 describes the results of our randomized multiple treatment trial. We enrolled 11 subacute stroke patients who were offered three different mobilization techniques in a randomized order: 1) combined soft tissue mobilization in the scapular plane, 2) scapular mobilization without glenohumeral movements and 3) angular glenohumeral mobilization in the frontal plane. The results of this study lead to an underpinned preference for the application of the combined soft tissue mobilization for the hemiplegic shoulder as this was the only technique that demonstrated an improvement of the passive range of motion for external rotation. Preservation of the passive range of motion for external rotation is important in stroke patients. First, as it is an important mechanism to prevent impingement in the shoulder by moving the tubercles away from the acromion. Secondly, correct scapula setting provides the optimal length-tension relationship for the rotator cuff muscles to function which allows recruitment of the triceps brachii muscle to facilitate forward reaching. Therefore, preservation of the passive range of motion of external shoulder rotation is a prerequisite for efficient shoulder movements during reaching. Even though there are methodological limitations to this study (e.g. sample size), these results can contribute to understanding how therapists can perform a safe and effective mobilization of the hemiplegic shoulder in stroke patients.

Overall, this doctoral thesis provides an overview of the current practices regarding upper limb therapy in stroke patients in Flanders. This resulted in a number of research questions concerning the more passive interventions that are often applied to patients with severe motor impairments of their upper limb and considering the actual evidence regarding risk factors on the development of hemiplegic shoulder pain.

With appropriate caution (sample size, profile of stroke patients,…) we advise not to use a sling automatically as a generic measure in stroke patients, but apply it in case of specific indications as mentioned above. Results from former published research together with the results from our own studies indicate that in view of clinical reasoning concerning the use of arm slings a patient-tailored approach is mandatory. Therapists should take into account and critically evaluate both the more obvious reasons (e.g. shoulder subluxation and pain) as well as the less evident effects of arm slings (e.g. possible beneficial effects on gait and balance or disadvantages like contractures, reduced sensory input, learned non-use, …) in every stroke patient on an individual basis.

The most effective technique to mobilize the hemiplegic shoulder that can be proposed, concerns the combined soft tissue mobilization in the scapular plane. This technique was the only one that demonstrated an improved passive external rotation of the shoulder, which is an essential biomechanical component to guard in the prevention of hemiplegic shoulder pain. It seems to be essential to apply transversal stretch to hypertonic muscles (m. pectoralis major and minor, m. biceps, m. lattisimus dorsi and teres major) first in order to avoid possible muscular resistance as much as possible to achieve the aimed capsular stretch during mobilization. With respect to the preservation of glenohumeral congruence the elbow must be placed anterior to the shoulder joint during the passive mobilization with a patient in supine position. Finally, during the entire mobilization the arm should be kept in external rotation as good as can be.

Chapter 8

Samenvatting

Onmiddellijk na een cerebrovasculair accident (CVA) of beroerte ervaart 76% van de patiënten beperkingen van het bovenste lidmaat aan de aangedane zijde. De prognose van het herstel van dit bovenste lidmaat is meestal minder gunstig in vergelijking met het onderste lidmaat. Het grootste deel van de CVA patiënten (70%) komt namelijk uiteindelijk terug tot zelfstandig stappen, al dan niet gebruik makend van een hulpmiddel. Het volledig functioneel inzetten van de arm na een CVA is daarentegen slechts weggelegd voor 5-20% van de CVA patiënten. De negatieve invloed van een slecht recupererende arm op de zelfstandigheid, zelfredzaamheid en levenskwaliteit van CVA patiënten is sterk invaliderend gezien de zo belangrijke rol die is weggelegd voor het bovenste lidmaat in het dagelijkse leven. Daarom zijn zorgverstrekkers voortdurend op zoek naar meer efficiënte en effectieve therapeutische strategieën met als doel het potentieel herstel van de arm te maximaliseren en mogelijke complicaties, zoals schouderpijn, te minimaliseren.

Met het oog op het toetsen van klinisch relevante onderzoekshypotheses binnen dit doctoraal proefschrift werden via een enquête bij kinesitherapeuten en ergotherapeuten in Vlaanderen de huidige therapeutische strategieën gericht op de hemiplegische arm in kaart gebracht. Er werd eveneens geïnformeerd naar de mening en noden ter zake bij de CVA patiënt zelf (hoofdstuk 2). De resultaten hiervan leerden ons onder andere dat de preventie van een subluxatie van de hemiplegische schouder en het verminderen van hemiplegische schouderpijn permanente uitdagingen zijn voor de therapeuten en bovendien als de meest voorkomende indicaties worden gezien voor het gebruik van een sling. Dit terwijl vanuit eerdere studies onvoldoende bewijs is geleverd dat het dragen van een dergelijke sling echt een positieve invloed heeft op de subluxerende schouder en/of op de schouderpijn bij CVA patiënten. Meer nog, het dragen van deze slings zou zelfs aanleiding kunnen geven tot een aantal belangrijke nadelen (vb. het ontwikkelen van contracturen, verminderde sensorische input, stimuleren van learned non-use…). De combinatie van deze wetenschappelijke evidentie of het gebrek ervan met de aangeleverde informatie uit de dagelijkse praktijk resulteerde tot de onderzoeksvraag die werd onderzocht in hoofdstuk 3 van dit proefschrift.

Hoofdstuk 3 geeft de resultaten weer van een gerandomiseerde studie die de onmiddellijke en lange termijn effecten onderzocht van het gebruik van slings (Actimove® BSN medical SA-NV, Leuven België en Shoulderlift, V!GO België) op de subluxatie van de schouder (afstand gemeten op echografie), op schouderpijn en op de passieve beweeglijkheid van de schouder bij CVA patiënten. In deze studie werden de patiënten gerandomiseerd onderverdeeld in 3 groepen. In 2 groepen werd gedurende de dag de hemiplegische arm van de patiënt ondersteund door één van de onderzochte slings, terwijl in de 3^de^ groep de patiënten geen armsling kregen, maar algemene postioneringsmaatregelen werden aangeboden. De resultaten toonden aan dat de subluxatie afnam bij patiënten die geen sling hadden gedragen (groep 3), terwijl de subluxatie in de Actimove groep ongeveer gelijk bleef en in de

Shoulderlift groep er zelfs een beperkte toename was van de gemeten subluxatie. Een mogelijke verklaring zou kunnen zijn dat patiënten die geen sling dragen zelf (pro)actieve aandacht moeten besteden aan de positie van hun arm tijdens het dagelijkse leven waardoor er mogelijks (correctieve) onwillekeurig spieractiviteit wordt gegenereerd in de proximale schouderspieren die bijdragen tot het stabiliseren van het gewricht. Om deze hypothese te kunnen bevestigen, is echter verder gedetailleerd onderzoek nodig. Deze vaststelling mag evenwel niet impliceren dat er absoluut geen indicaties zijn voor enige meerwaarde voor het dragen van een sling. Patiënten met neglect, ernstige cognitieve en/of taalproblemen kunnen namelijk nood hebben aan een dergelijke sling omdat zij immers de noodzakelijk informatie om voor hun hemiplegische arm te zorgen of deze te beschermen moeilijk begrijpen. Ook patiënten bij wie reeds schouderpijn aanwezig is en bij wie deze pijn afneemt door het dragen van een sling, zouden zeker gebaat kunnen zijn door het (tijdelijk) gebruik van zo'n sling. Deze genuanceerde visie op de aanbeveling van het gebruik van een sling is overeenkomstig de informatie verkregen uit onze enquête. Indien er toch een sling moet worden gedragen, is er een lichte voorkeur voor het gebruik van de Shoulderlift. Deze sling toonde een betere correctie aan in vergelijking met de Actimove sling onmiddellijk na het aanbrengen en dit zowel bij aanvang als na 6 weken in de studie. Bovendien vertoonden de patiënten in de Shoulderlift groep gedurende de periode van de interventie geen afname van de passieve mobiliteit voor schouder abductie en schouder exorotatie, terwijl de passieve mobiliteit wel afnam bij de patiënten in de andere 2 groepen. Er moet namelijk worden opgemerkt dat een beperkte schoudermobiliteit op zich aanleiding kan geven tot het ontstaan van hemiplegische schouderpijn.

Naast de meest voor de hand liggende en 'lokale' redenen voor het dragen van een sling (schoudersubluxatie en –pijn), vermelden sommige auteurs ook mogelijk gunstige effecten van de sling op het evenwicht en op het stappatroon bij CVA patiënten. Deze klinische relevante veronderstellingen werden onderzocht voor dezelfde slings als in de vorige studie en de resultaten hiervan werden beschreven in hoofdstuk 4. Patiënten ondergingen een aantal evenwichtstesten (DynStable®, Motekforce Link) en een eenvoudige loopanalyse (GAITRite®) in 3 willekeurig aangeboden condities: 1) met de Actimove sling en dus met de arm gefixeerd tegen het lichaam, 2) met de Shoulderlift die de schouder proximaal ondersteunt, maar de arm vrij laat om eventueel actief te bewegen en 3) vrij, zonder sling. Er kon voor geen van de onderzochte parameters enig significant verschil worden gedetecteerd tussen de verschillende condities. Deze resultaten impliceren dus dat het dragen van een sling geen effect heeft op het evenwicht en op het gangpatroon binnen een populatie met beschreven karakteristieken (subacute patiënten met een trage gangsnelheid en spierzwakte van de proximale schouderstabilisatoren). Op basis van deze populatierestrictie is deze conclusie uiteraard niet generaliseerbaar naar alle CVA-patiënten, maar toch een basis voor een afweging in het algemeen.

Passieve mobilisatie bleek uit de enquête bij ongeveer 84% van de Vlaamse therapeuten inherent deel uit te maken van het standaard range of motion-protocol binnen hun dienst. Deze passieve mobilisatie van de hemiplegische arm wordt door de Vlaamse therapeuten gemiddeld 3 tot 4 maal per week uitgevoerd met een gemiddelde duur van 11-20 minuten per sessie. In de literatuur worden de preventie van contracturen en het verminderen van schouderpijn als de meest voorkomende redenen aangeduid om een mobilisatie van de hemiplegische arm toe te passen. Desondanks werden er tot op heden geen vergelijkende studies uitgevoerd die de specifieke effecten van (verschillende) passieve mobilisatie(technieken) op de hemiplegische arm onderzochten. In hoofdstuk 5 worden de resultaten beschreven van een studie waarin aan 11 CVA patiënten in de subacute fase 3 verschillende manieren van mobilisatie voor de hemiplegische schouder werden aangeboden: 1) een gecombineerde weke delen mobilisatie in het scapulair vlak, 2) een scapulaire mobilisatie zonder glenohumerale bewegingen en 3) een angulaire mobilisatie in het frontale vlak. De resultaten van dit onderzoek suggereren een onderbouwde voorkeur voor het toepassen van de gecombineerde weke delen mobilisatietechniek voor de hemiplegische schouder. Dit was namelijk de enige techniek die erin slaagde om een verbetering aan te tonen van de passieve exorotatie-uitslag van de schouder. Het bewaren/verbeteren van deze passieve schouder-exorotatie is net belangrijk om 2 redenen: als belangrijk mechanisme om impingement in de schouder te voorkomen en als een goede oriëntering van het schouderblad voor de optimale lengte-spanning verhouding voor de rotator-cuff spieren opdat deze optimaal zouden kunnen functioneren en dus de meest gunstige conditie kunnen waarborgen voor een goede werking van de m. triceps brachii in functie van de reikbeweging. Een bewaarde exorotatie in het schoudergewricht is derhalve een belangrijke basisvoorwaarde voor optimale schouderbewegingen in functie van het reiken met de hemiplegische arm. Ook al zijn er enkele methodologische beperkingen aan deze studie, zoals de beperkte steekproefgrootte, toch kunnen deze resultaten bijdragen tot het inzicht in een meer veilige en effectieve manier om de schouder van CVA patiënten te mobiliseren.

Globaal geeft dit doctoraal onderzoek een overzicht van de huidige therapeutische strategieën betreffende het behandelen van de hemiplegische arm bij CVA patiënten in Vlaanderen. Van daaruit werden een aantal onderzoeksvragen geformuleerd over de meer passieve interventies voor patiënten met een beperkte functie van hun bovenste lidmaat en waarbij rekening werd gehouden met de huidige evidentie rond risicofactoren op het ontwikkelen van hemiplegische schouderpijn.

Met de gepaste omzichtigheid menen we te kunnen adviseren dat het gebruik van een sling niet automatisch mag worden gezien als een algemeen toe te passen interventie bij CVA patiënten, maar enkel aangewezen is bij de welomschreven specifieke indicaties. In het klinisch rederneerproces ter zake wijzen de onderzoeken uit de literatuur en in dit proefschrift erop dat teneinde correct en geïndiceerd gebruik van slings te realiseren een op-maat-gemaakte benadering wenselijk is. Hierbij moeten therapeuten zowel voor de hand liggende indicaties (vb. schouder subluxatie en schouderpijn) als de minder voor de hand liggende effecten (vb. eventuele positieve effecten op gang en evenwicht of mogelijke nadelen zoals contracturen, verminderde sensorische input, het ontwikkelen van learned non-use, …) in rekening brengen en kritisch evalueren bij iedere individuele patiënt.

De meest effectieve techniek om de hemiplegische schouder te mobiliseren is de gecombineerde weke delen mobilisatie in het scapulair vlak. Deze techniek was de enige die een verbetering kon aantonen in de biomechanisch essentiële bewegingsvrijheid in het kader van het ontwikkelen van schouderpijn: passieve exorotatie van de schouder. Het blijkt dus essentieel om eerst dwarse rek toe te passen op eventuele hypertone spieren (m. pectoralis major en minor, m. biceps, m. lattisimus dorsi en teres major) om tijdens het mobiliseren de noodzakelijke kapselrek niet te verhinderen door musculaire weerstand. Verder is het belangrijk om de congruentie van het schoudergewricht zo goed als mogelijk te bewaren. Dit kan in de praktijk worden vertaald door de elleboog anterieur van de schouder te positioneren bij een patiënt in ruglig en de arm gedurende de gehele mobilisatie zo veel mogelijk in exorotatie te houden.

Appendices

List of abbreviations
Survey therapists
Survey patients subacute phase
Survey patients chronic phase
Curriculum Vitae

LIST OF ABBREVIATIONS

AC	Adhesive capsulitis
ADL	Activities of daily living
AHD	Acromiohumeral distance
ARAT	Action Research Arm Test
AROM	Active Range of Motion
BBS	Berg Balance Scale
C7	Cervical vertebra 7
CRPS	Complex Regional Pain Syndrome
CVA	Cerebrovasculair Accident
dAHD1	Level of subluxation
dAHD2	Level of correction of the subluxation
FM FE	Finger extension item of the Fugl-Meyer Assessment
FMUE/FMUL	Fugl-Meyer assessment upper extremity part
FMUE_SE	Shoulder elbow part of the Fugl-Assessment for the upper limb
GHS	Glenohumeral subluxation
HSP	Hemiplegic shoulder pain
LL	Lower limb
MAS	Modified Ashworth Scale
MEP	Motor Evoked Potential
MI SA	Shoulder abduction item of the Motricity Index
MRC scale	Medical Research Council scale
MRI	Magnetic Resonance Imaging
NIHSS	National Institutes of Health Stroke Scale
NMES	Neuromuscular Electrical Stimulation
OT	Occupational therapist
PM	Passive mobilization
PREP	Predict Recovery Potential
PROM	Passive Range of Motion
PT	Physiotherapist
QoL	Quality of Life
ROM	Range of motion
SHS	Shoulder-hand syndrome
SIPS	spina iliaca posterior superior
T8	Thoracic vertebra 8
TENS	Transcutaneous electrical nerve stimulation
TIS	Trunk Impairment Scale
TMS	Transcranial Magnetic Stimulation
UL	Upper limb
VAS	Visual Analogue Scale

ENQUETE Therapeuten

DEEL I: PASSIEVE MOBILISATIE BOVENSTE LIDMAAT

1. Voert u regelmatig (minstens éénmaal per week) een passieve mobilisatie uit van het bovenste lidmaat?
   JA *(> vraag 2)*
   NEE *(> deel II: actieve oefentherapie van het bovenste lidmaat)*

2. Is de passieve mobilisatie van de hemiplegische arm bij CVA patiënten een standaard behandeling op uw afdeling? JA/NEE

   Indien NEE, wat zijn de indicaties om niet te mobiliseren?

   - Er zijn geen beperkingen van de passieve beweeglijkheid
   - Er is geen sprake van spasticiteit of hypertonie in het bovenste lidmaat
   - De patiënt heeft pijn tijdens de mobilisatie van de arm
   - De patiënt heeft toch geen actieve mogelijkheden met de hemiplegische arm
   - Overige *(zelf in te vullen)*

3. Hoe vaak per week wordt de passieve mobilisatie van de hemiplegische arm uitgevoerd bij een patiënt?
   - 1-2 x per week
   - 3-4 x per week
   - 5-6 x per week
   - 7 x per week
   - Meermaals daags

4. Hoe lang neemt de passieve mobilisatie van de hemiplegische arm (schouder tot en met hand) gemiddeld in beslag?
   - < 10 min
   - 10 – 20 min
   - 20 – 30 min
   - > 30 min

5. Welke technieken past u toe om de hemiplegische schouder te mobiliseren?
   - Scapulaire mobilisaties
   - Passieve glenohumerale mobilisaties
   - Passief/actieve mobilisaties
   - Dwarse rek schouderspieren
   - Kapselrek
   - Overige *(Omschrijf)*

DEEL II: ACTIEVE OEFENTHERAPIE VAN HET BOVENSTE LIDMAAT

6. Hoe snel na het ontstaan van het CVA start u met actieve oefentherapie van het bovenste lidmaat? *Met actieve oefentherapie bedoelen we iedere vorm van actief of actief-geassisteerd oefenen van het bovenste lidmaat. Ook wanneer er nog geen bewegingsamplitudo merkbaar is maar de patiënt wel de spieren kan aanspannen.*
   - o Zo snel mogelijk. Vanaf het ogenblik dat de patiënt medisch stabiel is.
   - o In elk geval in de eerste week na het CVA
   - o Pas na de eerste week na het CVA
   - o Andere *(omschrijf)*

7. Wordt er actieve oefentherapie gegeven bij personen met zeer weinig recuperatie *(d.w.z. geen mogelijkheid tot selectief – gedissocieerd bewegen)* ?
   - o JA, indien het CVA nog geen 3 maanden geleden is
   - o JA
   - o NEE

   Indien NEE: waarom niet?
   - o De patiënt kan met de arm toch geen dagelijkse activiteiten uitvoeren
   - o De prognose van de arm is meestal slecht na een CVA
   - o Het is moeilijk om oefeningen aan te bieden aan patiënten met zeer weinig recuperatie
   - o Er is onvoldoende tijd binnen de therapie uren om de patiënten intensief te begeleiden indien ze niet zelfstandig kunnen oefenen
   - o Overig *(omschrijf)*

8. Bestaat er op uw afdeling een protocol dat wordt gevolgd betreffende het behandelplan van het bovenste lidmaat bij een CVA patiënt?
   - o JA *(>vraag 9)*
   - o NEE *(>vraag 12)*

9. Is dit een uitgeschreven protocol? JA/NEE

10. Door welke disciplines is dit protocol gekend?
    - o Kine
    - o Ergo
    - o Verpleegkundigen
    - o Artsen
    - o Overig: *(omschrijf)*

11. Hoe wordt het protocol verspreid onder de teamleden? *(open vraag)*

DEEL III: IMMOBILISATIE VAN HET BOVENSTE LIDMAAT

12. In hoeveel % van de patiënten met een hemibeeld na het doormaken van een CVA wordt een sling voorgeschreven/gebruikt?
    - 0-25%
    - 26-50%
    - 51-75%
    - 76-100%

13. Welke preventieve indicaties (om de ontwikkeling van schouderpijn tegen te gaan) worden op uw afdeling gehanteerd om over te gaan tot het gebruiken van een sling bij CVA patiënten?
    - Subluxatie van de schouder
    - Schouderpijn
    - Schouder hand syndroom
    - Neglect
    - Ernstige cognitieve beperkingen waardoor de patiënt onvoldoende zorg draagt voor zijn arm
    - Overig *(omschrijf)*

14. Welke therapeutische indicaties (om aanwezige schouderpijn te behandelen) worden op uw afdeling gehanteerd om over te gaan tot het gebruiken van een sling bij CVA patiënten?
    - Subluxatie van de schouder
    - Schouderpijn
    - Schouder hand syndroom
    - Neglect
    - Ernstige cognitieve beperkingen waardoor de patiënt onvoldoende zorg draagt voor zijn arm
    - Overig *(omschrijf)*

15. Welke types slings worden voorgeschreven op uw afdeling?
    - Draagdoek met positionering in horizontale positie (Vb. Dupuy verband)

    - Klassieke sling in 8-vorm (Vb. Actimove)

- o Preel bandage

- o Arm-schouderwraps (Vb. Omo neurexa, Shoulderlift, Shoulderwrap, Omo-hit)

- o Anders *(omschrijf)*

16. Welke voordelen ervaart u van het gebruik van een armsling voor de revalidatie van de CVA patiënten? (meerdere antwoorden kunnen aangeduid worden)
    - o De schouderpijn neemt af
    - o De subluxatie van de schouder wordt gecorrigeerd
    - o De patiënt heeft meer aandacht voor de arm
    - o De arm is in een veilige positie
    - o Patiënt heeft een beter evenwicht
    - o Het gangpatroon is meer symmetrisch
    - o Patiënt heeft een beter lichaamsinzicht
    - o De andere personen die in contact komen met de patiënt hebben meer aandacht voor de arm
    - o Geen
    - o Overig *(omschrijf)*

17. Ondervindt u eventuele beperkingen van het gebruik van de armsling voor de revalidatie van de CVA patiënt? (meerdere antwoorden kunnen aangeduid worden)
    - o De subluxatie wordt niet gecorrigeerd
    - o De schouderpijn neemt niet af

- o De patiënt ontwikkelt pijn
- o De patiënt heeft minder aandacht voor de arm
- o De patiënt heeft het moeilijk met posities van de arm die afwijken van de positie in de sling
- o De patiënt heeft een minder goed lichaamsbeeld
- o De sling is vaak foutief aangebracht door de patiënt
- o De sling is vaak foutief aangebracht door anderen
- o Er ontstaan contracturen
- o De arm van de patiënt recupereert minder volledig
- o De arm van de patiënt recupereert minder snel
- o De patiënt krijgt minder sensorische input
- o Geen
- o Overig *(omschrijf)*

18. Hoe adviseert u de patiënt om de sling te dragen:
    - o Tijdens bepaalde activiteiten?
    - o Gedurende een aantal uur per dag?
    - o Permanent (zonder nachtrust)
    - o Permanent (met nachtrust)

19. Wordt het gebruik van de sling afgebouwd na enige tijd?
    - o NEE
    - o JA

    Indien JA: wat zijn de indicaties om het gebruik af te bouwen? *(open vraag)*

DEEL IV: PERSOONLIJKE GEGEVENS

20. Leeftijd
    - o < 30 jaar
    - o 31 – 40 jaar
    - o 41 – 50 jaar
    - o 51 – 60 jaar
    - o 61 – 65 jaar
21. Geslacht
    - o M
    - o V
22. Discipline
    - o Kine
    - o Ergo
23. Aantal jaren ervaring in het behandelen van CVA patiënten
24. Plaats tewerkstelling
    - o Ziekenhuis
        - ▪ Dienst neurologie

    - Sp dienst
    - Andere:
  - Revalidatiecentrum
    - Ambulante revalidatie
    - Gehospitaliseerde revalidatie
    - Beiden

25. Werkt u ook in een privé praktijk?
  - JA
  - NEE

ENQUETE PATIENTEN Revalidatie fase (< 6 maanden na CVA)

DEEL I: MOTORISCHE MOGELIJKHEDEN VAN DE ARM

1. Ik kan mijn schouder van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - o JA
   - o NEE

2. Ik kan mijn elleboog van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - o JA
   - o NEE

3. Ik kan mijn pols van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - o JA
   - o NEE

4. Ik kan mijn hand en vingers van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - o JA
   - o NEE

5. Ik kan met mijn zwakkere hand een glas nemen en het naar mijn mond brengen om te drinken.
   - o JA
   - o NEE

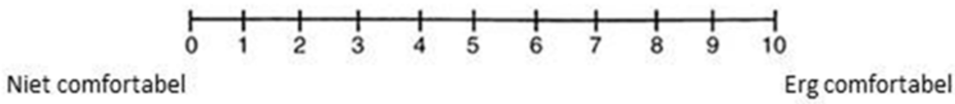
6. Ik kan met mijn zwakkere arm mijn haar kammen.
   - o JA
   - o NEE

7. Ik kan mijn naam schrijven met mijn zwakkere arm
   - o JA
   - o NEE

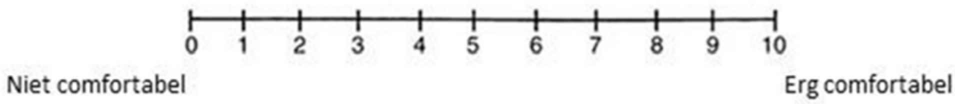
8. Welke verwachting hebt u over het herstel van uw arm.
   - o Mijn arm zal volledig herstellen
   - o Mijn arm zal deels herstellen
   - o Wat ik nu kan met mijn arm zal gelijk blijven
   - o In de toekomst zal ik minder kunnen met mijn arm

DEEL II: PIJN & COMFORT

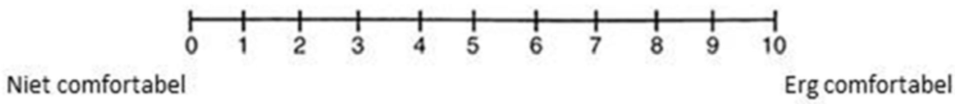
9. Hoe comfortabel is uw arm tijdens liggen in bed? (omcirkel het juiste cijfer)



10. Hoe comfortabel is uw arm tijdens zitten? (omcirkel het juiste cijfer)



11. Hoe comfortabel is uw arm tijdens stappen? (omcirkel het juiste cijfer)



12. Hebt u pijn aan uw arm?
    - o NEE (ga naar **vraag 15**)
    - o JA

13. Waar hebt u pijn?
    - o Schouder
    - o Elleboog
    - o Pols
    - o Hand en vingers

14. Wanneer heeft uw pijn?
    - o Tijdens rust
    - o Tijdens de nacht
    - o Tijdens activiteiten
        - Verzorging
        - Kleden
        - Oefentherapie
        - Mobilisatie
        - Transfers (verplaatsen tussen vb. stoel en bed)
        - …………………………………………………………………………..

15. Heeft het onvolledige herstel van uw arm een invloed op uw levenskwaliteit?
    - o NEE
    - o JA: verklaar

DEEL III: SLING GEBRUIK

16. Draagt u een sling?
    - o JA (ga naar **vraag 17**)
    - o NEE (ga naar **vraag 22**)

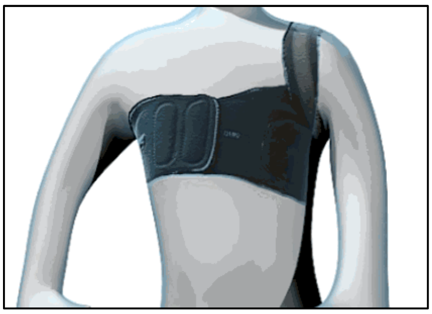
17. Hoeveel uur per dag draagt u een sling?
    - o 1-3u per dag
    - o 3-6u per dag
    - o > 6u per dag

18. Tijdens welke activiteiten draagt u een sling?
    - o Stappen
    - o Transfers
    - o Rolstoel rijden
    - o Keukenactiviteiten
    - o Verzorging
    - o Oefenmomenten
    - o Andere:…………………………………………………………………………………………………….

19. Welk type sling draagt u?
    - o Draagdoek met positionering in horizontale positie (Vb. DePuy verband)

- Klassieke sling in 8-vorm (Vb. Actimove)

- Preel bandage



- Arm-schouderwraps (Vb. Omo neurexa, Shoulderlift, Shoulderwrap, Omo-hit)

- Andere……..

20. Ondervindt u nadelen bij het dragen van de sling?

21. Ondervindt u voordelen bij het dragen van de sling?

22. Waarom draagt u geen sling?

DEEL IV: KINESITHERAPIE

23. Hoe vaak worden er actieve oefeningen gedaan met uw arm? (actief = waarbij u zelf een beweging moet inzetten of proberen inzetten en/of proberen verder zetten van een beweging die door de therapeut ingezet wordt)
    - o Tijdens elke sessie kinesitherapie
    - o Tijdens minstens de helft van de sessies kinesitherapie
    - o Uitzonderlijk
    - o Nooit

24. Vindt u dat er voldoende aandacht wordt besteed aan uw arm tijdens de therapie
    - o JA
    - o NEE

25. Hoe vaak per week wordt uw arm gemobiliseerd?
    - o 1-2 x per week
    - o 3-4 x per week
    - o 5-6 x per week
    - o 7 x per week

26. Hoe lang duurt deze mobilisatie?
    - o ≤ 10 min
    - o 10 – 20 min
    - o 20 – 30 min
    - o ≥ 30 min

27. Door wie wordt ze uitgevoerd?
    - o KINE
    - o ERGO
    - o Beiden

DEEL V: ERGOTHERAPIE

28. Hoe vaak worden er actieve oefeningen gedaan met uw arm? (actief = waarbij u zelf een beweging moet inzetten of proberen inzetten en/of proberen verder zetten van een beweging die door de therapeut ingezet wordt)
    - o Tijdens elke sessie ergotherapie

- Tijdens minstens de helft van de sessies ergotherapie
- Uitzonderlijk
- Nooit

29. Vindt u dat er voldoende aandacht wordt besteed aan uw arm tijdens de therapie?
    - JA
    - NEE

DEEL VI: VERZORGING

30. Vindt u dat er voldoende aandacht wordt besteed aan uw arm tijdens de verzorging?
    - JA
    - NEE

DEEL VII: PERSOONLIJKE GEGEVENS

31. Geslacht
    - M
    - V
32. Leeftijd
    - $\leq$ 30 jaar
    - 31 – 40 jaar
    - 41 – 50 jaar
    - 51 – 60 jaar
    - 61 – 65 jaar
    - > 65 jaar
33. Hoe lang geleden is uw CVA opgetreden?
    - < 1 maand geleden
    - 1 – 3 maand geleden
    - > 3 maand geleden
34. Welke therapie krijgt u?
    - KINE
    - ERGO
    - LOGOPEDIE
    - NEUROCOGNITIEVE TRAINING
35. Hoe vaak per week gaat u naar de kinesitherapie?
    - 1-2 x per week
    - 3-4 x per week
    - 5-6 x per week
    - 7 x per week

ENQUETE PATIENTEN Chronische fase (> 6 maanden na CVA)

DEEL I: MOTORISCHE MOGELIJKHEDEN VAN DE ARM

1. Ik kan mijn **schouder** van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - JA
   - NEE

2. Ik kan mijn **elleboog** van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - JA
   - NEE

3. Ik kan mijn **pols** van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - JA
   - NEE

4. Ik kan mijn **hand en vingers** van mijn verlamde zijde zelf bewegen zonder hulp van mijn niet-verlamde arm of van een andere persoon.
   - JA
   - NEE

5. Ik kan met mijn zwakkere hand een glas nemen en het naar mijn mond brengen om te drinken.
   - JA
   - NEE

6. Ik kan met mijn zwakkere arm mijn haar kammen.
   - JA
   - NEE

7. Ik kan mijn naam schrijven met mijn zwakkere arm.
   - JA
   - NEE

8. Welke verwachting hebt u over het herstel van uw arm.
   - Mijn arm zal volledig herstellen
   - Mijn arm zal deels herstellen
   - Wat ik nu kan met mijn arm zal gelijk blijven
   - In de toekomst zal ik minder kunnen met mijn arm

DEEL II: PIJN & COMFORT

9. Hoe comfortabel is uw arm tijdens liggen in bed? (omcirkel het juiste cijfer)

0 1 2 3 4 5 6 7 8 9 10

Niet comfortabel Erg comfortabel

10. Hoe comfortabel is uw arm tijdens zitten? (omcirkel het juiste cijfer)

0 1 2 3 4 5 6 7 8 9 10

Niet comfortabel Erg comfortabel

11. Hoe comfortabel is uw arm tijdens stappen? (omcirkel het juiste cijfer)

0 1 2 3 4 5 6 7 8 9 10

Niet comfortabel Erg comfortabel

12. Hebt u pijn aan uw arm?
    - o NEE (ga naar **vraag 15**)
    - o JA (ga naar **vraag 13**)

13. Waar hebt u pijn?
    - o Schouder
    - o Elleboog
    - o Pols
    - o Hand en vingers

14. Wanneer heeft u pijn?
    - o Tijdens rust
    - o Tijdens de nacht
    - o Tijdens activiteiten
        - Verzorging
        - Kleden
        - Oefeningen
        - Mobilisatie
        - Transfers (verplaatsen tussen vb. stoel en bed)
        - ………………………………………………………………………..

15. Is uw levenskwaliteit afgenomen doordat uw arm niet volledig hersteld is?
    - o NEE
    - o JA: verklaar

DEEL III: SLING GEBRUIK

16. Draagt u een sling?
    - JA (verder met **vraag 17**)
    - NEE (ga naar **vraag 22**)

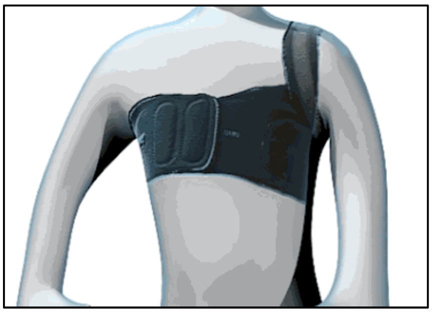
17. Hoeveel uur per dag draagt u een sling?
    - 1-3u per dag
    - 3-6u per dag
    - > 6u per dag

18. Tijdens welke activiteiten draagt u een sling?
    - Stappen
    - Transfers
    - Rolstoel rijden
    - Keukenactiviteiten
    - Verzorging
    - Oefenmomenten
    - Andere…….

19. Welk type sling draagt u?
    - Draagdoek met positionering in horizontale positie (Vb. DePuy verband)

    - Klassieke sling in 8-vorm (Vb. Actimove)

    - Preel bandage



o Arm-schouderwraps (Vb. Omo neurexa, Shoulderlift, Shoulderwrap, Omo-hit)

o Andere………..

20. Ondervindt u nadelen bij het dragen van de sling?

21. Ondervindt u voordelen bij het dragen van de sling?

22. Waarom draagt u geen sling?

23. Heeft u vroeger (kort na uw CVA) een sling gedragen?

- o JA (ga naar **vraag 24**)
- o NEE (ga naar **vraag 25**)

24. Waarom bent u gestopt met het dragen van een sling?

DEEL IV: KINESITHERAPIE

25. Hoe vaak worden er actieve oefeningen gedaan met uw arm? (actief = waarbij u zelf een beweging moet inzetten of proberen inzetten en/of proberen verder zetten van een beweging die door de therapeut ingezet wordt)
    - o Tijdens elke sessie kinesitherapie
    - o Tijdens minstens de helft van de sessies kinesitherapie
    - o Uitzonderlijk
    - o Nooit

26. Vindt u dat er voldoende aandacht wordt besteed aan uw arm tijdens de therapie
    - o JA
    - o NEE

27. Hoe vaak per week wordt uw arm gemobiliseerd?
    - o 1-2 x per week
    - o 3-4 x per week
    - o 5-6 x per week
    - o 7 x per week

28. Hoe lang duurt deze mobilisatie?
    - o ≤ 10 min
    - o 10 – 20 min
    - o 20 – 30 min
    - o ≥ 30 min

DEEL V: ERGOTHERAPIE

29. Volgt u nog ergotherapie?
    - o JA (ga naar **vraag 30**)
    - o NEE (ga naar **DEEL VII: persoonlijke gegevens**)

30. Hoe vaak worden er actieve oefeningen gedaan met uw arm? (actief = waarbij u zelf een beweging moet inzetten of proberen inzetten en/of proberen verder zetten van een beweging die door de therapeut ingezet wordt)
    - o Tijdens elke sessie ergotherapie
    - o Tijdens minstens de helft van de sessies ergotherapie
    - o Uitzonderlijk
    - o Nooit

31. Vindt u dat er voldoende aandacht wordt besteed aan uw arm tijdens de therapie
    - o JA
    - o NEE

DEEL VI: PERSOONLIJKE GEGEVENS

32. Geslacht
    - o M
    - o V
33. Leeftijd
    - o ≤ 30 jaar
    - o 31 – 40 jaar
    - o 41 – 50 jaar
    - o 51 – 60 jaar
    - o 61 – 65 jaar
    - o > 65 jaar
34. Hoe lang geleden is uw CVA opgetreden?
    - o 6 – 9 maanden
    - o 9 maanden – 1 jaar
    - o 1 – 5 jaar
    - o 5 – 10 jaar
    - o ≥ 10 jaar
35. Welke therapie krijgt u momenteel nog?
    - o KINE
    - o ERGO
    - o LOGOPEDIE
    - o NEUROCOGNITIEVE TRAINING
36. Hoe vaak per week volgt u kinesitherapie?
    - o 1-2 x per week
    - o 3-4 x per week
    - o 5-6 x per week
    - o 7 x per week

CURRICULUM VITAE

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Opleiding

1994-2000 Hoger secundair onderwijs
Latijn Wiskunde
Koninklijk Atheneum Turnhout

2000-2005 Universiteit Gent
Opleiding Kinesitherapie en Revalidatiewetenschappen
Optie Bijzondere groepen (Neurologie-pediatrie-geriatrie-cardiorespiratoir)
Afgestudeerd met grote onderscheiding

Bijkomende opleidingen

Erkende inleidingsweek in het Affolter-Model door dr. F. Affolter en dr. W. Bischofberger (2011)

Basiscursus Bobath voor volwassenen met NAH (2012)

Advanced course in the assessment and treatment of adults with hemiparesis and other neurological conditions. "The Bobath Concept with an emphasis on upper limb treatment, from function/structure to participation". (2015)

Aspirant Management Development Program. "Van Talent naar Leidinggeven. Van Zelf-Leiderschap naar Leidinggeven. Een Ontdekkingstocht." (2015)

Advanced Academic English: Conference Skills - Presentation Skills in English (2016)

Effective Graphical Displays (2017)

Advanced Bobath course: Bipedal Locomotion and recovery of walking competence. (2017)

Advanced Bobath course: Postural control related to reaching. (2018)

Werkervaring

Juli/augustus 2005: Woon- en zorgcentrum De hoge heide te Arendonk

September 2005 t/m maart 2006: UZ Gent – Labo voor bewegingsanalyse, Referentiecentrum voor Cerebral Palsy en Kinderrevalidatiecentrum

Maart 2006 t/m januari 2007: UZ Gent Kinderrevalidatiecentrum (deeltijds)

Maart 2006 t/m maart 2008: Praktijk voor ontwikkelingstherapie en neuromotorische revalidatie te Kluisbergen o.l.v. de heer Patrick Algoet (deeltijds)

Februari 2007 t/m september 2007: UZ Gent revalidatiecentrum afdeling NAH

Oktober 2007 t/m september 2008: UZ Gent Labo voor bewegingsanalyse, Referentiecentrum voor Cerebral Palsy en kinderrevalidatiecentrum
Tijdelijke wissel omwille van een zwangerschap van een collega kinesitherapeut op vraag van de betreffende artsen.

September 2008 tot op heden: UZ Gent revalidatiecentrum afdeling NAH

Augustus 2012 – tot op heden:
50% UZ Gent Revalidatiecentrum afdeling NAH
50% Ugent Vakgroep Revalidatiewetenschappen en Kinesitherapie – Mandaatassistent.

Publicaties

Shoulder subluxation in stroke patients: measuring the immediate and long-term effect of arm slings using sonography
Anke Van Bladel – Gert Lambrecht – Kristine Oostra – Guy Vanderstraeten - Dirk Cambier
Published: European Journal of Physical and Rehabilitation Medicine 2017 June;53(3):400-9.

Effect of arm slings on posture, balance and gait in subacute stroke patients
Accepted for publication Nov 8, 2017: International Journal of Therapy and Rehabilitation
Anke Van Bladel – Kristine Oostra – Tanneke Palmans – Cinthia Saucedo Marquez – Dirk Cambier

Current practices of upper limb rehabilitation after stroke in flanders: a survey among physiotherapists and occupational therapists
Submitted: International Journal of Rehabilitation Research
Anke Van Bladel – Bieke Van Deun – Kristine Oostra – Dirk Cambier

Mobilization techniques of the hemiplegic shoulder in subacute stroke patients with poor arm recovery: a randomized multiple treatment trial
Anke Van Bladel – Ann Cools – Marc Michielsen – Kristine Oostra – Dirk Cambier
Under review in Topics in Stroke Rehabilitation

Damage to Fronto-Parietal Networks impairs Motor Imagery Ability after stroke: A Voxel-Based Lesion Symptom Mapping Study
Kristine Oostra – Anke Van Bladel – Ann Vanhoonacker – Guy Vingerhoets
Published: Front. Behav. Neurosci. 2016 10:5

Paratonia in Flemish nursing homes: Current state of practice.
Bieke Van Deun, Nele Van den Noortgate, Cinthia Saucedo, Anke Van Bladel, Dirk Cambier
Accepted for publication in American Journal of Alzheimer's Disease and Other Dementias on January 30, 2018

Posterpresentaties

25/01/2014 International Congres of Physiotherapie (Brussel): Mirror and Audio-Feedback: A Transversal Pilot Study with EMG Registration in Stroke Patients

21-22 mei 2015 Congress on neurorehabilitation and neural repair (Maastricht): Measuring the immediate effect of an arm sling using sonography (a preliminary cross-sectional study)
Anke Van Bladel – Kristine Oostra – Cambier Dirk

29/09/2016 ESMAC (Sevilla): The effect of arm slings on posture, balance and gait in subacute stroke patients
Anke Van Bladel - Isabel Langenaekens - Jolien Lannoye - Kristine Oostra - Tanneke Palmans - Dirk Cambier

Congres Belgische Vereniging neurorevalidatie verpleegkundigen: Het effect van armslings op de hemiplegische schouder: adviezen voor de verpleegafdeling van een revalidatiecentrum (Prijs van beste poster)
Anke Van Bladel – Kristine Oostra – Guy Van de Velde – Dirk Cambier

22-24 mei 2017 2nd International congress on Neurorehabilitation and Neural Repair (Maastricht): A randomized controlled trial on the immediate and post-interventional effect of arm slings on shoulder subluxation in stroke patients
Anke Van Bladel - Gert Lambrecht - Kristine Oostra - Guy Vanderstraeten - Dirk Cambier

22-24 mei 2017 2nd International congress on Neurorehabilitation and Neural Repair (Maastricht): Effect of arm slings on posture, balance and gait in subacute stroke patients
Anke Van Bladel - Kristine Oostra - Tanneke Palmans - Cinthia Saucedo Marquez - Dirk Cambier

Voordrachten

26/03/2015 Seminarie Stagementoren IPVK
Hemiplegische schouderpijn: een update van de literatuur

17/09/2015 Gilde der kinesitherapeuten arrondissement Ieper
CVA en het bovenste lidmaat: hemiplegische schouderpijn

26-27/2/2016 Winter Meeting Belgische vereniging voor Gerontologie en Geriatrie
De hemiplegische schouder: van theorie naar praktijkrichtlijn

7-9/3/2017 Gymna themadagen
Herstel van het bovenste lidmaat na een CVA wat kunnen we verwachten en waar willen we naartoe

24/10/207 Kinekring Oudenaarde Ronse
De pijnlijke schouder bij CVA: invloed van de rompstabiliteit en aandachtspunten tijdens transfers

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