Using the C-Brace® Orthotronic Mobility System
A practical training guide
"I like being out and about with family and friends. With the C-Brace® I can do so much more."
Christin
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The C-Brace® offers many people with paralysis of the legs the chance to achieve a nearly physiological gait, something which is often a completely new experience for them. As a therapist you can support your patient in learning how to best use the C-Brace® in their everyday life.

The C-Brace® represents a new generation of orthosis systems. In the past, orthosis fittings for lower limb paralysis were greatly limited, with their sole function consisting of opening and locking the knee joint. In fact, newer stance phase control orthoses (SCO) have already made a certain amount of dynamic movement possible: Special systems lock the knee joint in the stance phase and open it for the swing phase without requiring manipulation from the user. However, the C-Brace® goes a step further.

As the world’s first mechatronic SSCO® system, it controls both stance and swing phases. The abbreviation SSCO® stands for "Stance and Swing Phase Control Orthosis". Thanks to the SSCO® system, the entire gait cycle can be controlled dynamically and in real time. In addition, users can now bend their leg under a load for the first time – such as when sitting down, or walking down stairs or inclines step-over-step. Their movement is more controlled and stable, even on uneven terrain.

Relief for the body
Compared with conventional orthosis systems, the C-Brace® supports more physiological movement through the entire gait cycle. This effect increases as users gain confidence in the orthosis and begin to make the most of its functions. A more natural posture can reduce excessive unilateral strain and resulting problems. Users often find walking much easier as well; they save energy and become more mobile.

How the C-Brace® works
The SSCO® system includes custom fabricated thigh, calf and foot components. A dynamic fibre composite spring with integrated sensor connects the foot to the calf component. An ankle moment sensor transmits signals to the microprocessor-controlled hydraulic knee joint unit, which is integrated into a carbon fibre frame along with the electronics. In addition, a knee angle sensor continuously measures the flexion of the knee joint and its angular acceleration. The system uses the sensors to recognise which phase of the gait cycle the user is in, and regulates hydraulic resistances, controlling flexion and extension accordingly. Thanks to ongoing calculations, the C-Brace® can even optimise the gait pattern in each individual phase.
**Thigh shell**
The custom thigh shell made of fibre composite prepreg guarantees maximum stability with minimal weight.

**Battery**
Integrated Li-Ion battery.

**C-Brace® joint unit**

**Control buttons**
The integrated control buttons are used to select the desired mode.

**Knee angle sensor**
The knee angle sensor in the joint axis measures the current position of the joint every 0.02 seconds.

**Microprocessor**
The microprocessor receives and processes sensor signals and controls walking with the C-Brace® in real time.

**Lower leg shell**
The lower leg shell is made of fibre composite prepreg and includes a clamp adapter for the spring element.

**Spring element**
Carbon or fibreglass spring with integrated ankle moment sensor.

**Foot component**
The foot component is made of fibre composite prepreg and includes a clamp adapter for the spring element.
Biomechanics of human gait

The gait cycle includes a stance phase and a swing phase. The stance phase begins at heel-strike (when the heel touches the ground) and ends with toe-off (when the toe leaves the ground). The swing phase begins with toe-off and ends at the next heel strike.

The **stance phase** begins as soon as the heel touches the ground. At heel strike the knee is controlled by the thigh and lower leg muscles. When the leg starts to bear weight the knee is stabilised by the thigh extensors. In the mid-stance phase, the thigh and lower leg muscles stabilise the leg up to the end of transition to the terminal stance phase, with the latter being accomplished by the lower leg muscles alone. The thigh extensors provide significant support during the stance phase. If this supporting function is missing or significantly weakened, the normal stance phase cycle is disturbed.

Following completion of the terminal stance phase, the **swing phase** begins with the pre-swing phase, with toe-off initiating the actual swing phase. In the pre-swing phase, the pretibial muscles and the hip flexors are primarily employed.

The initial swing phase is controlled by the hip flexors, the knee extensors and the anterior lower leg muscles. During transition to the mid-swing phase knee flexion is no longer needed to bring the leg with its pendulum mass into terminal swing phase. The terminal swing phase ends directly at initial heel contact, where the entire chain of muscles is needed to stabilise the knee joint.
Gait cycle with the C-Brace®

The SSCO® system of the C-Brace® mimics the biomechanics of human gait. It recognises which gait phase the user is in and regulates hydraulic resistances accordingly. With this function, the SSCO® system goes a step further than conventional orthosis systems. It is ...

... more than a locked orthosis
Because the leg is movable during the swing phase. The user is scarcely affected by the loss of the knee extensor muscles during this phase of the gait cycle. This makes immobilisation, which would contradict the human pattern of movement, unnecessary.

... more than just a stance phase control system (SCO)
Because damping ensures a nearly physiological roll-over of the foot in stance phase. This results in continuous forward movement – a flow of movement unequalled by stance phase control systems. In contrast to SCO systems, the C-Brace® orthotronic mobility system also uses damping in the swing phase. Damping makes movements softer and offers a high degree of safety when motion sequences change suddenly: If the user trips, swing phase damping prevents rapid buckling of the leg, with the orthosis smoothly sinking instead.

The orthotist can use various setting options to adjust the C-Brace® orthotronic mobility system to the user’s gait cycle.

1. Stance phase flexion damping: controlled stance phase damping supports the knee extending musculature upon heel strike
2. Stance phase flexion damping plus/time: additional damping option that supports the musculature as needed upon increased load transfer; time limitation for additional stance phase damping
3. Stance phase extension damping: knee extension damping in the stance phase for smooth, natural movement of the knee joint
4. Maximum load: definition of the safe switching point to trigger the swing phase
5. Swing phase initial flexion damping: switching to minimum resistance for optimum initiation of the swing phase
6. Swing phase knee angle threshold/swing phase dynamic factor: controls the end of swing phase flexion for an optimised gait pattern
7. Extension resistance: switching to minimum resistance during swing phase extension
8. Swing phase extension damping: final swing phase extension damping for softer breaking when user is changing walking speeds
Training is a significant part of fitting a patient with the C-Brace® orthotronic mobility system. The time it takes the user to learn how to use the C-Brace® to its best possible advantage varies depending on their physical condition and motivation.

**New possibilities for the patient**
- Flexion under a load is now possible for the first time, including when sitting down, walking down stairs step-over-step and walking down inclines
- Controlled and stable gait characteristics on uneven terrain
- Individual operating modes can be set by the orthotist and selected by the user according to the situation, e.g. bicycling
- Natural body posture helps reduce unilateral physical strain and resulting problems
- Potential for reducing energy expenditure, for example, when compared to locked systems
- Greater sense of security and newfound mobility often enhance quality of life

**Positive effects**
- Strengthening of previously little-used muscles
- Muscular atrophies can be reduced
- Contractures and joint damage caused by immobilisation can be prevented
- Cardiovascular performance is retained for everyday activities

**Training process**
Do you have a patient who might be able to use the C-Brace® orthotronic mobility system? Below you will find specific tests to help you establish whether the patient meets the basic requirements for a fitting.

If you have a patient who has already been fitted with the C-Brace®, you can start the training straight away. Preparatory exercises without the orthosis serve as the basis for training with the C-Brace® later. Once the user has become familiar with the C-Brace®, increase the exercises together until the user can move in a controlled manner outdoors and in their everyday life. It’s crucial that the user learns to trust both the motion sequences that are now possible for the first time, as well as the high level of security offered by the C-Brace®. This comes into play again and again when flexing the leg under a load, such as in stance phase, sitting down or walking down stairs – the user learns that the leg will not suddenly buckle, but bend smoothly instead.
Indications
In principle, the C-Brace® can be considered for all neurological indications of the lower limbs. The leading indications are incomplete paraplegia (lesion between L1 and L5) with very minor or no spasticity as well as post-polio syndrome or traumatic nerve injuries.

The following applies:
• The patient must be able to fully stabilise the trunk and to stand freely.
• The muscle strength of the hip extensors and flexors must permit the controlled swing-through of the affected leg.
• Compensation through hip movement must be possible.

Exclusion criteria
If any of the following apply to your patient, he or she cannot be fitted with a C-Brace® at this time:
• Unable to initiate the swing phase from a standing position
• Weight over 125 kg (275 lbs)
• Height less than 150 cm (59 in) (knee centre measurement)
• Severe spasticity
• Leg shortened more than 15 cm (5.9 in)
• Knee flexion contracture more than 15°
• Hip flexion contracture more than 15°
• Insufficient neuromuscular trunk stability for the trial phase
• Genu varus or valgus of more than 10° (uncorrectable) – unacceptable for cosmetic reasons
• Diseases that preclude the use of an orthosis (e.g. oedema, extensive skin irritation)
• Orthoprosthesis

Relevant medical prerequisites
In principle, the SSCO® system of the C-Brace® is suitable for any neurological indication of the lower limbs. There are, however, limitations. The functional status of the muscles is a decisive factor.
Is the C-Brace® right for your patient?

The following tests will help you determine whether a C-Brace® fitting can be considered for your patient in particular. The patient’s previous basic medical history serves as the starting point.

Testing trunk stability

The patient should be able to stabilise their upper body in the standing position without using their arms.

1. **Unassisted standing**
   Test the patient’s ability to stand freely with the current fitting between parallel bars. Can the patient hold their trunk upright and stabilise it?

2. **Sitting**
   Carry out the test in the sitting position only if the patient cannot stand freely. The patient’s feet are not in contact with the floor. Can they maintain an upright body position without using their arms? Can they grasp objects that are off to the side (lateral trunk stability)?

**Note**

If the patient is unable to stand, place special focus on the following tests. It may be too early for a fitting under some circumstances.
Testing joint mobility

1 **Hip joint mobility**
   A hip flexion contracture complicates the fitting of a C-Brace®. For this reason, check the range of motion of hip extension in particular (e.g. using the Thomas test).

2 **Knee joint mobility**
   A knee flexion contracture is also problematic for a fitting with the C-Brace®. For this reason, knee extension should be tested.

**Assessment of the leg axis**
Is there a valgus/varus malposition of the knee joint? Functionally, the best way to determine this is with the patient standing upright. If the patient is unable to stand without the orthosis, check the leg axis while they are lying down.
Checking muscle tone

Check for spastic hypertonia, especially in the knee extensors (quadriceps) and calf musculature (triceps surae). Increased tone usually results in a reduced knee angle and thus in reduced ground clearance in the swing phase under certain conditions. Swing phase initiation may also be impeded. Therefore, these patients may require a longer period of training.

1 You can get an initial indication of whether the muscle tone is increased by passively moving the affected leg. Flex the hip and knee and fix the foot in dorsiflexion. Move the hip and knee joints slowly into the extended position. This stretches the calf muscles. If a spastic hypertonia is present, you will feel persistent, and to some extent, strong resistance in the dorsiflexion direction. In many cases this will also trigger a clonus. [Clonus: involuntary, rhythmic series of contractions of muscles or muscle groups which is exhaustive or non-exhaustive. Triggered by a rapid stretch stimulus]

2 Have the patient lie in the supine position to check the muscle tone of the knee extensors. Ensure that the knee joint can be moved freely. Move the knee joint from the extended into a flexed position. If there is spastic tonicity, you will feel persistent resistance in the flexion direction.

Note
Hypertonia does not necessarily exclude the use of the C-Brace®. However, it is more difficult for these patients to learn to initiate the swing phase with a hip flexion movement. Walking on level surfaces will be less fluid.

Alternatively, the test can be carried out with the patient lying in the prone position.
Measuring muscle strength

Muscle strength should be tested and documented using common muscle function tests. The image illustrates a functional test of the hip flexors and extensors which has been adapted for the C-Brace® orthotronic mobility system. When carrying out the test, check whether your patient swings their leg forwards and backwards in a controlled manner. This can also take place through compensatory movements. The test is especially valuable as an initial indication of whether the user will later be able to initiate a swing phase with the C-Brace®. If your patient is not confident standing, carry out the test between parallel bars.

Sensitivity and leg length discrepancy

**Superficial sensitivity**
Check the patient's superficial sensitivity. Can your patient feel the difference between sharp, dull, cold and warm? If superficial sensitivity is impaired, check the leg for pressure points following training.

**Proprioception**
Can the patient feel which joint position their leg is in when their eyes are closed? The following starting position is suitable for a quick test of the knee joint: The patient is lying in the supine position with the leg hanging over to the side; the knee joint is freely movable. Now move the knee joint into a given position. The patient should be able to tell whether the joint is in a flexed or extended position, despite having their eyes closed. If proprioception is impaired, the patient typically finds it more difficult to learn new patterns of movement, as feedback on the joint's spatial position is missing.

**Leg length discrepancy**
Check whether there is a significant discrepancy in leg length. If this is the case, the leg length discrepancy should be taken into account in the alignment of the orthosis system.
The training

The training takes place in three steps to help your patient benefit as much as possible from the C-Brace® orthotronic mobility system.

1. Exercises without the orthosis to improve mobility and muscle strength

2. Specific exercises with the C-Brace®: The user becomes familiar with and uses the orthosis functions

3. Additional exercises with the C-Brace® to increase stability and muscle strength

You determine which exercises are suitable for your patient. In many cases, you can increase the level of difficulty – take your patient's condition and performance level into account when selecting exercises to ensure they always feel secure during training.
1. Exercises without the orthosis to improve mobility and muscle strength

Increasing mobility

The following stretching exercises maintain or improve your patient's range of motion. To achieve the desired effects, train the antagonists of the contracted muscles as well. If the hip flexors are contracted, for example, carry out parallel training for the hip extensors. The exercises should be performed on a regular basis to achieve long-term success. Encourage the patient to repeat the exercises independently at home.

Stretching the hip flexors and the quadriceps

The patient pulls a leg as far as possible towards their body while the other leg hangs down at the side of the therapy bed (lateral overhang). The lumbar spine should rest on the bed. Then flex the knee until the patient feels a stretching sensation in the hip or thigh. The prone position is typically more suitable when the patient is training independently. During independent training the lower leg can be pulled towards the buttocks, for example using a hand towel placed around the foot. In either case you should select a variation of the exercise which your patient can perform on their own.
Stretching the hamstring and calf muscles

This exercise is performed in the sitting position with the legs lying extended on the bed. The patient uses a towel to pull the foot towards their body until they can feel a stretching sensation in the calf or upper hamstring. This is an exercise which your patient can very easily perform at home.

Stretching the calf muscles while standing

If the patient is able to stand well, the calf muscles can also be stretched in the standing position. The patient stands with one foot forward, with the leg that is being stretched positioned a step behind it. The tips of the toes point straight forwards; the heel remains on the floor. The patient now pushes the pelvis forwards until they feel a stretching sensation in the calf. You can intensify the stretch by placing a small, rolled hand towel under the forefoot, for example.
Increasing trunk stability and muscle strength

The stronger your patient's trunk muscles, the easier it will be for them to walk with the C-Brace®. Increase the difficulty of the exercises step by step: First use a stable surface and then, if possible, an unstable one; train without and then with weights. Select exercises which your patient can easily perform at home. A few of these exercises are demonstrated below.

Bridging

There are many variations of bridging. For classical bridging, the patient lies on their back with their knees bent. They then move the pelvis slowly up and down while their head remains on the bed. Apply a small amount of resistance to the knee or pelvis to increase the degree of difficulty. Have the patient hold the position a bit longer on one repetition and check that they can sufficiently stabilise their trunk and pelvis. If the exercise is going well, use an unstable surface like a balance trainer or a soft ball.
Sitting on an unstable surface

Can your patient already sit confidently on a stable surface? If so, you can go a step further and use an unstable surface to further increase trunk stability. A balance trainer, rocker board or balance pad is suitable for this purpose. The feet do not touch the floor during any of these exercises. If your patient can keep their trunk in the upright position, you can further increase the difficulty. Apply a slight amount of resistance to the trunk while the patient tries to sit upright again. The exercise can be further enhanced with dynamic arm movements or in combination with a ball (pass the ball around the body, hold it over the head, throw/catch). Your patient can also perform these exercises with light weights. For example, a pair of plastic water bottles, a therapy band or similar work well for home training.
2. Specific exercises with the C-Brace®: The user becomes familiar with and uses the orthosis functions

Exercises with the C-Brace®

In the following section, your patient will learn to move about with the C-Brace®. Good, intensive training is crucial so the patient can feel how the orthosis system reacts and how it supports them right from the start.

Your basic technical knowledge of the functionality of the orthosis system is important when it comes to providing the patient with the best possible support during training. For the first time, the C-Brace® orthotronic mobility system enables flexion of the leg under a load and thereby the ability to walk smoothly step-over-step on stairs, inclines and uneven terrain. Depending on their previous fitting, the patient will require more or less time to build up their confidence in this new function. These exercises help the patient to become familiar with the functionality of the C-Brace® step by step and use it in their everyday life.

Donning the orthosis

The best way to practise donning the orthosis is while sitting. First, the patient opens all the closures and bends the orthosis knee joint. They then slip their foot into the foot component and place their leg into the lower and upper leg shells. Make the patient aware that all pads should lie flat and not be folded. After this, the patient can close and tighten the closures, working from the foot upwards. Finally, they put on their shoe and check the closures once more in the standing position.
Starting exercises

The initial exercises with the C-Brace® focus on standing balance and a symmetrical transfer of weight. In these exercises, the patient first becomes acquainted with the orthosis while standing.

Make sure that the patient feels secure. Start each exercise between parallel bars. The patient should hold on to the bars at first.

2 Stable standing

The patient tries to stand without holding onto anything and to distribute their weight evenly on both legs. They then practise shifting their weight from one leg to the other.

If the patient finds this exercise easy, take it a step further: Use your hands to provide resistance at the trunk level, either from the sides or from the front. If the patient can maintain their body position while you do this, practise more dynamic arm movements with them, e.g., "drumming" rapidly with the forearms ("playing percussion"), dynamic movements with two gymnastics batons or reactive exercises, e.g., throwing/catching a ball or balloon.

Two paper cards are a simple way of giving the patient feedback on whether they are placing adequate weight on the orthosis. To do so, place the cards under both forefeet. If the patient is placing equal weight on both legs, you won’t be able to pull out the cards. If you can move the card under the orthosis side slightly, this is a sign that the patient is not placing adequate weight on the orthosis. They should try to hold both cards still while standing by placing equal weight on both feet.
2 Initiating the swing phase

Two criteria must be met for your patient to initiate the swing phase: At the end of the stance phase (terminal stance), the forefoot must be loaded and the knee extended at the same time. The patient can then swing the leg forwards using a hip flexion movement. Patients who have previously walked with a circumduction of the hip typically take their weight off the orthosis too early in the stance phase. This means no forefoot load can be measured and the swing phase is not initiated. These patients now need to learn once more to roll cleanly through the foot and to initiate the swing phase via the hip flexors. An alternating gait pattern is a basic prerequisite for initiating the swing phase.

Process

Start the exercise between parallel bars and make sure the patient is only using their hands for minimal support and balance. Then place a gym ball in front of the patient. The patient should step forward with the contralateral leg. To initiate the swing phase, a load must now be placed on the forefoot while the knee is extended. The patient thus stands only on the forefoot of the rear leg. The patient now pushes off the forefoot and then tries to kick the ball. Even patients who otherwise walk with circumduction can usually successfully activate the hip flexors during this exercise. If no other option is available, the patient can tilt the pelvis to initiate the flexion movement. However, try practising the motion sequence over and over first.

• If the patient has difficulties initiating the swing phase, the reasons can usually be found in the stance phase. Stance phase training can help to improve the swing phase.

Note

It’s important that the patient strikes the ball in the center and not from the side. The patient will expend a great deal of energy at first. However, as time goes by they should learn to perform the exercise minimal effort. Reduce the support you are giving them as much as possible. If the exercise goes well, the patient should try to apply what they have learned when walking.

Scan this QR code with your smartphone and watch the video C-Brace: "Triggering the Swing Phase" with Peter, a C-Brace® user.
3 Sitting down and standing up

The C-Brace® orthotronic mobility system enables knee flexion under load for the first time. This makes it possible to place an equal load on both legs when sitting down. The “stance phase flexion resistance” set by the technician simulates the muscular activity of the quadriceps femoris muscle here.

The following exercise offers multiple benefits

• The user gains an initial impression of how knee flexion under a load feels.
• The exercise practises equal weight transfer. It helps the orthotist to set the appropriate stance phase flexion resistance for the patient during an initial adjustment.
• Thanks to the even distribution of weight, the user learns to relieve the load on their other leg in the long-term.
• At an initial adjustment there is no harm in setting the resistance too low and then too high to give the patient the opportunity to compare them.
• Stance phase flexion resistance is properly set if the user can place equal weight on both legs when sitting down, if the orthosis knee joint bends equally in comparison to the other side, and if the user feels secure.

• The patient will feel the same resistance later when walking on stairs and inclines.

Start by selecting a chair with armrests. Position it in such a way that it will not slide across the floor, and so that the user feels secure. Ask your patient to distribute their weight evenly on both legs before sitting down. You can place cards under their feet to check this (see note on page 21). Your patient should use the armrests to help them when sitting down at first. Use the foot cards to check whether they are still placing equal weight on both legs. The patient should shift their upper body far enough forwards that they can successfully sit down and stand up as well.

Have the patient reduce the amount of weight placed on the armrests after a few repetitions. Your patient should place more of their weight on the orthosis now. The greater the weight placed on the orthosis, the more the patient will feel the flexion resistance provided by the C-Brace®.
4 Gaining confidence: stance phase flexion

Objective
The patient has already practised knee flexion under a load while sitting down and has felt the set stance phase flexion resistance. Your patient will now use this resistance again and again, such as when going down ramps and stairs, walking on level surfaces, on uneven terrain, and catching themselves when tripping. In short, they will use it in any situation which normally requires the muscle function of the quadriceps femoris muscle.

The next exercises help the user practise knee bending under a load while standing and moving so they can gain further confidence in the orthotronic mobility system and in their own skills.

Process
The patient first stands in the stepping position while holding on to the parallel bars. The leg with the orthosis is in front. Secure and stabilise the patient by checking the knee and hip. The patient now puts their weight on the C-Brace® and pushes the knee forward into the knee flexion position. As they do so, your patient can feel the resistance against knee flexion.

Caution: Knee flexion is not limited, which means the patient can flex the knee completely. For this reason, they should start by only bending the knee as far as they can still stabilise themselves. Repeat this exercise multiple times. The more confident the patient becomes, the more you can reduce your support and their hold on the parallel bars.

Enhancement
To further increase confidence in the orthotronic mobility system, the patient can start walking and take a small step with the knee slightly bent. If the patient were, for example, to unexpectedly step on a small object while walking, the movement characteristics of the knee would feel the same as during the exercise.

Note
When walking normally on level surfaces the knee should always be extended at the end of the stance phase, since the swing phase cannot otherwise be initiated.
Walking on level surfaces

Once your patient is familiar with the basic functions such as initiating the swing phase and stance phase flexion damping, continue practising and honing their ability to walk on level surfaces.

**Stance phase flexion**
The C-Brace® enables the patient to bend their knee slightly during load transfer following heel strike – a movement similar to the physiological gait pattern. The knee is then extended once more in the mid-stance phase. This helps to absorb shock. Encourage your patient to allow their knee to bend during the first steps. It’s possible that they will still feel uncertain at the beginning.

**Sequence of the exercise**
The patient stands in the stepping position with the leg that is being trained in front. The heel is on the floor; the orthosis knee joint is extended. The patient can hold on to the parallel bars at first. Now provide support from initial heel contact to the mid-stance phase. Pull the patient’s knee slightly forwards so the entire surface of the foot is in contact with the floor. The pelvis should now move forwards over the foot. Guide the movement at the pelvis. If the motion sequence can be performed smoothly, the patient should try to transfer this to walking between the bars. You can provide proximal support at the pelvis as they do so.

Caution: Confirm your patient’s muscle status to make sure they’re capable of controlling the movement. Training the forward movement of the patient’s centre of gravity is also essential.
The following exercises help to further improve walking on level surfaces:
If the gait width is too large, have the patient walk between two lines. An appropriate gait width results in a better rollover motion over the foot and therefore good swing phase initiation. This can also reduce compensatory movements such as lateral trunk inclination.
If the step length varies significantly, you can use marks on the floor to provide the patient with visual feedback. A metronome or music are also helpful for developing an even walking rhythm.

Note
Depending on the previous fitting, patients may tend to take a very large step on the orthosis side. The disadvantage here is that the centre of gravity is not shifted over the foot until very late. The patient finds it more difficult to stabilise himself.

Objective
• The patient should avoid circumduction and hip hike
• Stride length is appropriate and uniform
• Gait width is appropriate
• Foot, knee and hip movement is linear

Once the patient feels secure while walking on even ground, practise walking on uneven terrain. Stance phase flexion is particularly advantageous here. The patient quickly gains full-surface contact with the sole of the foot, which enables them to better stabilise themselves. Check whether the patient can initiate the swing phase and practise this if necessary.
Stairs and ramps

With the set stance phase flexion resistance, the C-Brace® helps the patient descend stairs step-over-step. They feel the same flexion resistance on stairs and ramps as they do when sitting down. This is a completely new experience, which for many patients has not been possible for years.

1 Stairs – first exercise

Because the orthosis’ foot joint does not permit dorsiflexion, only the heel should have contact with the step. This ensures fluid rollover behaviour when descending the stairs. Apply a strip of tape to the user’s shoe to facilitate foot positioning. This provides the patient with visual feedback: the foot is positioned so that the tape is lined up with the edge of the step. The marker is especially helpful when training on the stairs later.

Once the foot is correctly positioned, the user steps down from the step trainer with the other leg. To do this, they must learn to allow the orthosis knee joint to bend. Stance phase flexion damping plays the role of the quadriceps here, by enabling controlled flexion of the orthosis knee joint under load.

During the motion sequence, make sure
- that the patient steps down vertically and does not just “fall” forward in the direction of movement,
- that the patient maintains the leg axis: that the foot, knee and hip remain in a line.

At first, you can support foot placement and guide the knee during the movement. However, you should gradually reduce your support.

For this reason you should practise descending stairs and ramps step by step to build up the necessary confidence.
2 Training on the stairs
Continue training on the stairs. Begin on the lowest step. First repeat the same training steps you performed with your patient in the parallel bars. Then increase the number of steps. The patient should go step over step: first with the affected leg, then with the other leg. The patient should avoid active extension of the hip and knee.

Focus on
• Foot placement with heel strike
• Maintaining the leg axis
• The safety of the patient
• A fluid sequence of motion

3 Descending stairs step-over-step
When the patient can position their foot securely and sink smoothly into the orthosis knee joint, practise an alternating step sequence and pay attention to the same details as before.

Support your patient at the beginning of foot placement. Make sure the sequence of motion is performed slowly at first.

4 Ascending stairs
As with other orthosis systems, stairs are ascended one step at a time. The unaffected leg leads, the affected leg follows. The patient should make sure they always place the entire foot on the step. This provides a secure stance.

Caution: If the patient places only the forefoot of the orthosis leg on the step, swing phase could accidentally be initiated (forefoot load with knee extension).

- Initially, the patient should use the contralateral handrail for support and also receive stabilisation from the therapist
- Train with the same-side handrail later on
  You can guide the knee as the user descends or pull it slightly into the flexed position

Scan this QR code with your smartphone to see the video “C-Brace: Stairs” with Peter, a C-Brace® user.
Note regarding exercise 3
If the patient has a great deal of difficulty sinking into the orthosis knee joint when descending the stairs, you should check the damping resistance. If damping is too high or too low, this could cause insecurity for the patient.

Possible clinical indications for damping that is set too high:
• The patient sinks into the orthosis knee joint poorly; the motion sequence is very irregular
• Strong external rotation of the leg when bending it under a load

Possible clinical indications for damping that is set too low:
• The patient sinks into the orthosis knee joint quickly
• The patient feels insecure, holds on to railing very tightly, etc.

The therapist and technician must set the damping to suit the patient, their current training condition and phase of training. In the case of initial fittings, you should check the settings after three weeks or so.
5 Descending a ramp

Walking techniques
There are two different walking techniques which can be used according to the slope of the ramp: On flat slopes, the patient can initiate a normal swing phase such as when walking on level ground. However, this won’t be possible on steeper slopes. Here, the patient will bend the knee joint the orthosis knee joint under the load just as they did on the stairs and roll over the entire foot.

Process
Starting at the lower end of the ramp; the patient leads with the orthosis leg. Following heel contact, the patient should now allow the knee to flex and simultaneously take a step with the other leg. Support your patient at the pelvis and at the knee. The patient can use your shoulder for support in addition to the contralateral handrail. Smaller steps are easier at first because the stance phase is short on the affected leg. Nonetheless, you should ensure the patient is walking step-over-step from the beginning.

To achieve a fluid sequence of motion, the patient should avoid active extension of the hip during rollover. If the patient has already built up some confidence, you can reduce your support. You can also vary the side that the handrail is on. The goal is for the patient to master the ramp independently and without a handrail if possible.

6 Ascending a ramp
The swing phase can be initiated when ascending ramps. Walking is equivalent to walking on even ground.

Note
Practise walking on slopes of varying inclines as soon as possible.

Check that:
• Leg axis is maintained
• Trunk is upright
• Line of vision is to the front

Train with various walking speeds: small steps at a lower speed and larger steps at a higher speed.
Reducing auxiliary devices

The goal of training is for your patient to become as independent of auxiliary devices as possible, in accordance with their physical condition.

- The first training sessions take place in the parallel bars
- Practise the four-point and two-point gait in the parallel bars
- Enhancement: walk around the outside of the bars with additional support from a crutch
- Enhancement: use two crutches in a four-point or two-point gait
- Enhancement: the same with two crutches (more difficult as there is less support from the wrist and forearm; alternatively, use reversed forearm crutches)
- You can also use two Nordic walking poles as an alternative
- Walking with just one pole is also an option. Please keep an eye on body symmetry in this case; one-sided loads should be avoided
- Depending on their physical constitution, the patient may be able to walk without assistance
Outdoor training

Training should be moved out of doors as soon as possible. There, you’ll be better able to prepare your patient for their everyday life. Focus the training on what is involved in the user’s everyday life and what they want to do – at work, with their family, and in their free time. Use the same walking devices during outdoor training as you did indoors at first. If the user simply requires balance support, Nordic walking poles are a good option.

The goal is for the patient to feel secure. Everyday life offers many challenges that have a different effect on training when compared to indoors. Does the patient load the orthosis as well as they did indoors? Can they reliably initiate the swing phase? Can your patient manage slopes and stairs outdoors? How do they find walking on uneven terrain? Outdoor training offers a good indication of whether the orthosis settings are appropriate for the user.

**Practise:**
- Walking on different surfaces
- Changes in direction
- Changing walking speed
- Going over/around obstacles
- Walking on slopes of varying inclines
- Walking up and down stairs

**Pay attention to details, e.g.:**
- Uneven ground: Can the patient initiate the swing phase?
- Going down slopes: Does the patient roll over the foot well? Do they allow the knee to bend? Do they choose their walking technique according to the incline of the ramp?
- Walking down stairs: Does the patient use stance phase damping to bend under a load? Do they roll over the foot? Do they maintain the axis of the leg?
3. Additional exercises with the C-Brace® to increase stability and muscle strength

The following exercises improve the patient’s stability when walking. The better their trunk stability, for example, the easier it will be for the patient to stabilise themselves. Stance phase training naturally improves stance stability first and foremost, but it often results in an improved swing phase as well. The patient develops greater confidence in themselves and the orthotronic mobility system. Exercises are selected on an individual basis. It should be possible for the patient to perform the exercises independently at home.

Exercises while sitting

A gym ball offers many training options: You can use it to improve trunk stability and encourage body awareness. Pelvic control, which is practiced in the first exercise, is important for stabilising the stance phase and initiating the swing phase.

1 Upright sitting position and pelvic control
Your patient sits upright on the gym ball with their feet on the floor. You might let them hold onto a bench or similar at first. The goal of the exercise is to find an upright body position by moving the pelvis. The patient alternates between tilting the pelvis forwards and backwards until they have found an upright position. This is a difficult exercise, especially for patients with incomplete paraplegia. The exercise mobilises the pelvis effectively and trains the patient’s perception.
2 Stabilise
A further stabilisation exercise while sitting: 
Apply slight resistance to a ball, an object the patient is holding, or to the patient themselves. 
The patient tries to stabilise themselves and keep their body centred as you do this.

3 Greater mobility
Dynamic exercises also help the patient to improve their stability and balance even in the sitting position:
• Walking in place
• Reactive training with a balloon, ball, etc.

Make sure the patient feels secure and has something to hold on to if they lose their balance.
4 Strengthen

You can carry out strengthening exercises in the sitting position, for example, with a therapy band. First, the patient moves their arms. The focus here is on an upright trunk position (top image). The following exercise is suitable for strengthening the abductors/extensors (bottom image): Wrap the therapy band tightly around the patient’s knees. Now position the feet hip-width apart.

Variation one

The patient brings their knees into abduction and holds this position briefly.

Variation two

The patient stretches the band as described above and at the same time slightly raises their buttocks from the gym ball. This is only possible if the upper body is leaning far forwards. Thanks to the C-Brace® orthotronic mobility system, an equal amount of weight can be placed on both legs during the exercise. Alternatively, this exercise can be performed from a seat which has been elevated significantly.

The focus in all the variations is to keep the band stretched at all times.
Exercises while standing

2 Special standing leg training
The following exercises are geared especially towards improving stability in the stance phase. A focused stance improves swing phase initiation in turn, and thereby promotes a more fluid gait. Begin the training between parallel bars.

The patient stands on stable ground at first. The healthy leg now performs the dynamic part of the exercise, using the toes to push a sheet of paper to the front, back and side. The patient must stabilise the orthosis leg in extension/abduction/adduction while doing so.

In the next exercise you will use a step trainer. The patient straightens their trunk and stabilises the standing leg. The foot of the sound leg is now placed repeatedly on the step and then back down. The trunk and other leg should remain stable during the exercise. Your patient may hold on to something at first. However, support should be reduced as time goes on.

Repeat the exercise next to the step trainer. The leg with the C-Brace® stands next to the step and the patient steps up, 'crossing over' with the healthy leg. This enhances abductive/adductive stability. This exercise is very difficult for many patients. Make sure the pelvis remains horizontal and the patient avoids excessive pelvic rotation. Repeat the exercises depending on the patient’s endurance.
2 Maintaining balance
On a stable surface, on unstable ground, and while moving – the following training exercises will help your patient gain more confidence while standing. Select the exercises according to your patient’s dexterity and skill. Make sure that they feel secure. Start each exercise between parallel bars.

In the first exercise, the patient stands on a stable surface. Throw a ball back and forth to one another. Ball games in a free standing position are a good alternative for active breaks or at the beginning of a training session. You can practise moving sideways with and without support no matter the performance level. Combining the exercises with music is a good way to achieve different speeds and a uniform step sequence.

If the patient finds these exercises easy, take it a step further: Select an unstable surface, such as a rocker board, a wobble board or a soft balance pad. Repeat the previous exercises according to the patient’s capability.
3 Strengthening
A therapy band or plastic bottles filled with a bit of water, for example, are suitable for strengthening exercises in the standing position. The exercises should be selected so that the patient can perform them independently at home. The focus is on trunk stability. To increase the level of difficulty, select an unstable surface.

The exercise illustrated in the bottom image is well suited for strengthening the hip abductors and extensors. It also encourages confidence in the orthotronic mobility system: The patient can place an equal load on both legs and flex them slightly.

Wrap the therapy band tightly around the knee. The feet should be hip-width apart. The patient now starts to build up tension by spreading their knees apart. Make sure that not only the "strong" leg is pressing outwards. If your patient can steadily hold this position, have them flex the knee slightly – but only as far as they can while stabilising themselves. They then return to the upright position. If your patient is still unstable, the same exercise can be performed from an elevated seat. In this case, the patient stretches the band while sitting and maintains the tension as they stand up.
Intensive gait training

Every patient has their own walking speed. However, when it comes to everyday situations such as crossing the street, they should be able to change their walking speed. Start each exercise at the parallel bars. Select the exercise according to your patient's dexterity and skill.

1. Start by practising a fluid gait at a comfortable speed. Support your patient's rhythm by snapping your fingers, clapping, or using a metronome or music.

During the next exercise, you will change walking speeds. Walk next to the patient and ask them to keep pace with you while you speed up or slow down. You can once again provide support through clapping or other sounds.

Enhance the training by changing directions, walking in circles or going around obstacles. Now combine changes in direction and speed. This improves the patient's flexibility.

2. Walking becomes more demanding when you perform all of these exercises on a soft, uneven surface, such as an exercise mat.

Music is often a valuable aid for walking exercises. And it makes training fun!
“When I´m walking, I don´t pay close attention to bumps and simply enjoy the world around me.“
Lucia
A new quality of life – with your help

Gait training is a demanding--and likely new--experience for your patient. This is certainly nothing unusual for you as a therapist. What's incredible is that the patient's everyday life, interests and perception of themselves often change for the better with the C-Brace® orthotronic mobility system. Many previously used a wheelchair. With the C-Brace®, users undergo a transformation. They learn to trust the system and its damping, and they experience physiological movements, perhaps for the very first time. This is truly unique! And it only works with your help!
Tailor the training specifically to your patient. Add your own exercises to enhance his training. Below you'll find a place for your notes.
Please contact us if you have any further questions or would like more information.