Chapter

Rehabilitation Medicine Management of Spasticity

Seyed Mansoor Rayegani, Marzieh Babaee and Seyed Ahmad Raeissadat

Abstract

Spasticity is a poorly recognized but common symptom, present in a wide range of neurological conditions. It can have a major impact on those affected, much of which is potentially preventable. This chapter provides an excellent paradigm to incorporate many of the key elements fundamental to the management of chronic conditions and it is of relevance to those who work in spasticity rehabilitation.

Keywords: spasticity, rehabilitation, orthoses, drug, physiotherapy, occupational therapy

1. Introduction

Spasticity is one of the common symptoms in a wide range of neurological conditions, and it needs multidisciplinary approach for best management. This chapter provides an excellent paradigm to incorporate many of the key elements fundamental to the management of chronic conditions and it is of relevance to those who work in spasticity rehabilitation. This chapter presents a comprehensive view about rehabilitation with these subtitles:

- Assessment of the individual with spasticity
- Provision of education and promoting self-management
- Physical management of spasticity(physiotherapy or occupational therapy)
- Orthoses
- Pharmacological intervention
- Setting up a service

2. Assessment of the individual with spasticity

Accurate assessment of spasticity is the starting point to make a proper and valuable plan for this route. In addition to assessing physical changes, resistance to movement, weakness, and contractures, the impact of spasticity on the activities of

daily life should be considered as well. These assessments should also be carried out in the follow-up visits. In some references, it is recommended to perform the assessments by a professional in this area in a multidisciplinary visit with a team of specialists and clinicians instead of assessments by different specialists in several visits. The assessment consists of two parts: history and physical examination.

2.1 History

The ultimate goal of assessment of history is to provide a thorough history that encompasses the impact of the disease on the patient's communications and interactions with the environment and also covers all aspects of the disease. Therefore, the provision of a checklist is recommended (Appendix 1). In addition to the suggested questions, the answers to these two questions are very important in history taking and should be included in the treatment plan: Does the spasticity contribute to improving your performance? And is this spasticity a local problem or a generalized one?

2.2 Physical examination

The physical examination involves three steps, as follows.

2.2.1 Observation

For observation, it is recommended to evaluate the items of posture, alignment, presence of spontaneous spasms, seating if applicable, movement patterns when moving (e.g., walking, transferring or picking up objects), and pressure sores. However, observation alone is not enough and outcome measurements (Appendix 2) such as timed 10-meter walk test and goniometry are useful.

2.2.2 Assessment of active movement, including range of motion and muscle strength

The grading scale of the Medical Research Council (MRC) (**Table 1**) can be used to assess both weakness and spasticity. However, its application in severe to moderate spasticity is difficult.

2.2.3 Assessment of resistance to passive movement, including assessment of the full range of motion and contracture identification

Trunk and limb spasms are evaluated in this step. This assessment is usually performed using the Modified Ashworth scale. However, it may fail to distinguish

Grade	Definition
0	No contraction
1	Flicker of contraction only
2	Active movement with gravity eliminated
3	Active movement against gravity
4	Active movement against gravity and resistance
5	Normal power

Table 1.
Medical Research Council (MRC) grading of muscle strength.

Perform three passive movements only and record the score of the resistance felt on the third movement
The score is taken within the available range
Move the limbs in the best alignment possible, record position and use when repeating measures
Regulate the speed by counting 1001, 1002, 1003

Table 2.
Recommendations to standardize the measurement of the Ashworth scale.

between neuronal and non-neuronal causes of spasticity [1]; thus, the items addressed in **Table 2** should be noted to avoid misinterpretation [2]. It is effective to use the Tardiu scale [3] to differentiate between the neuronal component and the non-neuronal one because of the evaluation at different velocities [4]; however, it is more time-consuming than the Ashworth test. It should be noted that the suggested tests are specified for spasticity evaluation in limbs, and if one of the patient's chief complaints is trunk spasticity, the verbal or visual analog scales can be used as well as measuring the distance between two fixed points on the trunk in fast and slow trunk flexions by using a tape.

It is important to use outcome measures in clinical evaluation; however, it is always challenging to maintain a balance between test simplicity and speed with its reliability and validity [5], so different tests and methods have been suggested with respect to the disease diagnosis. In this book, we recommend the outcome measure of the National Hospital of Neurology and Neurosurgery (NHNN) in London with a few modifications [2], which is typically used for patients with moderate to severe spasticity (Appendix 2).

When the assessment is over and the treatment plan is being outlined, any physician should ask himself an important question: "why should I treat this spasticity?" and the more important question is "what are the patient's expectations of this treatment?" So the ultimate goal should be discussed with the patients and their caregivers to expect a realistic outcome. Since these goals are different for each patient, the following desires can be addressed: sitting comfortably in a wheelchair, adequate and comfortable night sleep, easier catheterization for bladder drainage, etc.

Different algorithms [6–8] have been developed for the evaluation of and therapeutic approach to spasticity; one of the most applied of them has been developed by Stevenson et al. [2] and is presented in **Figure 1**.

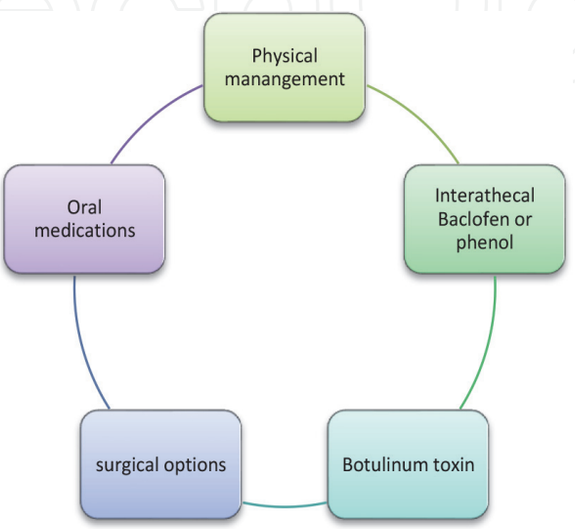

Figure 1.
Therapeutic approach to spasticity.

3. Provision of education and promoting self-management

Nowadays, it has been found that the patient's awareness of the disease and the situation he/she is dealing with promotes the therapeutic process and interventions. This view and its results have also led to the development of courses known as Expert Patient Programmes [9]. The patient and his/her caregivers' understandings of the medical conditions and therapeutic interventions are crucial and effective to the treatment and therapeutic protocol selection. This is especially because different therapeutic interventions for spasticity do not have a linear nature and several treatments are sometimes considered for the patient at the same time (**Figure 1**).

To improve the spasticity treatment efficacy, some instructions should be presented to the patient, either verbally or using a written material [10]. These instructions include the following:

A. Maintaining movement and adequate positioning and B) Recognizing and preventing factors that may aggravate or trigger spasticity and spasms.

B. Maintaining movement and adequate positioning:

   A main factor in the spasticity treatment is to maintain the joints' range of motion, which should be performed by the patient or his/her caregiver. Moreover, maintaining muscle length is the second factor that is usually achieved by stretching or splinting [8]. Thus, sitting and standing positions are also critical.

C. Recognizing and preventing factors that may exacerbate spasticity and spasms:

Elimination of unwanted sensory triggers is an important factor in spasticity reduction. Naturally, cutaneous and visceral triggers (**Table 3**) regulate the interneuronal activity by signaling to the spinal cord. Elimination and dysfunction of some modulating pathways can inhibit polysynaptic reflexes (such as flexor withdrawal) and cause spasm [11].

Similarly, abnormal activities of spinal cord circuits induce discharges in motor neurons innervating several muscles, thereby causing a concurrent contraction of these muscles and aggravating spasticity [12, 13]. Sometimes, some patients are aware of such stimuli exacerbating their symptoms (e.g., bowel habit) while having no clue how to modulate or reduce them. The patients should consider the following:

1. Optimization of bladder and bowel management. Any defecation alteration including urinary retention, infection, constipation, or diarrhea can

Cutaneous stimuli	Visceral stimuli
Skin lesion (red or inflamed skin, broken skin, infected skin, pressure sores, ingrown toenails)	Bowel and bladder dysfunction: for example, constipation, overflow or diarrhea, infections, retention or incomplete emptying
Tight-fitting clothes or urinary leg bag straps	Any systemic or localized infection
Uncomfortable orthotics or seating systems	Deep-vein thrombosis

Table 3.
Sensory stimulations that may aggravate spasticity.

exacerbate the symptoms. Even the mild infection (e.g., Candida) can aggravate the symptoms.

2. Maintaining skin integrity. Avoiding any skin irritation, infection, and pressure sores is effective in spasticity reduction. So skin examinations, especially in the vulnerable areas including the areas under pressure or under orthosis, as well as preventing ingrown toenails and deep-vein thrombosis are needed.

Sometimes, there are individual factors that each patient gradually realizes (e.g., in some women, symptoms exacerbate during menstruation period). Knowledge of some of these risk factors is important in treatment choice. In some cases, elimination of some of these factors or waiting for a few days (e.g., in menstruation period) and or a temporary rise in the drug dosage is very effective in solving the patient's problem.

Another point of patient education is that the weakness and spasticity are concomitant [2]; so the patient should know that sometimes the weakness becomes more pronounced by medication use and subsequent spasticity reduction while patients consider this effect as a drug side effect or lack of response. So, in case the spasticity is an effective factor in preserving some of the patient's functions (e.g., standing up and going to the bathroom in the morning), the medication should be taken after the desired activity (going to the bathroom).

Patients should receive written information on the medication dosage, side effects, and follow-up tests for the response to treatment. There should be a telephone number in the form for convenient communication with the health care center or the physician.

4. Physical management of spasticity(physiotherapy or occupational therapy)

The key to a satisfying treatment for spasticity is to educate the patient properly and ensure that the patient follows the instructions correctly. Also, as spasticity changes during the treatment, treatment regimens should change with the patient's condition and be flexible. Proper patient management requires physiotherapy initiation immediately after the disease diagnosis and at regular intervals throughout the disease course, depending on the patient's condition and the diagnosis made by the treatment team. On the other hand, assessment and differentiation between the neuronal and non-neuronal (connective tissue, joint component, muscle, and tendon) causes of hypertonia are critical because the treatment of non-neuronal [14] (passive) causes involves physical therapies such as stretching and splinting; these problems do not respond to medical treatments.

4.1 Physical management strategies

The goal of physical management is to maintain and even improve the performance level and prevent the problems secondary to spasticity. In fact, spasticity reduction is not always a treatment goal, as in some cases maintaining the patient's function requires a little spasticity and increased tone. Therefore, physical management focuses on the performance, discomfort and pain relief, and prevention of secondary complications including contractures and pressure ulcers. The key goals of a physical management plan include the following [2]:

- Maintaining the viscoelastic characteristics of tissues including tendons, muscles, and joints to prevent contractures. This goal is achieved through active and passive movements as well as standing and stretching with splints.

- Controlling the spasticity and spasm so that they will not be self-perpetuating; for example, using techniques and methods in the situations and positions exacerbating the symptoms.

- Maintaining the individual's level of performance. It can be achieved by strengthening activities and keeping cardiovascular fitness.

- Evaluation of spasticity as a positive factor in the patient's function. But a balance should be maintained between the benefits and spasticity-induced complications.

- Generally, there is no single physical modality and the treatments are parallel and concomitant, depending on the patient's conditions. In the following, the treatment options will be discussed in detail.

4.2 Standing

Standing is considered as a therapeutic option since it activates the anti-gravity muscles, improves flexibility, reduces contractures, modulates the neuronal component of spasticity, reduces sensory inputs and lower limb spasms, and has positive psychological effects [15–18]. Regarding the duration and frequency of this physical therapy, studies have suggested a duration of between 30 minutes and 1.5 hours while most patients have performed this exercise for 40 minutes and with a frequency of three to four times a week [18–20]. Remember that the duration and frequency depend on the patient's condition; so, the decision should be made based on this factor. However, at least 30 minutes of standing seems to be reasonable. The best standing position is in an extended posture with neutral alignment of the trunk, pelvis, and lower limb joints, carried out actively by the patient himself/herself or by using standing aids including Oswestry standing frames, motorized or hydraulically assisted standing systems, standing wheelchairs, or at least a tilt table (according to the patient symptom severity respectively) [2]. In all these cases, hypotension is the most notable complication, which can be prevented by arrangements such as avoiding sudden position change or by using compression stockings.

4.3 Active exercise and promotion of optimal movement patterns

In most of the cases, patients with spasticity are advised for spasticity reduction and less attention is paid to muscle weakness, and sometimes strengthening exercises are not prescribed because of the concern for spasticity exacerbation [21]. It is recommended, to the extent possible, to perform active exercises in order to increase the strength, re-educate movement patterns, and improve cardiovascular fitness. The outcomes achieved by these exercises are not usually observed in passive exercises. Nowadays, it has been found that not only is antagonist muscle weakness effective in spasticity, but also an imbalance between agonist and antagonist muscles exacerbates the symptoms and causes atrophy [21]. The movement patterns should also change; in fact, proper movement patterns should be instructed. At the same time with limb exercises, the alignments of the trunk and pelvic girdle should be maintained. These exercises alter muscle functions and structures [22]. The strengthening recommendations should be realistic and close to

the patient's daily life activities and include all the involved muscles [23, 24]. Although no specific protocol has been suggested for this kind of patients, most studies recommend the protocol adapted from the sport sources. These traditional training rates are a load of 60–80% of one repetition maximum (the maximum load that can be lifted once), three sets of 10 repetitions carried out three or four times a week.

Alongside these exercises, cardiovascular fitness exercises have been recommended in various papers [25, 26]. Because these exercises are being neglected in these patients due to their inactivity especially.

The task-focused active-use therapy techniques such as the constraint-induced movement therapy can sometimes be used for upper limbs. The techniques should be used in an intensive program over a short period (e.g., 4–8 weeks) [27].

4.4 Passive movement

When the patient cannot move his/her limb, passive movements can be carried out by another person. In passive movement, generally, all the body joints should be moved in their ranges of motion daily. According to the studies, it seems that using passive movements can be effective in changing spasticity pattern, alleviating secondary non-neuronal complications, and improving positioning [2]. It is recommended to perform the passive movements daily, and it can be carried out before the patient repositioning. These movements should be safe and comfortable for both the patient and caregiver. Spasmolytic medication taking in 20–30 minutes before the movements can be helpful [2]. Sometimes sudden stretching can exacerbate the spasm, so the movements should be performed at slow speed. Skin irritations can cause symptom exacerbation as well; thus, the best way is to desensitize the skin on a gradual basis or handling the limb on top of clothes. Grabbing and holding the ball of the foot should be avoided because it is usually a sensitive point for these triggers and better not to be touched [2]. Moreover, the movements should be carried out with the best alignments of the muscles and joints, overstretching should not occur, and stereotypical spasticity patterning (e.g., flexing the hip in the midline rather than in adduction and internal rotation) should be avoided.

The critical point is that after the movements are over, the patient should be positioned properly. The position should not be the same as the previous position caused by spasms to keep the benefits of the movements [2]. Usually, these movements are not performed by the physician or therapist because it is time-consuming and is not cost-effective. So in addition to providing written material on the right techniques for the patient and caregivers, assistance appliances such as continuous passive movement machines (CPMs) or lifters (hoist) can also be used [2].

4.5 Stretches

Typically, with a 2-day immobilization, muscle changes initiate, including muscle shortening and atrophy, muscle compliance reduction, and increasing the ratio of collagen to muscle fibers [21]. Following these changes, there will be an increase in the sensitivity of muscle spindles to stretching, which can exacerbate the neuronal component of spasticity and subsequently the non-neural component [28]. On the other hand, stretching induces actin and myosin synthesis; as a result, the number of sarcomeres as well as the muscle length increases [21, 29]. So far, there is no agreement on the duration and frequency of stretching exercises but the following protocol can be considered for the daily schedule [30, 31].

It is suggested to administer the stretching according to the patient's daily schedule and his/her posture [2]. The stretching can be carried out actively or passively (by someone else or with FES). We can use the positioning, for example standing, sitting, or lying down with using splints and orthosis, to achieve a prolonged stretching. Another important point is that while stretching a muscle, the antagonist muscle shortens, so there should be a balance in the stretching schedules for all the muscles [2, 32]. Regarding the duration of stretching, studies have suggested 20, 30, or even 60 minutes. So, there is no single protocol [30], but it seems that the efficacy increases with longer durations. Also, it seems that stretching before the exercises has a more favorable effect.

The patient should be given written instruction on stretching. Stretches should include the back muscles, quadriceps, hip flexors, hip adductors, hamstrings, calf muscles (gastrocnemius and soleus), wrists, and fingers, and should be performed actively or passively. The therapist should modify the stretching based on each patient's condition.

4.6 Positioning

As well as improving the effective stretching and subsequent maintaining of range of motion, correct positioning also helps in altering the spasticity pattern, modifying asymmetry, and decreasing the risk of pressure-induced skin injuries [33]. The golden key to good positioning is to change the position during the day. An ideal position is important in both lying and sitting; moreover, the presence of exacerbating factors and triggers (e.g., pressure sore, pain) is critical in position selection. Performing passive exercises before positioning is helpful; for example, when the patient tries to use a T roll for the leg flexion position, performing several knee and hip flexions and bending the hips and knees up toward the chest and abdomen facilitate this position [34].

In correct positioning, muscles should be stretched and longer than usual. For example, these are the suggestions to improve the positioning in a patient with continuous spasticity-induced hip adduction: The patient should monitor his/her sitting position and try to keep his/her knees apart while sitting so that he/she does not get accustomed to the wrong position. The impact of trunk and pelvis positions on the legs should be evaluated. In a flexed posture with a posteriorly tilted pelvis, the legs tend to be in internal rotation and adduction; so, having a firmer seat base, a contoured cushion, or extra trunk support may facilitate a more anteriorly tilted pelvis position, trunk extension, and better lower limbs alignment. In patients unable to reduce adduction, using aids including a pummel, rolled-up towel, cushion or T roll can help in reducing the adduction.

4.7 Wheelchair and seating

In patients suffering from spasticity, the sitting position should be modified to improve the performance, accommodate to contractures and deformities established, maintain comfort, and reduce fatigue [35, 36]. The main requirements for a good sitting position are a firm seat base and backrest with subtle changes by altering the seat base to promote an anterior tilt of the pelvis to help in achieving hip flexion, abduction, and external rotation as well as trunk extension.

Patients with weakness in the trunk and neck extensors can use the tilt-in-space systems [37, 38], where the patient seat has a reclining at the back and flexion at the hip. In this system, hip flexion decreases the extension tone and spasticity as well as

providing support for the patient's back (by the backward movement of the backrest). Also, these seats improve kyphosis and breathing of the patients and reduce fatigue and pressure ulcers.

As the patient's spasticity status changes throughout the treatment, it is necessary to re-evaluate the patient's sitting position.

5. Orthosis

Orthoses or splints are tools for improving limb performance and preventing deformity. These appliances are usually custom-made [39]. Non-removable splinting devices made of plaster or casting tape are referred to as "casts." Casts are also a type of splint. Orthoses are used for the following treatment goals [27, 39]:

- Providing control over the joint's range of motion and thus improving its performance.
- Maintaining prolonged stretches on the muscle's tendon to alter or modify the changes occurred in tissues.
- Modifying deformities established (e.g., using heel raise in leg length discrepancy).
- Changing the neuronal component of spasticity through prolonged stretches and sensory input alteration.
- Increasing the patient's comfort.
- Correction of the posture.
- Correction of upper extremity performance.
- Improving walking efficiency.
- In children, preventing hip migration or slowing its progress.

In administering orthoses, in addition to discussing the treatment goals with patients, the method of use, duration, and times of use should be discussed as well. In each visit, the patient should be asked about pain, discomfort, and sleep disorder, while muscle wasting and the places under pressure by orthosis should be examined. Incorrect orthosis usage and feeling discomfort with orthosis use can exacerbate the symptoms and cause new deformities. There is no contraindication for administering orthoses; however, some problems addressed in **Table 4** can limit the use of splints, so these points should be noticed during the follow-up visits and proper solutions should be considered [2].

The most common splints based on the usage area are discussed here according to the evidence from different sources and guidelines. Evidence grading is according to **Tables 5** and **6** [40]. However, some of the splints are not mentioned here, we did not intend to deny their effects but only the splints with the best evidence are discussed.

Sensory impairment	Uncontrolled epilepsy
Unstable intracranial pressure	Heterotrophic ossification
Poor skin condition	Edema
Vascular disorder	Acute inflammation
Fracture or severe soft tissue injury	Medically unstable
Behavioral/cognitive disorders	Frequent spasms
Access to limb required for medical purposes	

Table 4.
Precautions for the use of splints or orthoses.

Quality of evidence	Grading	Characteristics
High	A	Based on consistent results from well-performed randomized controlled trials, or overwhelming evidence of an alternative source, for example, well-executed observational studies with strong effects
Moderate	B	Based on randomized controlled trials where there are serious flaws in conduct, inconsistency, indirectness, imprecise estimates, reporting bias, or some other combination of these limitations, or from other study designs with special strengths
Low	C	Based on observational evidence, or from controlled trials with several very serious limitations
Very low	D	Based on case studies or expert opinion

Table 5.
GRADE quality of evidence grading.

Strength	Grade	Benefits and risks
Strong	1. "It is recommended. .."	Benefits appear to outweigh the risks (or vice versa) for the majority of the target group
Conditional	2. "It is suggested. .."	Risks and benefits are more closely balanced, or there is uncertainty in likely service user values and preferences

Table 6.
Strength of grade.

5.1 Ankle

The following advice is suggested to correct contractures [40]:

- It is possible to use casts at the end of the range of motion for acute brain injury and stroke patients to improve the range of motion (2C). The cast should be replaced every 5–7 days. Use the cast for a 2- to 12-week period.

- In severely spastic patients, we can use casts with botulinum toxin injection (2B). The cast should be replaced every 5–7 days. Use the cast for a 2- to 12-week period.

- Using adjustable ankle splints at the end of the range of motion improves the joint's range of motion (2C). Splints are used 6–23 hours a day for

2–12 weeks and should be adjusted with improvements at the end of the range of motion.

- While using non-custom-made splints, necessary precautions should be taken to prevent pressure sores (2D).

Contracture prevention [40]:

- Using ankle casts at the end of dorsiflexion range can prevent contractures in ABI patients (2C). Primary casts should be replaced every 5–7 days depending on the change in the range of motion until the patient can maintain the plantar grade position. The last cast should be used as a bivalved plantar grade cast for 18 hours a day until the splint can maintain the range of motion.

- The ankle splint can prevent the limitation of the ankle's range of motion when the ankle is at a plantar grade position (2B). The recommended duration of use for ankle splint is 6–10 hours at night for 2–5 weeks.

- While using non-custom-made splints, necessary precautions should be taken to prevent pressure sores (2B).

Performance improvement [41]:

- The plantar spasticity ankle foot orthosis (AFO) can be used for better walking. In the case of mild spasticity, the single midline posterior stop AFO is used. The type of AFO with pins in the posterior channels can be used for more severe cases. Moreover, in patients with weak extensors of hip or knee, the solid type is recommended while the hinged type is suitable for patients with adequate control. In patients with crouched gait and passive range of motion in hip joints and pelvis, a ground reaction force AFO can be used.

5.2 Knee

Contracture improvement [40]:

- It is possible to use casts at the end of range of motion for acute brain injury and stroke patients to improve the knee's range of motion (2D). The cast should be replaced every 5–7 days. Use the cast for 2–12 weeks.

- Short-term application of the cast (1–4 days) entails fewer complications compared to the longer uses (5–7 days) (2C).

Contracture prevention [40]:

- Using casts at the end of range of motion in acute brain injury and stroke patients can prevent contractures (2C). The cast should be replaced every 5–7 days. Use the cast for a 2- to 5-week period.

- Use this cast with caution in the patients with acute lesions (acute brain injury and stroke) and decreased level of consciousness for preventing secondary complications such as pressure sores (2C).

- Knee splints can be used for standing control and walking improvement as well.

5.3 Wrist and hand

Contracture improvement [2, 40]:

- Using splints for deformity correction in hand and wrists is not routinely advised for every patient (e.g., in stroke and acute brain injury patients). However, they can be used in certain cases in an optional way (2B). These splints are custom-made or serial and adjustable (10 degrees wrist extension and finger extension with MCP flexion, wrist at neutral, or maximal available range of movement). Most of them are used for 20 minutes to 12 hours a day for a 1- to 8-week period.

Contracture prevention [2, 40]:

- Using splints for deformity prevention in hand and wrists is not routinely advised for every patient (e.g., in stroke and acute brain injury patients). However, they can be used in certain cases in an optional way (2B). In the studies, the splints have been used in different positions (10 degrees wrist extension and fingers fully extended, wrist at neutral, or close to maximal available range of movement) with duration of 6–12 hours a day for a 1- to 8-week period.

- Using splints in combination with botulinum toxin in selected cases can be effective in reducing the spasticity that has resulted in range of motion loss (2C). The splint is used at the end of the available range of movement but is not adjusted daily. On the other hand, strapping is used at the end of available range of movement, with daily adjustment to maximal stretch for 6 days.

- Using electrical stimulation in combination with splints is not recommended for contracture prevention (2A).

- Custom-made hand and wrist splints should not be used routinely for prevention from spasticity exacerbation in acute brain injury and stroke patients (2B).

- A wrist splint at neutral position can be effective in hand pain prevention caused by joint malalignment (2A). These splints should be used for minimum 6 hours a day for 13 weeks.

Performance improvement [2, 42]:

- Sometimes, a splint is also used to improve performance (**Figure 2**) or prevent tissue damage (e.g., sheepskin palm protector).

- Using volar splints in children with cerebral palsy can reduce the spasticity and improve the range of motion and performance in upper limb. However, theses splints are not effective on the upper limb movements in stroke patients.

- Using dorsal splints has no effect on spasticity, range of motion, and performance of upper limb in stroke patients.

- Dynamic splints can improve the upper limb performance and accelerate spasticity reduction.

Figure 2.
sheepskin palm protector is used to prevent tissue damage.

- The use of C-Bar splint is an effective method to improve hand performance and range of motion while decreasing spasticity in upper limb of cerebral palsy children.

- Using anti-pronation splints can be an effective technique to improve the performance of upper limb, range of motion of forearm supination, and wrist extension, as well as reducing the severity of spasticity in forearms pronator muscles and wrist flexor muscles. These splints are also effective in improving the gripping and pinching ability in children suffering from spastic diplegia cerebral palsy.

- Extension splints are not helpful in the rehabilitation program of stroke patients.

- As a modern splint, SAEBO splints can be helpful in improving the upper limb of stroke patients.

- In general, volar, dorsal, anti-pronation, and C-Bar splints are effective in spasticity reduction and performance improvement of upper limb in children with cerebral palsy while SAEBO and dynamic splints are useful for performance improvement and spasticity reduction of upper limb.

5.4 Elbow

Contracture improvement [40, 42]:

- Using casts is recommended at the end of range of motion to modify the elbow's range of motion (2C). The cast should be replaced every 3–7 days. Use the cast for a 1- to 4-week period.

- Short-term application of the cast (1–4 days) entails fewer complications compared to the longer use (4–7 days) (2C).

- Enough studies for contracture correction by splint are not available.

Contracture prevention [40]:

- Enough studies for contracture correction by splints are not available.

Performance improvement [42]:

- Elbow gaiters are recommended to maintain extension and improve function.

5.5 Spinal braces

- Spinal braces are usually used in cases with muscle weakness. In the patients with spasticity being the predominant complaint, spinal braces are not frequently used. It is because they are difficult to fit on the patients, are not comfortable, and can induce breathing problems and sores [2]. In these cases, the use of customized seating with individualized truncal and pelvic support can be a more beneficial and comfortable option. The braces can be used in patients with kyphosis and scoliosis if it helps in sitting.

6. Pharmacological intervention

On the decision for the treatment of spasticity, considering goals is a critical point and pharmacological interventions should be considered with non-pharmacological treatment for optimizing the effectiveness of management [2]. Another important point in prescription of drugs is about the patient's situation and the dosage and timing should be considered according to it. For example, painful nocturnal spasms may best be managed with a long-acting agent taken at night-time that has sedative side effects. As a rule for all medication, "start low and go slow" [2]. Although it is time-consuming, this approach will limit any deleterious effects on function or unwanted side effects. For better discussion, pharmacological interventions are categorized according to spasticity pattern including, generalized, segmental, and focal.

6.1 Generalized spasticity

There are several oral treatments for management of generalized spasticity. However, there is more interest for some medications according to the country strategy (e.g., there is more discussion in American papers for Clonidine, but it is currently little used in the UK) [39]. Generally, these drugs are used more for spasticity management: baclofen, diazepam, tizanidine, dantrolene, gabapentin, and clonidine (**Table 7**). They may be used to provide systemic effect for modest spasticity severity. Choosing the drug is dependent on patient problems and goals [2, 39]. For example, if the neuropathic pain is a problematic as well as spasticity, gabapentin should be considered for this patient. Besides, some of the drugs are more recommended in papers for specific diagnosis; for example, gabapentin is also recommended as first- or second-line treatment for spasticity in the UK National Guidelines for Multiple Sclerosis [39].

There is no evidence-based consensus for combination drug regimes for oral treatment. However, they can be used according to associated features [2, 43]. There is no right or wrong way to titrate drugs in combination, and professionals suggest avoiding polypharmacy. If there is intolerance for maximum dose of first-line drug, continue the highest level the individual can tolerate comfortably and added the second-line drug and titrated upward. If the patient's problem has

Drug	Starting dose	Maximum dose	Side effects
Baclofen	5–10 mg daily	120 mg daily, usually in three divided doses	Drowsiness, weakness, paresthesia, nausea, vomiting
Diazepam	2 mg daily	40–60 mg daily, usually in three or four divided doses	Drowsiness, reduced attention, memory impairment Dependency and withdrawal syndromes
Tizanidine	2 mg daily	36 mg daily, usually in three or four divided doses	Drowsiness, weakness, dry mouth, postural hypotension Monitor liver function
Dantrolene	25 mg daily	400 mg daily, usually in four divided doses	Anorexia, nausea, vomiting, drowsiness, weakness, dizziness, paraesthesiae Monitor liver function
Gabapentin	300 mg daily (can start at 100 mg daily)	2400 mg daily, usually in three divided doses	Drowsiness, somnolence, dizziness

Table 7.
Drugs in spasticity treatment.

been decreased with this regime, the first drug can be cautiously withdrawn to see if monotherapy with the second-line drug alone is sufficient to achieve the goal of treatment. For optimizing the treatment, it is very important the patient has had written information about treatment goals and efficacy and side effects of drugs.

Evidence-based recommendations for choosing the drug are listed below:

Baclofen: It is more effective in patients with either multiple sclerosis (MS) [44] or spinal cord injury and few have concentrated on spasticity of cerebral origin, including stroke or traumatic brain injury [43].

Tizanidine: It reduces sign and symptoms in MS, spinal cord injury and stroke; no functional benefit has, however, been demonstrated in MS and spinal cord injury [45].

Dantrolene: It is the only available agent that works out of CNS with direct action on skeletal muscle. So, it can be prescribed for spasticity originating from both spinal and supraspinal lesions. It is effective in management of MS patient and has modest effect in spinal cord injury, stroke, and cerebral palsy [46–48]. It does not demonstrate any changes in function.

Diazepam: The efficacy of it in spinal cord injury, cerebral palsy, and MS has been proven. However, its side effects are more than those of other drugs in the studies [43].

Gabapentin: There is beneficial effect of gabapentin on measures of spasticity in MS and spinal cord injury [49, 50].

Clonidine: Its major use has been as an anti-hypertensive agent, but it is efficient in the spinal cord injury spasticity [43].

In children's spasticity, baclofen (for long treatment) and diazepam (for rapid onset) are recommended by NICE guideline [27].

6.2 For regional or segmental spasticity

This type of spasticity benefits from interathecal administration. This route of administration delivers the medication directly to where it is needed with less unwanted side effects like drowsiness and impaired cognition. Interathecal baclofen pump has been used since 30 years ago [39]. It is effective for lower limbs and trunk spasticity [51]. To manage changing needs, the dose and timing of drug delivery can be programmed over the 24-hour period. It has the beneficial effect in the autonomic storming in people with brain and spinal cord injury [39]. The risk of infection and the need to attend clinics every 3 months or so to have the pump refilled are its significant disadvantages.

The pump is recommended in children with severe motor function impairment (GMFCS level 3, 4, and 5) and bilateral spasticity affecting upper and lower limbs [27].

An intrathecal baclofen test to assess the therapeutic effect and adverse events is necessary before making the decision for intrathecal pump implantation. For evaluation of response, assessing the patient is necessary within 3–5 hours after sedation and recovery. Before pump implantation, written information is necessary including possible adverse effects, signs and symptoms suggesting the dose is too low or high, complications and follow-up appointments [27].

Implantation of the infusion pump can occur within 3 months of satisfactory response to intrathecal baclofen test [39].

Using intrathecal phenol injections is suggested in some studies too [52]. Compared with the intrathecal phenol, baclofen pump has complication of surgical procedure for implantation of pump, malfunction of pump, needing for dose adjustment and refilling the pump [52]. The advantages of intrathecal phenol include: less individual responsibility, low cost, no requirement of special equipment, and avoiding the regular clinical visits for refills. But the complications of this procedure are bladder and bowel incontinence, limb weakness, and paraesthesia, which are the reasons for intrathecal phenol not being considered for spasticity management routinely [52].

6.3 Focal spasticity

The most famous treatments that are used in this category are phenol neurolysis and botulinum toxin.

Phenol nerve block has been used for the treatment of spasticity since the 1960s and it has advantages in comparison with botulinum toxin including: faster onset of spasticity relief and greater degree of muscle relaxation for much longer and at much less expense [27, 39]. But it has disadvantages including, neurogenic pain or paraesthesia (if applied to a mixed motor/sensory nerve) and careful localization (needing for experienced hand), so some specialist prefer Botulinum toxin. However, it is appropriate for patients with troublesome spasticity and dystonia of hip adductors and calf muscles, especially for non-ambulant patients or "walkers" who are already dependent on an ankle-foot orthosis (AFO) [27, 39].

Botulinum toxin use has shown significant effects on improving the symptoms of patients with focal spasticity or dystonia [27, 39, 43]. The method of use and injection is discussed in detail in chapter x. Here is a brief explanation of its indications and contraindications.

There is more interest in botulinum toxin injection. This procedure for patients with focal spasticity in upper limb should be considered in the following cases [27]:

- Impeding fine motor function
- Compromising care and hygiene

- Causing pain
- Impeding tolerance of other treatments, such as orthoses
- Causing cosmetic concern to the child and young person

Botulinum toxin injection for patients with focal spasticity in lower limb should be considered in the following cases [27]:

- Impeding gross motor function
- Compromising care and hygiene
- Causing pain
- Disturbing sleep
- Impeding tolerance of other treatments, such as orthoses and use of equipment to support posture
- Causing cosmetic concern to the child and young person

Botulinum toxin is not recommended in the following cases [27]:

- Has severe muscle weakness
- Had previous adverse reaction or allergy to the botulinum toxin type A
- Is receiving aminoglycoside treatment

Administration of botulinum toxin should be done with caution in the following cases [27]:
The person has any of the following:

- Bleeding disorders for example due to anticoagulant therapy
- Generalized spasticity
- Fixed muscle contracture
- Marked bone deformity

There are concerns about people likelihood of engaging in post treatment adapted physical therapy treatment.

7. Setting up a service

Setting up a spasticity clinic or service depends on the local conditions and available resources. Setting up a clinic needs a team in which every member has certain tasks. Undoubtedly, the roles and duties will overlap, but it is important to understand the abilities and skills of each professional to evaluate what they can offer for the treatment process [2]. Thus, outlining the key skills and roles of each team member and providing a competency framework can help in making an efficient team.

In general, four professionals have roles in a spasticity clinic team including a physician (a pediatric or adult neurologist or a physical medicine and rehabilitation specialist), nurse, occupational therapist, and physiotherapist [2]. In the following, the tasks of each professional are briefly discussed.

Physician:

- Understanding the underlying condition, prognosis, natural history, associated features, and possible complications. Identifying the abnormal features or unexpected changes that may be caused by a secondary cause.
- Being experienced in neuromuscular history-taking and physical examination.
- Being able to perform necessary interventions including administering oral medications, botulinum toxin injection, intrathecal drug, and splint.

Nurse:

- Educating the patient and his/her caregivers to manage spasticity.
- Managing cutaneous and visceral triggers.
- Advising the patient on posture, moving, and handling.
- Managing psychosocial issues and considering the impact of spasticity on employment and social activities of the patient and managing it.
- Monitoring the patient's and caregiver's adaptations with the treatments and ensuring that they follow the protocols and guidelines properly.

Physiotherapist:

- Identifying the potential for movement patterns and functional ability to be improved.
- Identifying trigger factors of spasticity related to posture and movement.
- Identifying muscle weakness underlying the spasticity.

Occupational therapist:

- Assessing the patient for proper use of splints.
- Assessing the patient for posture and siting especially in a wheelchair.
- Assessing the impact of spasticity on the patient's performance.
- Evaluating the patient's access to work, home, and community environments.

Permanent presences of other specialists in the team are not necessarily needed, but they can be helpful in the treatment process. These specialists include orthopedics, neurosurgeons, speech therapists, orthotists, social workers, continence advisors, and psychologists.

One of the valuable points in setting up such services is their growth and development to provide better services. This goal is achieved through data

collection, organization, and extraction so that effective and useful proposals will be presented. The development of these services based on this information results in optimizing the services as much as possible and targeted funding for treating these patients.

8. Conclusion

Spasticity is one of the common symptoms in a wide range of neurological conditions and it needs a multidisciplinary approach for best management. This chapter provided an excellent paradigm to incorporate many of the key elements that are fundamental, including: assessment of the individual with spasticity, provision of education and promoting self-management, physical management of spasticity (physiotherapy or occupational therapy), orthoses, pharmacological intervention, and setting up a service.

Conflict of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in this chapter.

Appendix 1.

Demographic data and checklist for impact of the spasticity on the patient's communications and interactions with the environment.

Patient's name:	**Date of birth:**	**Date:**	**Diagnosis:**
Current medication	Please comment on dose, route, times, and any side effects experienced		
Other medication used in the past for spasticity: Why did they stop taking it (ineffective, not tolerated, other reason?)			
Primary difficulty: Is it attributed to spasticity: Yes/No		Severity rating out of 10	
Other difficulties related to spasticity:			
Spasticity	Please comment on site and severity of spasticity		
Not needing to be assessed			
Clonus	Please comment whether spontaneous		
Not needing to be assessed			
Spasms	Please comment on which muscles, extensors or flexors, severity, pain, frequency, and duration		
Not needing to be assessed			
Pain	Please comment on presence, severity, and management. Indicate if pain has been getting worse, better, or remains the same		
Not needing to be assessed			
Sleep patterns	Please comment on disturbances, positions, and quality		
Bed mobility	Please comment on how much, type of mattress used		
Not needing to be assessed			
Bladder	Please comment on current management		

Patient's name:	**Date of birth:**	**Date:**	**Diagnosis:**
Not needing to be assessed			
Bowel	Please comment on current management		
Not needing to be assessed			
Skin	Please comment on the presence of pressure ulcers and the ability to relieve pressure, change position and sensation, and any aids used (Waterlow Tool)		
Not needing to be assessed			
Mobility	Please comment on outdoor, indoor, aids, speed, and distance		
Not needing to be assessed			
Toilet/bath/shower transfers	Please comment on ability and aids required. Indicate if this has been getting worse, better, or remains the same		
Not needing to be assessed			
Transfers	Please comment on car, bed, chair, level of independence and assistance required		
Not needing to be assessed			
Wheelchair	Please comment on posture, position, type, and make of chair and cushion		
Not needing to be assessed			
Previous therapy and nursing input	Please comment on physiotherapy, OT, seating assessments, and nursing advice. Ensure details of time, date, and location of treatment obtained, including names, addresses, and contact details		
Options discussed with patient			
Assessment by:	Signature:		

Appendix 2. The outcome measures of spasticity

Name:	**Data**	
Goniometry to measure range of passive movement (Norkin and White 1985):	**Resting angle Right/left**	**Full range available Right/ left**
Hip flexion-extension		
Hip abduction-adduction		
Knee flexion-extension		
Ankle PF-DF		
Maximum distance between knees as measured during passive hip abduction (Hyman 2000):	Distance in mm:	
Modified Ashworth scale (Bohannon and Smith,1987):	Right	Left
Resistance to: hip and knee flexion in supine		
Resistance to: hip and knee extension in supine		
Resistance to: hip abduction in crook lying		
Resistance to: ankle dorsiflexion with knee extended		
Clonus and spasms score (self-report) (Smith 1994)*		

Name:	**Data**
Clonus	
Spasms	
Pain intensity by visual analogue scale(VAS)	
Seating posture score (please record 0 = yes, 1 = no)	
Are the feet well positioned on the footplates?	
Are the knees apart?	
Are the hips well aligned?	
Is the trunk posture symmetrical?	
Total	
Record the frequency of falls over the last month(0 = No falls, 1 = two to three falls per week, 2 = five to six falls per week, 3 = daily falls, 4 = more than one fall per day)	
10-metre timed walk (Wade 1987)	
No. of steps	
Time	
Aid used	
Identify the main problem that is amenable to treatment:	

**0 = absent; 1 = Provoked by painful stimuli only; 2 = Provoked by touch, light pressure and/or occasionally spontaneous (5/day and/or < 2night); 3 = Provoked by passive movements (during physical therapy or nursing care) and/or frequently spontaneous (>5 day and/or 2/night).*

Author details

Seyed Mansoor Rayegani, Marzieh Babaee* and Seyed Ahmad Raeissadat
Physical Medicine and Rehabilitation Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

*Address all correspondence to: rambabaee@yahoo.com

References

[1] Ashworth B. Preliminary trial of carisoprodol in multiple sclerosis. Practitioner. 1964;**192**:540-542

[2] Stevenson V, Jarrett L. Spasticity Management: A Practical Multidisciplinary Guide. Boca Raton: CRC Press; 2006

[3] Tardieu G. A la recherche d'une technique de mesure de la spasticite. Revista de Neurologia. 1954;**91**:143-144

[4] Barnes MP. Management of spasticity. Age and Ageing. 1998;**27**(2): 239-245

[5] Haas B, Bergström E, Jamous A, Bennie A. The inter rater reliability of the original and of the modified Ashworth scale for the assessment of spasticity in patients with spinal cord injury. Spinal Cord. 1996;**34**(9):560-564

[6] Barnes MP. An overview of the clinical management of spasticity. In: Johnson GR, Barnes MP, editor. Upper Motor Neurone Syndrome and Spasticity: Clinical Management and Neurophysiology. Cambridge: Cambridge University Press; 2008. pp. 1-8

[7] Ward A. A summary of spasticity management–a treatment algorithm. European Journal of Neurology. 2002;**9**: 48-52

[8] Thompson A, Jarrett L, Lockley L, Marsden J, Stevenson V. Clinical management of spasticity. Journal of Neurology, Neurosurgery and Psychiatry. 2005;**76**(4):459-463

[9] Tattersall R. The expert patient: A new approach to chronic disease management for the twenty-first century. Clinical Medicine. 2002; **2**(3):227

[10] Nicklin J. Improving the quality of written information for patients. Nursing Standard (through 2013). 2002; **16**(49):39

[11] Schmit BD, Benz EN, Rymer WZ. Reflex mechanisms for motor impairment in spinal cord injury. In: Sensorimotor Control of Movement and Posture. Boston, MA: Springer; 2002. pp. 315-323

[12] Norton JA, Wood DE, Marsden JF, Day BL. Spinally generated electromyographic oscillations and spasms in a low-thoracic complete paraplegic. Movement Disorders. 2003; **18**(1):101-106

[13] Sheean G. Neurophysiology of Spasticity. England: Cambridge University Press Cambridge; 2008, 2001

[14] Dietz V. Spastic movement disorder: What is the impact of research on clinical practice? Journal of Neurology, Neurosurgery and Psychiatry. 2003; **74**(6):820-821

[15] Edwards S, Charlton P. Splinting and the use of orthoses in the management of patients with neurological disorders. Neurological Physiotherapy. 2002;**2**:219-253

[16] Odeen I, Knutsson E. Evaluation of the effects of muscle stretch and weight load in patients with spastic paraplegia. Scandinavian Journal of Rehabilitation Medicine. 1981;**13**(4):117-121

[17] Tremblay F, Malouin F, Richards CL, Dumas F. Effects of prolonged muscle stretch on reflex and voluntary muscle activations in children with spastic cerebral palsy. Scandinavian Journal of Rehabilitation Medicine. 1990;**22**(4):171-180

[18] Eng JJ, Levins SM, Townson AF, Mah-Jones D, Bremner J, Huston G. Use of prolonged standing for individuals with spinal cord injuries. Physical Therapy. 2001;**81**(8):1392-1399

[19] Dunn RB, Walter JS, Lucero Y, Weaver F, Langbein E, Fehr L, et al. Follow-up assessment of standing mobility device users. Assistive Technology. 1998;**10**(2):84-93

[20] Walter SJ, Sola GP, Sacks J, Lucero Y, Langbein E, Weaver F. Indications for a home standing program for individuals with spinal cord injury. The Journal of Spinal Cord Medicine. 1999;**22**(3): 152-158

[21] Gracies J-M. Pathophysiology of impairment in patients with spasticity and use of stretch as a treatment of spastic hypertonia. Physical Medicine and Rehabilitation Clinics of North America. 2001;**12**(4):747-768

[22] Bruton A. Muscle plasticity: Response to training and detraining. Physiotherapy. 2002;**88**(7):398-408

[23] Dodd KJ, Taylor NF, Damiano DL. A systematic review of the effectiveness of strength-training programs for people with cerebral palsy. Archives of Physical Medicine and Rehabilitation. 2002;**83**(8):1157-1164

[24] White L, McCoy S, Castellano V, Gutierrez G, Stevens J, Walter G, et al. Resistance training improves strength and functional capacity in persons with multiple sclerosis. Multiple Sclerosis Journal. 2004;**10**(6): 668-674

[25] Hebert J. Impact of aerobic training on fitness and quality of life in multiple sclerosis. Journal of Neurologic Physical Therapy. 2000;**24**(4):161-162

[26] Rietberg MB, Brooks D, Uitdehaag BM, Kwakkel G. Exercise therapy for multiple sclerosis. Cochrane Database of Systematic Reviews. 2005;**1**:CD003980

[27] National Institute for Health and Care Excellence. Clinical Guidelines. In: Spasticity in under 19s: Management. London: National Institute for Health and Care Excellence (UK) Copyright (c) NICE 2018; 2016

[28] O'dwyer N, Ada L, Neilson P. Spasticity and muscle contracture following stroke. Brain. 1996;**119**(5): 1737-1749

[29] Goldspink G, Tabary C, Tabary J, Tardieu C, Tardieu G. Effect of denervation on the adaptation of sarcomere number and muscle extensibility to the functional length of the muscle. The Journal of Physiology. 1974;**236**(3):733-742

[30] Bovend'Eerdt TJ, Newman M, Barker K, Dawes H, Minelli C, Wade DT. The effects of stretching in spasticity: A systematic review. Archives of Physical Medicine and Rehabilitation. 2008;**89**(7):1395-1406

[31] Kalkman BM, Bar-On L, O'Brien TD, Maganaris CN. Stretching interventions in children with cerebral palsy: Why are they ineffective in improving muscle function and how can we better their outcome? Frontiers in Physiology. 2020;**11**:131

[32] Williams P. Use of intermittent stretch in the prevention of serial sarcomere loss in immobilised muscle. Annals of the Rheumatic Diseases. 1990; **49**(5):316-317

[33] Salazar AP, Pinto C, Ruschel Mossi JV, Figueiro B, Lukrafka JL, Pagnussat AS. Effectiveness of static stretching positioning on post-stroke upper-limb spasticity and mobility: Systematic review with meta-analysis. Annals of Physical and Rehabilitation Medicine. 2019;**62**(4):274-282

[34] Pope PM. Management of the physical condition in patients with chronic and severe neurological pathologies. Physiotherapy. 1992;**78**(12): 896-903

[35] Herman JH, Lange ML. Seating and positioning to manage spasticity after brain injury. NeuroRehabilitation. 1999; **12**(2):105-117

[36] Pope P. Posture management and special seating. In: Neurological Physiotherapy: A Problem-Solving Approach. 2nd ed. Edinburgh: Churchill Livingstone; 2002. pp. 189-217

[37] Chan A, Heck C. The effects of tilting the seat position of a wheelchair on respiration, posture, fatigue, voice volume, and exertion outcomes in individuals with advanced multiple sclerosis. Journal of Rehabilitation Outcomes Measurement. 1999;**3**(4):1-14

[38] Kheder A, Nair KPS. Spasticity: Pathophysiology, evaluation and management. Practical Neurology. 2012; **12**(5):289-298

[39] Physicians. RCO: Spasticity in adults: Management using botulinum toxin. Royal College of Physicia. 2018

[40] Therapists CoO, Neurology AoCPi. Splinting for the Prevention and Correction of Contractures in Adults with Neurological Dysfunction: Practice Guideline for Occupational Therapists and Physiotherapists. London: College of Occupational Therapists Limited; 2015

[41] Braddom RL. Physical Medicine and Rehabilitation e-Book. Philadelphia: Elsevier Health Sciences; 2010

[42] Pashmdarfard M, Amini M. Effect of different types of splinting on spasticity and function of upper exterimity of Cva and CP patients: A systematic review. The Scientific Journal of Rehabilitation Medicine. 2017;**6**(1):254-263

[43] Chang E, Ghosh N, Yanni D, Lee S, Alexandru D, Mozaffar T. A review of spasticity treatments: Pharmacological and interventional approaches. Critical Reviews in Physical and Rehabilitation Medicine. 2013;**25**(1–2):11-22

[44] Shakespeare D, Boggild M, Young CA. Anti-spasticity agents for multiple sclerosis. Cochrane Database of Systematic Reviews. 2003;**4**:CD001332

[45] Kamen L, Henney HR 3rd, Runyan JD. A practical overview of tizanidine use for spasticity secondary to multiple sclerosis, stroke, and spinal cord injury. Current Medical Research and Opinion. 2008;**24**(2):425-439

[46] Haslam RH, Walcher J, Lietman P, Kallman C, Mellits E. Dantrolene sodium in children with spasticity. Archives of Physical Medicine and Rehabilitation. 1974;**55**(8):384-388

[47] Ketel WB, Kolb ME. Long-term treatment with dantrolene sodium of stroke patients with spasticity limiting the return of function. Current Medical Research and Opinion. 1984;**9**(3): 161-169

[48] Katrak PH, Cole AM, Poulos CJ, McCauley JC. Objective assessment of spasticity, strength, and function with early exhibition of dantrolene sodium after cerebrovascular accident: A randomized double-blind study. Archives of Physical Medicine and Rehabilitation. 1992;**73**(1):4-9

[49] Mueller ME, Gruenthal M, Olson WL, Olson WH. Gabapentin for relief of upper motor neuron symptoms in multiple sclerosis. Archives of Physical Medicine and Rehabilitation. 1997;**78**(5):521-524

[50] Formica A, Verger K, Sol J, Morralla C. Gabapentin for spasticity: A randomized, double-blind, placebo-controlled trial. Medicina Clinica. 2005; **124**(3):81-85

[51] Furr-Stimming E, Boyle AM, Schiess MC. Spasticity and intrathecal baclofen. In: Seminars in Neurology.

Thieme Medical Publishers; 2014.
pp. 591-596

[52] Anwar F, Antiga S, Mee H, Al Khayer A. Management of spasticity with intrathecal phenol injections: The past and the present. The Journal of the International Society of Physical and Rehabilitation Medicine. 2019;**2**(2):94