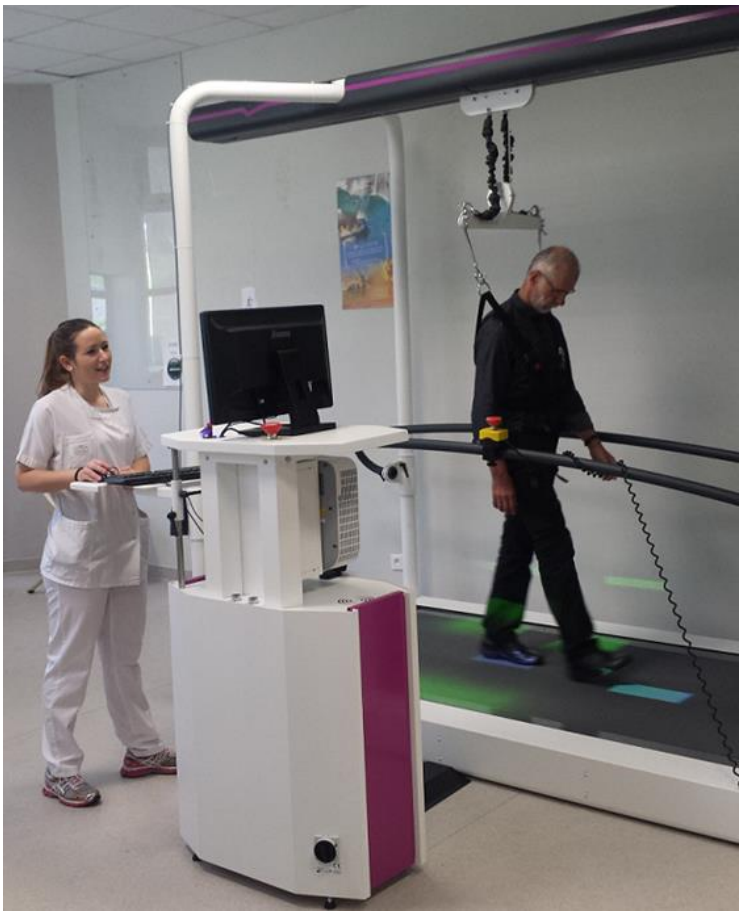
C-Mill Therapy Guideline



Motek
a DIH brand

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

1 Preface

Preservation of mobility is a prerequisite for healthy independent ageing. It prevents elderly from entering a vicious circle leading to dependency and aggravation of co-morbidity and quality of life.[1] One third of the elderly is suffering from physical limitations and recurrent falls, therefore preservation of mobility is of vital importance for them.[2]
Evidence is emerging that treatment focused on targeted mobility enhancement is successful.[3] Training of gait ability is a key component of fall prevention and plays a major role in the rehabilitation process.

Over 50% of fall incidents are caused by tripping, slipping or awkward foot placement while walking. In many of these cases an external factor, such as an obstacle, causes the fall.[4] An increased fall risk is especially apparent for people suffering from gait impairments or having problems with gait adaptability.
This emphasizes the importance of training gait-specific adaptive skills instead of only walking on a smooth surface. A training with gait-specific adaptive skills includes obstacle avoidance, acceleration and deceleration of walking speed and proper foot placement based on guided and variable cues. This training could improve patients' functional walking skills and ability to adapt their walking pattern to the requirements of the environment.

The C-Mill is developed with the aforementioned possibilities in mind. The C-Mill is a versatile system that is offering multi-sensory input to the patient. The combination of a treadmill with a built-in force plate and belt projection allows for training of functional walking skills. For example, by projecting targets or obstacles on the treadmill, a walking pattern can be dictated and, more importantly, this pattern can be influenced in terms of step length, step width, cadence and symmetry. It can be stated that the **C-Mill can assess and improve the patient's gait pattern and gait adaptability**.[6, 7] The C-Mill also allows for training of acceleration or deceleration while walking. Therefore, the C-Mill can be successfully implemented in gait research as well as in gait rehabilitation.[5]

Besides training of gait adaptability, the **C-Mill offers balance assessments and training**. Balance is vital to everyday activities, for example during transfer from sit to stance or during walking. People with neurologic, orthopedic or vestibular disorders may exhibit sensorimotor, biomechanical or sensory integration issues affecting their balance, posture and mobility.
Clinical research has clearly demonstrated that a broad spectrum of patients can benefit from comprehensive balance interventions and for optimal recovery of impaired balance an **early start of the rehabilitation is essential**. Therefore, it is also possible to execute balance assessments and training on the C-Mill, allowing an **easy transition into gait training**.

In conclusion, The C-Mill system can be successfully implemented in clinical rehabilitation by offering **objective assessments and task-specific balance and walking training with direct feedback on performance**. The difficulty level of the training can be adapted to the patient's needs and goals. This allows a safe, but challenging training environment for every patient.
This guideline describes the clinical workflow on the C-mill system and explains the different categories **Stand, Step** and **Walk** with their corresponding treatment goals, assessments and training for patients with balance and walking impairments.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

Medical Disclaimer

The information described in this guideline relates to the systems offered by Motek Medical. Motek Medical does not provide any responsibility, guarantee or warranty for this information.

The guideline is not intended to be a substitute for professional medical advice, diagnosis or treatment. The decision whether a patient is able to start the C-Mill therapy should always be made by the clinician, who has the medical responsibility for the patient. The information in this guideline should support, not replace, the knowledge, judgement and experience of the clinician.

If you have feedback, comments or questions regarding this guideline, please send an email to support@motekforcelink.com.

Contents

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

2 Introduction

The C-Mill therapy consists of 6 steps:

1. Referral; The possible indications and contraindications for the different categories **Stand, Step** and **Walk** are provided and can be discussed with the referring specialist.
2. Intake; to determine the treatment goals for the patient. These goals are categorized in **Stand, Step** and **Walk**.
3. Assessment; various parameters can be measured to evaluate treatment goals using dedicated assessments.
4. Training; various training protocols can be performed in order to reach the treatment goals for functional rehabilitation.
5. Re-Assessment; to monitor progression re-assessment and comparison with previous outcome parameters is recommended.
6. Evaluation; to evaluate the C-Mill therapy with both the patient and referring specialist by using an evaluation report.

The 6 steps of the C-Mill therapy are schematically presented in Figure 1 and will be described in the following chapters.

Figure 1: C-Mill therapy

3 Referral

The medical specialist or therapist should decide if the patient is indicated on the C-Mill system.

Indications
The C-Mill can be used for elderly with increased fall risk and patients with neurological, cardiovascular or orthopedic conditions affecting balance and gait.

During the referral, the therapist or referring specialist should determine whether there are any contraindications for the patient to start the C-mill therapy, in which a safety harness is used. This decision is made by a clinician who has the medical responsibility for the patient. In this therapy phase the possible contraindications are discussed. Table 1**Error! Reference source not found.** and Table 2 describe the contraindications for the C-Mill and Body Weight Support system.

Contraindications C-Mill
• A severe cognitive, visual or hearing impairment where the patient is not able to follow the instructions of the therapist. • More than 135 kg total bodyweight • More than 2.00 meter body height • Open skin lesion or bandage in the area of harness contact. • < FAC 2
Risk factors C-Mill
• Severe reduced bone density • Spinal instability or unstable fractures. • Severe vascular disorders or cardiac abnormalities that affect the ability to exercise safely • Running < FAC 5

Table 1. Contraindications C-Mill

Contraindications C-Mill with Body Weight Support
• A severe cognitive, visual or hearing impairment where the patient is not able to follow the instructions of the therapist. More than 135 kg total bodyweight • More than 1.90 meter body height • Open skin lesion or bandage in the area of harness contact. • < FAC 1; i.e. cannot walk, or needs help from 2 or more persons • Pregnancy
Risk factors C-Mill with Body Weight Support
• Severe reduced bone density • Spinal instability or unstable fractures • Severe vascular disorders or cardiac abnormalities that affect the ability to exercise safely

Table 2: Contraindications C-Mill with BWS

* FAC (Functional Ambulation Categories). See the FAC level explanation in paragraph 4.1 Start Level.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

4 Intake

Once the contraindications have been ruled out for the patient, the intake of the C-Mill therapy will be accomplished. During the intake a therapist determines the start level for the patient, to select the treatment goals that best fit their patient's capacity. These treatment goals are categorized in **Stand, Step** and **Walk**, as shown in Figure 2.

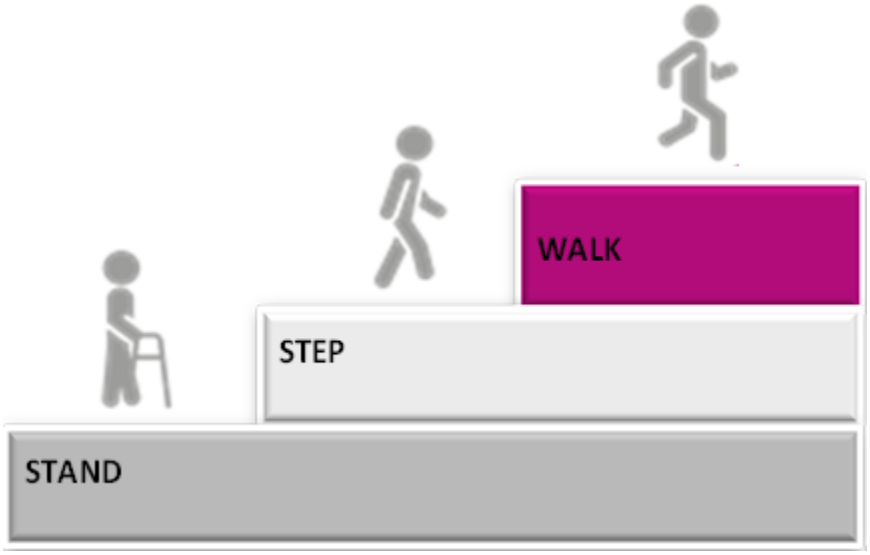


Figure 2: A representation of the three categories applicable for the C-Mill therapy

The aim of the three categories:
Stand: Improve postural control while standing and shifting weight
Step: Improve stepping balance, stepping ability and one-leg stance
Walk: Improve gait functionality and adaptability

4.1 Start Level

Figure 3 provides the Functional Ambulation Categories (FAC) scores to determine the start level for **Stand, Step** and **Walk.**

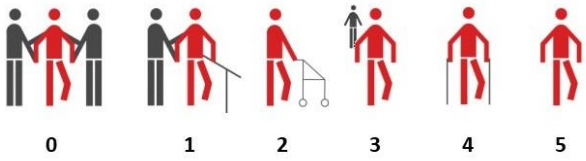


Figure 3: FAC scale to determine start level for the patient.

FAC: Functional Ambulation Categories

- FAC 0: Patient cannot walk, or needs help from 2 or more persons
- FAC 1: Patients needs firm continuous support from 1 person who helps carrying weight and with balance

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

- FAC 2: Patient can walk with continuous or intermittent support of one person to help with balance and coordination.
- FAC 3: Patient can walk but requires verbal supervision/stand-by help from one person without physical contact
- FAC 4: Patient can walk independently on level ground, but requires help on stairs, slopes or uneven surfaces
- FAC 5: Patient can walk independently anywhere.

Table 3 describes the start level for the three categories. A distinction is made between **with** or **without Body Weight Support (BWS).**

	Start level	Training goals
Stand	FAC level ≥ 1 (with BWS) FAC level 2	- Dynamic balance - Weight shifting
Step	FAC level ≥ 1 (with BWS) FAC level ≥ 2	- Stepping balance - One leg stance
Walk	FAC level ≥ 1 (with BWS) FAC level ≥ 3	- Gait - Gait adaptability

Table 3. Start levels of the intake (with and without Body Weight Support (BWS)

4.2 Treatment goals

C-Mill therapy is especially suitable for training of the adaptive walking skills in the early phases of the rehabilitation process. Additionally, the C-Mill automatically determines gait parameters in order to optimize the gait pattern.

For each category a set of C-Mill therapy treatment goals can be selected. These selected goals correspond to a selection of C-Mill assessments and training. Table 4 provides an overview of the treatment goals for the C-Mill therapy.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

Category	Treatment goals
STAND	Improve static balance Improve dynamic balance Improve weight distribution and shifting
STEP	Improve single leg stance Improve stepping sideways
WALK	Improve step length, step symmetry and step width Improve stance phase duration Improve gait adaptability by obstacle avoidance Improve various step lengths Improve walking speed and walking accelerations Improve re-active obstacle avoidance (we-move) Improve gait stability and decrease step width Improve gait stability during stepping sideways Improve gait adaptability on an easy, medium and hard level

Table 4. Treatment goals for C-Mill therapy

The C-Mill therapy can be used for all patients with balance and walking disorders and provides intensive, repetitive and truly task-specific balance and walking training with direct feedback on performance. [1]

The optimal therapy dose for rehabilitation of patients is not established yet, but the recommended intensity of the C-Mill therapy is:

- **Frequency** of training should be at least 2 times per week, preferably 3 times per week when possible. [11,12]
- **Session length** should have a minimal duration of 20 minutes. For patients with a low level of fitness, shorter session duration may be necessary.[11]
- **Total duration** of minimal 5 weeks.

The duration and intensity of the C-Mill therapy will have to be established in consultation with the patient.[13]

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

5 Assessments

The purpose of the assessments is to determine the balance and gait baseline (adapt)ability of the patient with objective outcomes and to evaluate the effect of training.
Table 5 provides an overview of the assessment goals, assessments and their outcomes.

Assessments			
Category	**Assessment goals**	**Assessment**	**Outcome measures**
STAND	Static postural control	Postural Stability	CoP velocity in cm/s
	Dynamic mediolateral (ML) weight shifting	Limits of Stability	ML CoP displacement in cm
	Dynamic anterior-posterior (AP) weight shifting		AP CoP displacement in cm
STEP	Currently not available		
WALK	Walking adaptability	C-Gait	C-Gait score
		Gait Adaptability	Incorrect or correct consecutive step
	Walking functionality; observation of the walking pattern	Gait	Step length Step width Stance duration Step symmetry

Table 5. C-Mill assessments

5.1 Stand assessments

The following requirements should be met when performing the balance assessments “Limits of Stability” and “Postural Stability” to assure consistency of the outcome.

- The patient should wear flat shoes.
- The patient should not talk during the measurements.
- Instruct the patient and pay attention to compensatory movements.
- The patient should be comfortable with the assessment application.
- The patient should be comfortable wearing a harness.
- It is recommended to allow the patient to practice the assessment before the actual measurement.
- Measure the patient’s performance with exactly the same arm and foot position when performing a re-assessment.

Procedure Limits of Stability:

- The patient needs to stand with his/her feet **on the projected feet** (visible on the belt).
- The patient should be standing upright with the arms held **next to the body** or **crossed in front** of the chest and looking forward. Choose at least one of those conditions for a patient when performing a(n) (re)assessment.
- The patient moves his/her upper body as far as possible in **4 directions** (forward, backward, left and right).
- The **balance level** of the patient is measured.

Procedure Postural Stability:

- The patient needs to stand with his/her feet **on the projected feet** (visible on the belt).
- The patient should be standing upright with the arms held **next to the body** or **crossed in front** of the chest and looking forward. Choose at least one of those conditions for a patient when performing an (re) assessment.
- The static postural control of the patient is measured during **4 tasks:**
    - **Standing with eyes open**
    - **Standing with eyes closed**
    - **Tandem stance**
    - **One leg stance**

Foot position for both assessments

The **projected feet on the belt** is a standardized feet stance width by setting the heel distance to 11% of body height and the stance angle to 14° (both sides), as shown in Figure 4. These stance measures have been shown to be within the values of normal stance.[19]

Figure 4: The foot positioning during the assessments

Limits of Stability

During this assessment the patient's direction-specific limits of stability is determined. The ability to safely move towards a target is an indication of the *dynamic balance* within the base of support.

The assessment measures the limit of stability of the patient in 4 directions (forward, backward, left and right).

The Limits of Stability (LoS) marks the area in which the body's Center of Mass (CoM) may relocate without losing balance of the body.[14, 16] When the CoM exceeds the LoS a patient becomes unstable and needs to make compensatory steps, thus changing the base of support.[15] Constraints on the limits of stability may result in abnormal postural alignment. According to the theory describing the human body as an inverted pendulum, higher limits of stability increases a patient's balance performance and lowers the risk of falling. [17]

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

A study concluded that the LoS test is a reliable measure of functional stability and makes it an interesting alternative to measure Centre of Pressure (CoP) in quiet standing.[18] The displacement of the CoP is an indication of the patients' stability/balance limits towards a given direction. A higher CoP displacement (in cm) is an indication for better dynamic balance, postural control and lower risk of falling.
The total CoP area (in cm2) is an area defined by the CoP displacement for all given directions and is an indication of the patient's overall ability to move his/her CoP in all directions.

Postural stability
Measures the patient's body sway by the CoP velocity in 4 different static conditions: standing with eyes open, standing with eyes closed, tandem stance and single-leg stance. This assessment provides information about the patient's static balance and postural control in standing posture.

Postural control is the foundation of our ability to stand and to walk independently. Diminishing postural stability in older people may contribute to falls during activities of daily life. Impaired balance has been correlated with an increased risk of falling.[20] The postural stability assessment identifies the risk of falling for elderly and can be used as a preliminary screening tool. The findings of a study shows an increase in body sway in narrow base stance, especially in a mediolateral direction, in older people who experience recurrent falls.[21] A different study concluded that the single-leg stance balance (one of the 4 conditions) is a reliable method to assess balance, especially when performed in a static position.[22]

The outcome is the CoP velocity (in cm/s) in 4 conditions. A lower CoP velocity during increasingly difficult conditions is an indication of improved balance control.

5.2 Walk assessments

C-Gait assessment
C-Gait assessment is a test to visualize the functional walking performance (or adaptation ability while walking). C-Gait assessment lasts approximately 18 minutes and consists of 7 different tasks: visually guided stepping, tandem walking, obstacle avoidance, slalom walking, reaction to unexpected situations, speed adaptations and, if applicable, walking while performing an auditory, cognitive dual task.*
Each task should be executed twice at different degrees of difficulty: once at an easy degree and once at a higher degree. This will be necessary to determine the level of difficulty of the patient's C-Mill training. After the assessment, the scores of each task will be presented using the spider diagram.
The assessment will be executed at comfortable walking speed to facilitate comparison to daily life walking outside. The complete C-Gait assessment is presented in Table 6.

* The C-Gait auditory task is only available for customers participating in the C-Gait study. Please contact Motek Medical for more information.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

C-Gait assessment		
Familiarization on the treadmill	±3 min†	Determine comfortable walking speed
Gait adaptability assessment Low difficulty level	±10 min	1.5 min: visually guided stepping 2 min: obstacle avoidance 1.5 min: slalom walking 2 min: speed adaptations 1.5 min: tandem walking 1.5 min: reaction to unexpected situations
Assessment of cognitive dual task	±1 min	Walking while performing an auditory Stroop task
Gait adaptability assessment High difficulty level	±10 min	1.5 min: visually guided stepping 2 min: obstacle avoidance 1.5 min: slalom walking 2 min: speed adaptations 1.5 min: tandem walking 1.5 min: reaction to unexpected situations

Table 6. C-Gait assessment

De results of the seven C-Gait tasks are displayed in Figure 5. The results of the patient are indicated by a bold line, connecting the results of each task.

† Depending on the walking speed

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

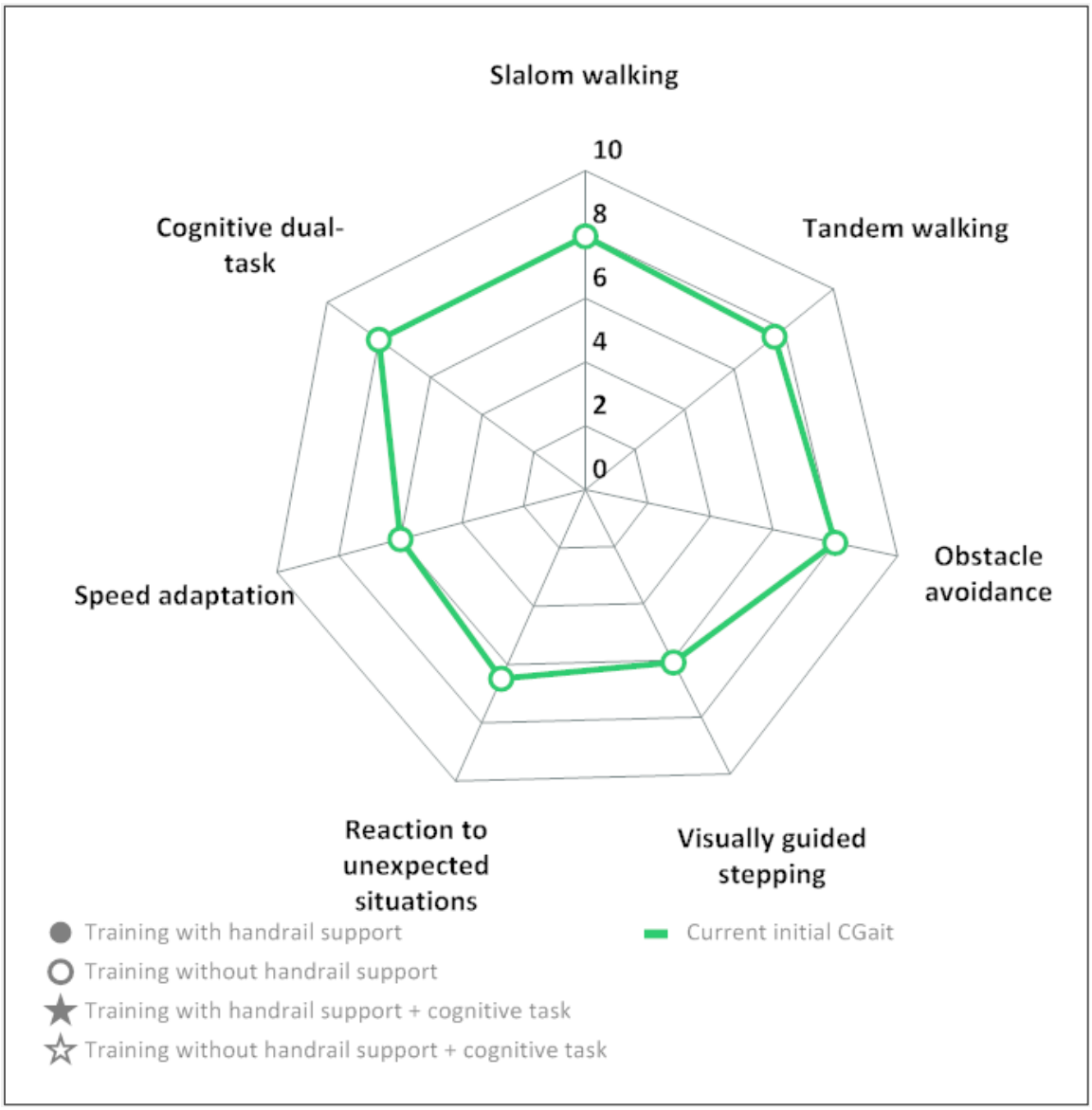


Figure 5: C-Gait assessment outcome measurements.

Gait adaptability assessment

The Gait adaptability assessment evaluates the patient´s capability to **avoid obstacles.** The assessment consists of two blocks with obstacles. The difference between those two blocks is the number of steps the patient has to make before stepping over the obstacle. The results of one of the blocks are shown in Figure 6.

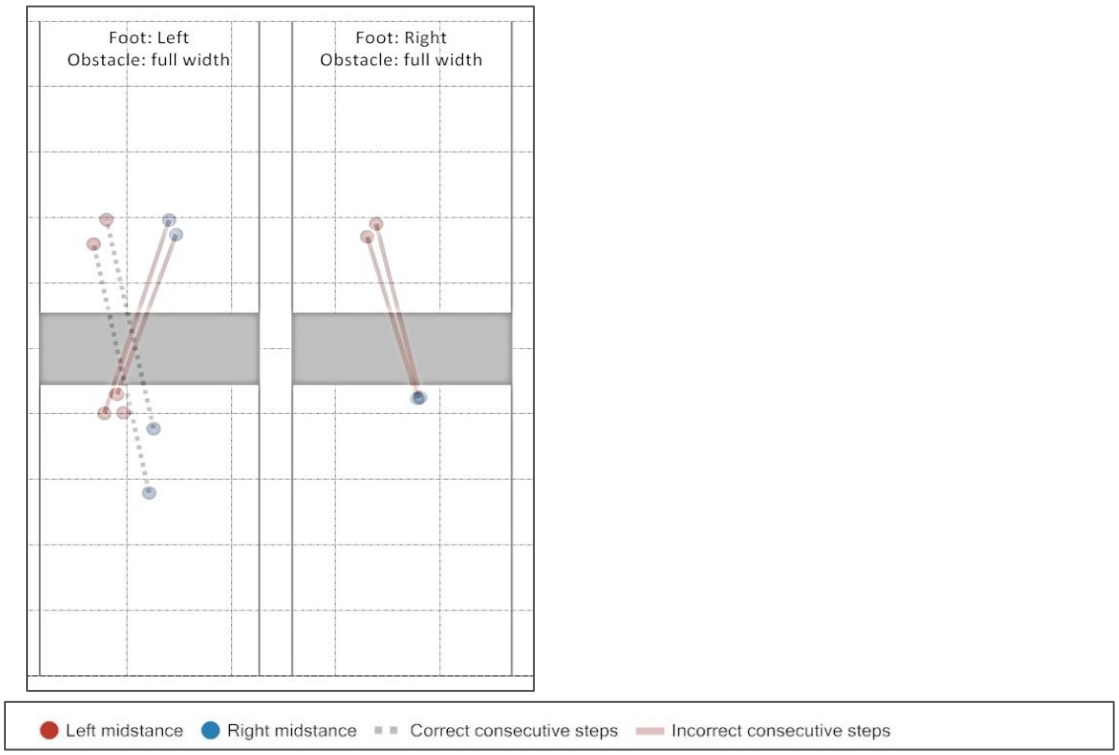


Figure 6: Results of obstacle avoidance.

Gait assessment

The purpose of the Gait assessment is to evaluate the patient´s walking pattern. The assessment is executed at the patient's comfortable walking speed.

The assessment consists of 3 minutes walking. During this assessment the therapist measures the walking pattern and, if applicable, records reference video images. When the patient is not able to walk for 3 minutes, the assessment can be stopped after several minutes. How to interpret the results of the walking pattern is described in Chapter 6.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

6 Gait interpretation

To analyze the results of the gait pattern it is necessary to have some knowledge about the normal gait pattern.

Gait Cycle

Walking is the result of a cyclic series of movements. As such, it can be conveniently characterized by a detailed description of its most fundamental unit: a gait cycle (Figure 7).[35] The gait cycle is initiated as soon as the foot contacts the ground. Because foot contact is normally made with the heel the 0% point, or beginning of the gait cycle, is often referred to as heel contact or heel strike. The 100% point, or completion of the gait cycle, occurs as soon as the same foot once again contacts the ground. Initial contact is often used as a substitute term for heel contact when an individual first contacts the ground with a part of the foot other than the heel, but for the purpose of this chapter, focusing on normal walking, the term heel contact will be used.

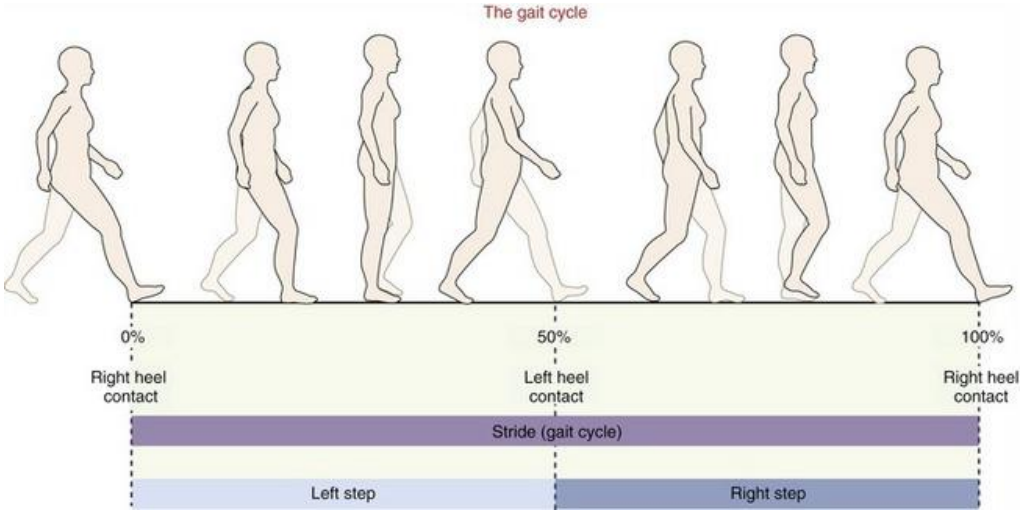


Figure 7: The gait cycle from right heel contact to subsequent right heel contact.

The most basic spatial descriptors of gait include the length of a stride and the length of a step (Figure 8). Stride length is the distance between two successive heel contacts of the same foot. Step length, in contrast, is the distance between successive heel contacts of the two different feet. Comparing right with left step lengths can help to evaluate the symmetry of gait between the lower extremities. [24]

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

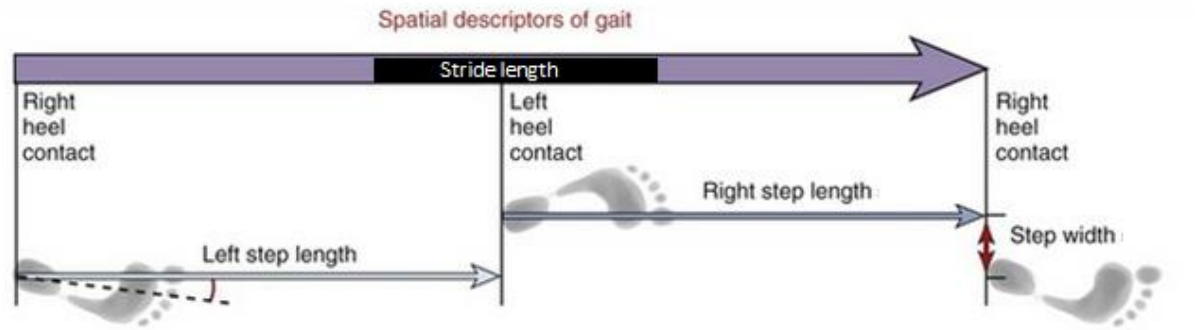


Figure 8: Spatial descriptors of gait and their typical values for a right gait cycle.

Stance and Swing Phases

To describe when gait events take place during the gait cycle, it is commonly used to subdivide the gait cycle from 0% to 100%. As stated earlier, heel or foot contact with the ground is considered the start of the gait cycle (0%) and the successive ground contact made by the same foot is considered the end of the gait cycle (100%). Throughout this chapter, gait is described using the right lower extremity as a reference. A full gait cycle for the right lower extremity can be divided into two major phases: stance and swing (Figure 9).

Stance phase (from right heel contact to right toe off) occurs as the right foot is on the ground, supporting the body weight.

Swing phase (from right toe off to the next right heel contact) occurs as the right foot is in the air, being advanced forward for the next contact with the ground.

At normal walking speed, the stance phase occupies approximately 60% of the gait cycle and the swing phase occupies the remaining 40%. [24]

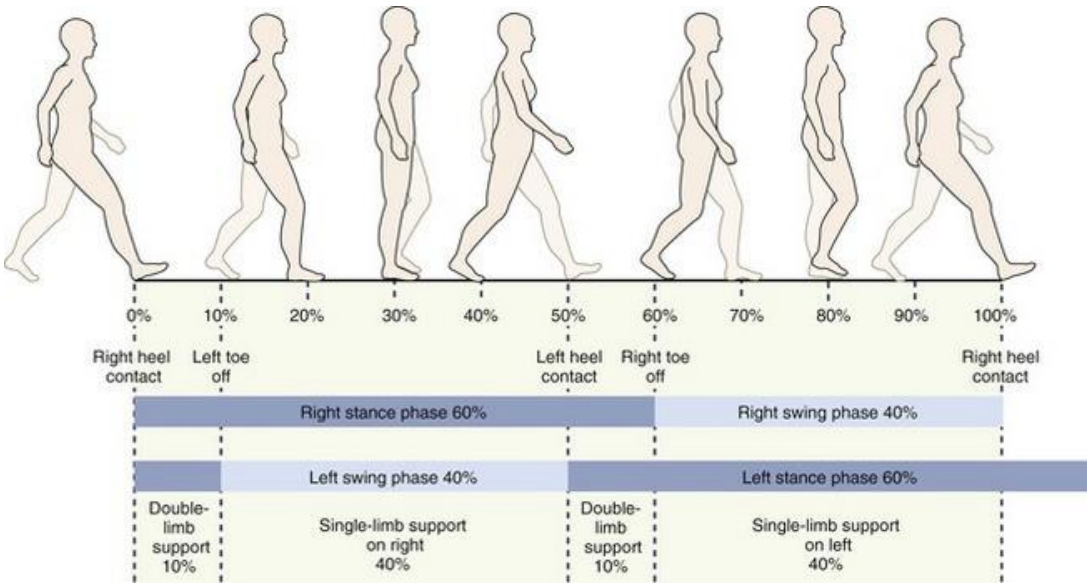


Figure 9: Subdivision of the gait cycle illustrating the phases of stance and swing and periods of single- and double-limb support.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

CoP movement

During walking on the C-Mill the Centre of Pressure (CoP) is registered during stance phase by the C-Mill force plate. The trajectory of the CoP is a repetitive profile in the shape of a butterfly (Figure 10). The CoP moves backwards during the stance phase, because the treadmill belt slides backwards over the force plate.
The latter is why the CoP trajectory has the shape of a butterfly during treadmill walking. The shape of the butterfly provides characteristics of the gait pattern.[5] Appendix 1 provides additional information about the butterfly.

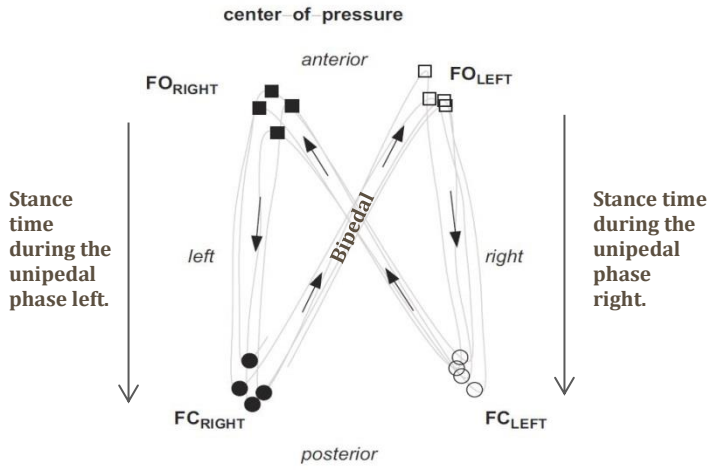


Figure 10: The butterfly: representation of the CoP profile during gait on a treadmill. The moment in time of FC and FO is shown. The arrows indicate the direction of the CoP during gait.

Aggregated forces

The ground reaction force (GRF) characteristics during human walking can serve as an important indicator of pathological gait and can be easily obtained during routine clinical gait analysis as a complementary measure for standard data reporting.[23] The vertical component of the GRF has a typical shape (Figure 11).

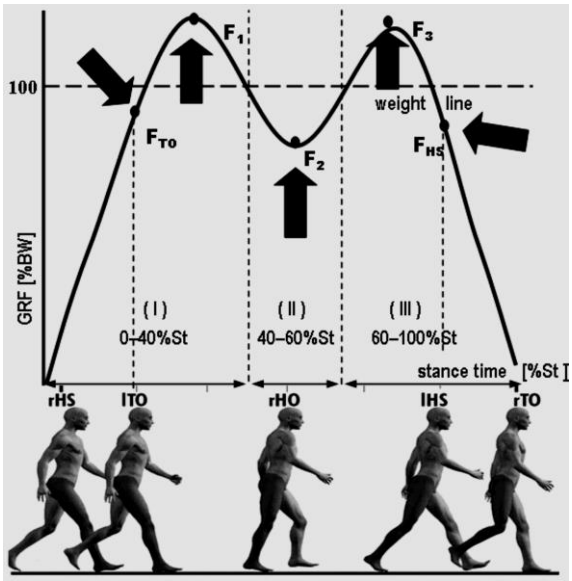


Figure 11: Vertical component of the Ground reaction force.

- During the early midstance the GRF is 10% above the body weight (F1).
- During midstance the GRF is 25% under the body weight (F2).
- During the latest midstance, just before toe off, the GRF is again 10% above the body weight (F3).

7 Results

The purpose of this chapter is to give a few examples of outcome measures to understand the interpretation of these results. These results will be used to offer training possibilities. These training possibilities are further described in Chapter 8.

Spatial data

Figure 12 presents the spatial data with a difference between the left and right step length in meters. A possible treatment goal could be to improve the symmetry between the left and right step. A training suggestion to move the symmetry more towards 50-50% for the left and right step is **'Stepping stones'**.

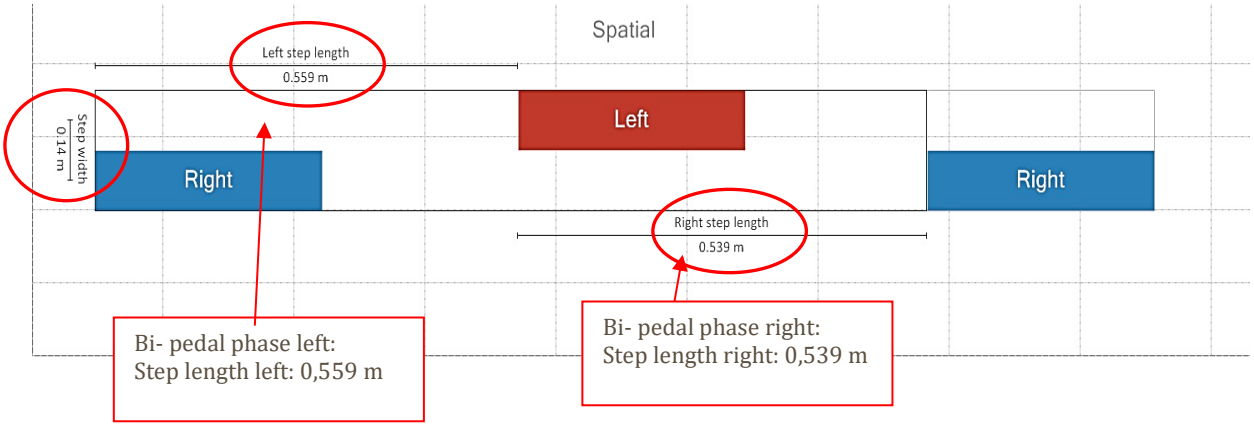


Figure 12: Spatial data

Temporal data

Figure 13 shows a shorter stance phase right compared to the stance phase left. The treatment goal could be to increase the stance phase on the right leg. A training possibility is the **training 'Stance phase ability'**. By increasing the number of obstacles for the left foot, the patient has to stand on the right leg to step over the obstacle with the left foot. Thereby, it is possible to increase the length of the obstacle for the left foot. The patient has to stand on the right foot for a longer period of time. The obstacle results, located under "Analysis", show which foot the patient used to step over the obstacles.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

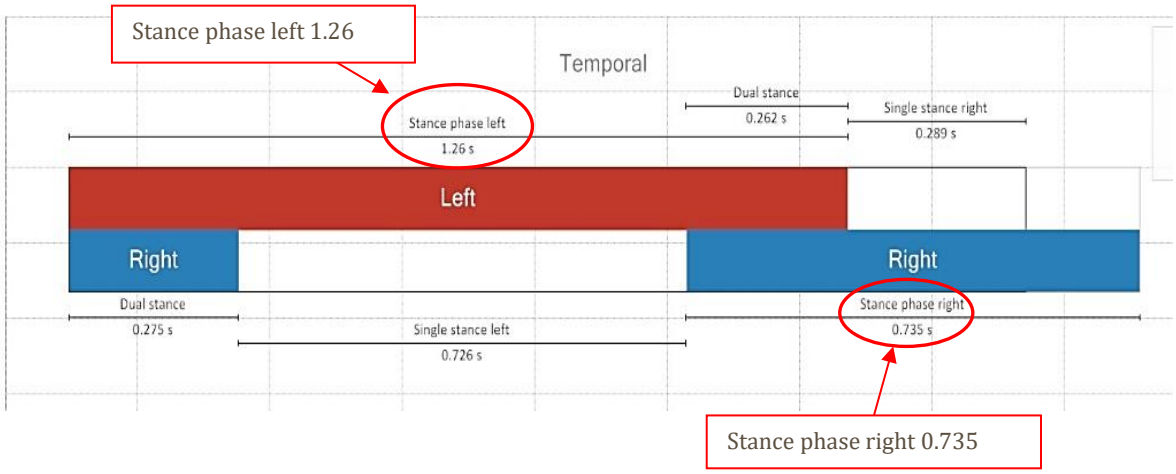


Figure 13: Temporal data

Butterfly

Figure 14 shows the butterfly results with a disbalance during the dual stance phase; shifting the weight from the left to right. The treatment goal for the training could be to increase dynamic stability while shifting the weight from the left to the right. A training option could be to use the **training 'Stepping stones' on slow speed.** When increasing the width between the stepping stones, the patient will walk with a large CoP movement from left to right. Another option is to use the slalom to train the stability by decreasing the Base of Support (BoS), or use the tandem to train the stability during the dual stance phase by decreasing the BoS. The tracks can be used to train the variability of weight shifting while walking.

In addition, it is recommended that the therapist uses the assessment outcomes to evaluate the effect of the C-Mill therapy.

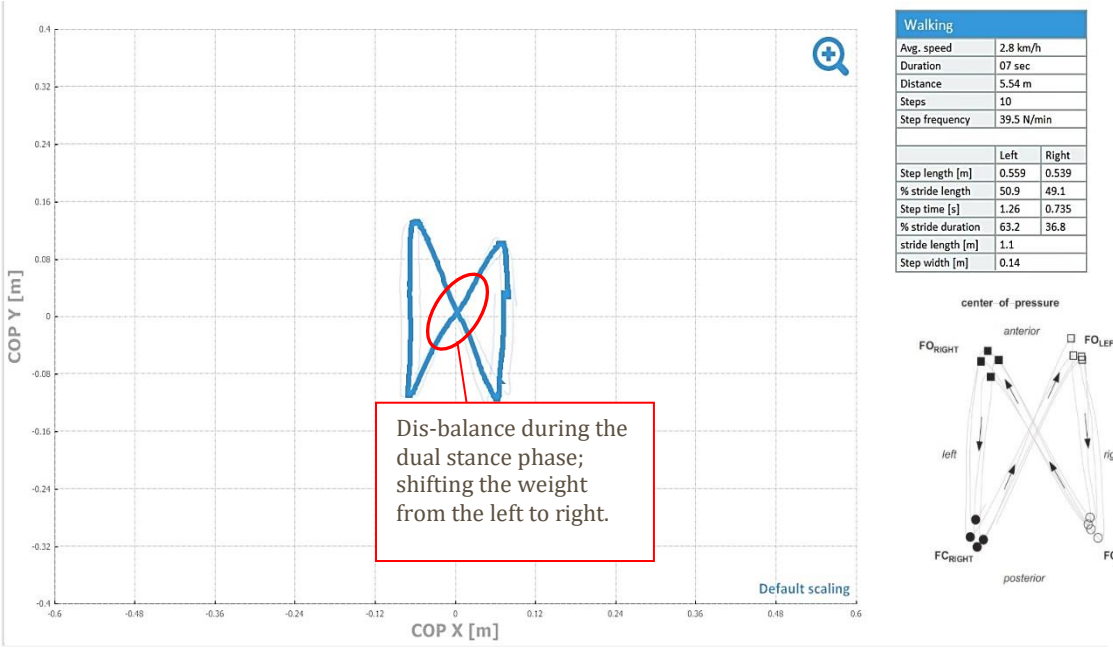


Figure 14: Representation of Butterfly

8 Training

Each of the treatment goals for the patient are linked to specific training protocols. In the tables below the training protocols are linked to the treatment goals. Table 7 shows the training with floor projection and Table 8 shows the training with the front display.

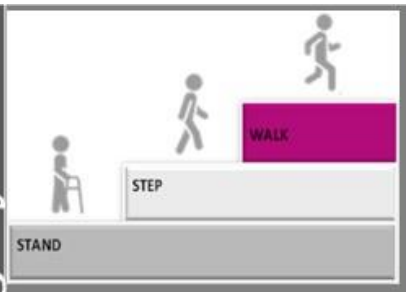
Category		Training (Floor)								
		Stepping stones	Auditive cueing	Obstacle avoidance	Random Stones	Speed adaptation	Re-active obstacles	Tandem	Slalom	Tracks (also applicable to Monster Game)
	Treatment goals									
WALK	Walking symmetry	*	*							
	Increase stance time	*	*	*						
	Increase step length	*		*	*					
	Improve gait stability			*				*	*	*
	Change step width	*			*			*	*	*
	Improve gait adaptability			*	*		*			*
	Improve walking accelerations					*				
	Train double task (with Stroop[1], Nature Island[2], Symmetry[3] or Italian Alps[4])	* 1,2,3	* 1,2,3	* 2,4	* 1,2	* 1,2	* 1,2,3	* 1,2,3	* 1	* 1,2

Table 7. C-Mill standard training with floor projection

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

Category	Treatment Goals	Training(Front)							
		Symmetry	Arkanoid	Catch	Soccer	Traffic Jam	Nature Island	The Italian Alps	Walk Symmetry
STAND	Improve weight distribution	*							
	Improve weight shifting		*	*	*	*			
STEP	Improve single leg stance					*			
	Improve stepping sideways		*	*	*				
WALK	Improve walking duration						*	*	
	Improve gait stability		*	*	*			*	
	Improve step length						*		*
	Improve walking symmetry						*		*
	Improve gait adaptability							*	

Table 8. C-Mill standard training with front display.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

9 Re-Assessment

After a couple of C-Mill sessions the effect of the C-Mill therapy can be measured by re-assessing. Figure 15 shows the progression of the objective outcome parameters. Compare the first assessment with the last assessment to check the progress of the patient's treatment. Make sure to use the same procedure during the re-assessment as during the initial or second assessment. This progress evaluation is based on the objective outcomes of the assessments. A re-assessment can be performed periodically.

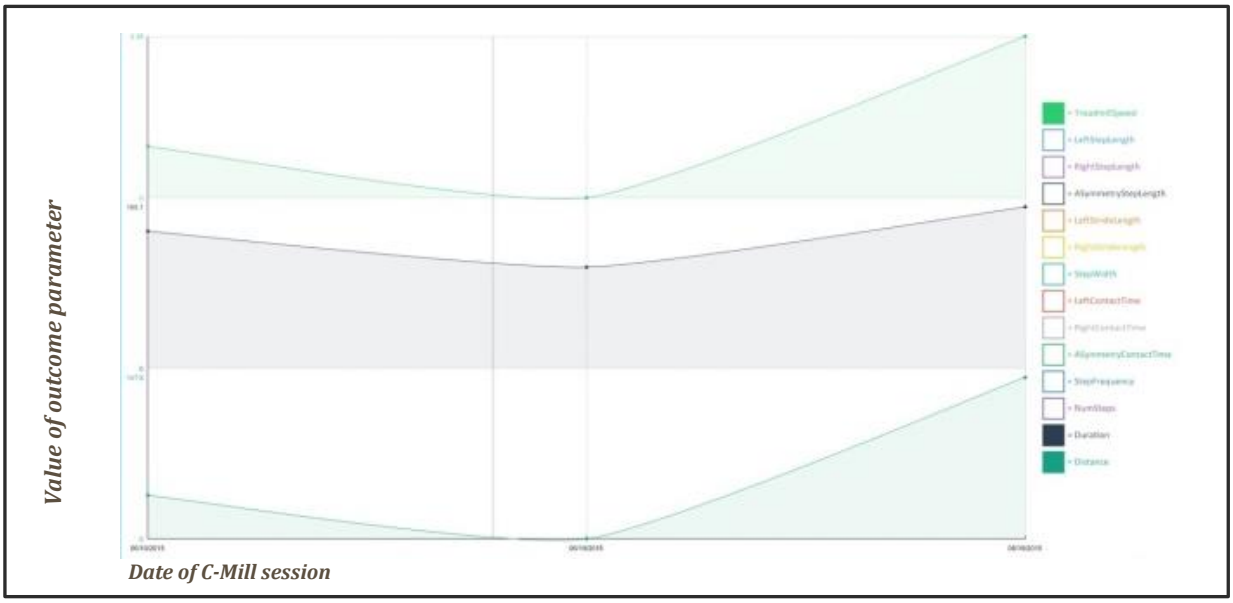


Figure 15: progression of C-Mill objective outcome parameters.

10 Evaluation

After the C-Mill therapy is finished, the therapist can evaluate the C-Mill therapy plan with a final assessment. This can be done with the same assessment as the patient has done before. Check the outcome measurements to determine if a patient has achieved his treatment goals and functional goals.

11 Reference list

1. Rubenstein LZ et al (2001). Quality indicators for the management and prevention of falls and mobility problems in vulnerable elders. Annals of Internal Medicine, 135, 686-693.
2. World Health Organisation (2007). Global report on falls prevention in older age. WHO, ISBN 9789241563536.
3. American Geriatrics Society (2001). Guideline for the prevention of falls in older persons. Journal of the American Geriatrics Society, 49, 664-672.
4. Cameron ID, Murray GR, Gillespie LD, Robertson MC, Hill KD, Cumming RG, Kerse N (2010). Interventions for preventing falls in older people in nursing care facilities and hospitals. Cochrane Database of Systematic Reviews, 20, CD005465.
5. Roerdink, M., Coolen, B. (H), Clairbois, B. (H)E, Lamoth, C. J. C., & Beek, P. J. (2008). Online gait event detection using a large force platform embedded in a treadmill. Journal of Biomechanics, 41(12), 2628–2632. Journal of Biomechanics.
6. Heeren A., Van Ooijen M. W., Geurts A. C. H., Day B. L., Janssen T. W. J., Beek P. J., Weerdesteyn V. 2013. Step by step: A proof of concept study of C-Mill gait adaptability training in the chronic phase after stroke. Journal of Rehabilitation Medicine, 45(7), 616–622.
7. Houdijk, H., van Ooijen, M. W., Kraal, J. J., Wiggerts, H. O., Polomski, W., Janssen, T. W. J., & Roerdink, M. (2012). Assessing Gait Adaptability in People With a Unilateral Amputation on an Instrumented Treadmill With a Projected Visual Context. Physical Therapy, 92(11), 1452–1460.
8. Holden, M. K., Gill K.M., et al. (1984). "Clinical gait assessment in the neurologically impaired. Reliability and meaningfulness." Phys Ther 64(1): 35-40.
9. Hesse S, Werner C, Paul T, Bardeleben A, Chaler J. Influence of walking speed on lower limb muscle activity and energy consumption during treadmill walking of hemiparetic patients. Arch Phys Med Rehabil 2001; 82:1547-1550.
10. Montoya R, Dupui P, Pagès B, Bessou P. Step-length biofeedback device for walk rehabilitation. Med. & Biol. Eng. & Comput. 1994; 32:416-420.
11. Gordon, N. F., Gulanick, M., Costa, F., Fletcher, G., Franklin, B. A., Roth, E. J. and Shephard, T. 2004. Physical Activity and Exercise Recommendations for Stroke Survivors: An American Heart Association Scientific Statement From the Council on Clinical Cardiology, Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention; the Council on Cardiovascular Nursing; the Council on Nutrition, Physical Activity, and Metabolism; and the Stroke Council. Circulation, 109, 2031-2041Rimmer, J. H., Rauworth, A. E., Wang, E. C., Nicola, T. L. & Hill, B. (2009) A preliminary study to examine the effects of aerobic and treatment (nonaerobic) exercise on cardiorespiratory fitness and coronary risk reduction in stroke survivors. Archives of Physical Medicine & Rehabilitation, 90, 407-12.
12. Best Practise Guidance for the Development of Exercise after Stroke services in Community Settings. The University of Edinburgh. November 2010. http://www.exerciseafterstroke.org.uk/resources/Exercise_After_Stroke_Guidelines.pdf.
13. Royal Dutch Society for Physical Therapy. KNGF Clinical Practice Guideline for Physical Therapy in patients with stroke. 2014. https://www.fysionet-evidencebased.nl/images/pdfs/guidelines_in_english/stroke_practice_guidelines_2014.pdf.
14. Mancini, M., & Horak, F. B. (2010). The relevance of clinical balance assessment tools to differentiate balance deficits. European journal of physical and rehabilitation medicine, 46(2), 239.
15. Horak, F. B. (2006). Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls?. Age and ageing, 35(suppl 2), ii7-ii11.
16. Nashner, L. M., & McCollum, G. (1985). The organization of human postural movements: a formal basis and experimental synthesis. Behavioral and brain sciences, 8(01), 135-150.

17. Gurfinkel, E. V. (1973). Physical foundations of stabilography. Agressologie: revue internationale de physio-biologie et de pharmacologie appliquees aux effets de l'agression, 14(Spec No C), 9-13.
18. Juras, G., Slomka, K., Fredyk, A., Sobota, G., Bacik, B. Evaluation of the Limits of Stability (LOS) Balance Test. J Hum Kinet. 2008;19:39–52.
19. McIlroy WE, Maki BE (1997) Preferred placement of the feet during quiet stance: Development of a Standardized foot placement for balance testing. Clinical Biomechanics 12: 66-70.
20. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988; 319: 1701–7.
21. Melzer I, Benjuya N, Kaplanski J. Postural stability in the elderly: a comparison between fallers and non-fallers. Age Ageing. 2004 Nov;33(6):602-7.
22. Ponce-González JG, Sanchis-Moysi J, González-Henriquez JJ, Arteaga-Ortiz R, Calbet JA, Dorado C.A reliable unipedal stance test for the assessment of balance using a force platform. J Sports Med Phys Fitness. 2014 Feb; 54(1):108-17.
23. SŁAWOMIR WINIARSKI*, ALICJA RUTKOWSKA-KUCHARSKA, Biomechanics Department, University School of Physical Education, Wrocław, Poland. “Estimated ground reaction force in normal and pathological gait”. Vol. 11, No. 1, 2009.
24. GUY G. SIMONEAU, PhD, PT Kinesiology of Walking. March-2015.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

Appendix 1

During walking on the C-Mill the Centre of Pressure (CoP) is registered by the force plate of the C-Mill. The profile of the CoP is a repetitive trajectory in the shape of a butterfly (Figure 16). With the use of this butterfly some characteristics of the gait pattern can be derived. This appendix describes the origin of the CoP profile and what parameters can be derived from the CoP profile.

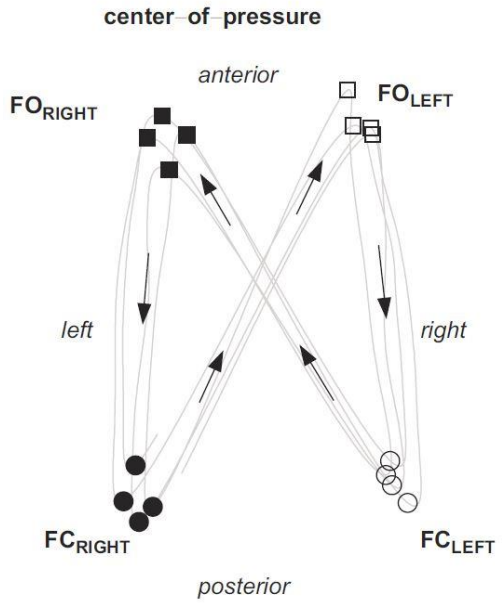


Figure 16: the butterfly: graphical representation of the CoP profile during gait on a treadmill. The moment in time of FC and FO is shown. The arrows indicate the direction of the CoP during gait (Roerdink, Coolen, Clairbois, Lamoth, & Beek, 2008).

Figure 16 shows the CoP trajectory from top view. An important thing to notice from this figure is that the CoP is always under the foot in contact with the floor, which implies:

- FC_R: the CoP is on the left side
- FC_L: the CoP is on the right side
- FO_L: CoP on the right side
- FO_R: CoP on the left side

So between FC_R and FO_L the CoP travels from the left side to the right side, which can be derived from the butterfly figure and CoP top view.

To understand the origin of the CoP butterfly profile, the CoP trajectory in Figure 16 is shown relative to stride and swing phase, viewed from top. Figure 17 shows that the CoP trajectory moves after FC_R from the left to the right leg, followed by a movement to the left leg right after FC_L. An example of interpretation is the red circle in Figure 17: the CoP is located underneath the right foot during a right stride, while at the same time the left leg is in swing phase.

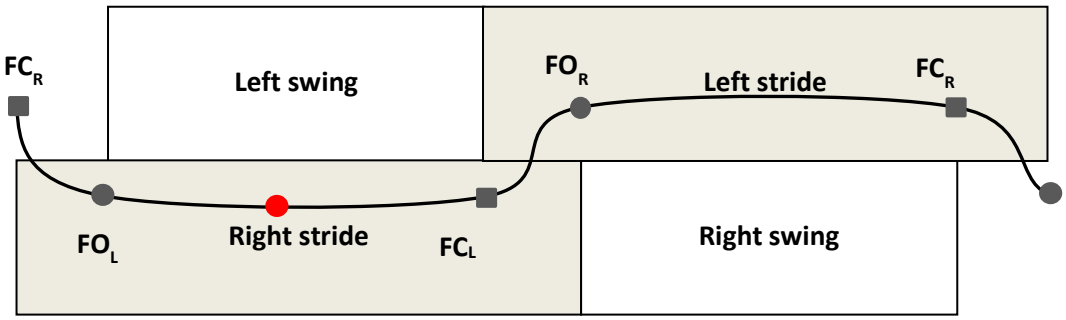


Figure 17: top view of the CoP trajectory shown relative to left and right stride and swing phase. FC = Foot Contact, FO = Foot Off.

A person walking on the C-Mill (almost) only moves relative to the belt and not relative to the force plate. This results in a repetitive profile of the CoP trajectory in the shape of a butterfly. In Figure 17 the same parameters can be found as in Figure 16: FC_R, FC_L, FO_R and FO_L.
Note: this figure is turned 180 degrees relative to Figure 16.

Figure 18, Figure 19, Figure 20 and Figure 21 show where in the CoP butterfly profile the single stance, dual stance, swing phase and step width can be found. These figures show the CoP trajectory for a healthy subject, which makes it possible to indicate deviating profiles from a healthy subject quickly.

SY012-7019_v8.0.docx/ 20190204 / Printed: 20190204
Printed copies are uncontrolled. Consult DMS for up-to-date versions. Form: MFL-05f011 / 20170113

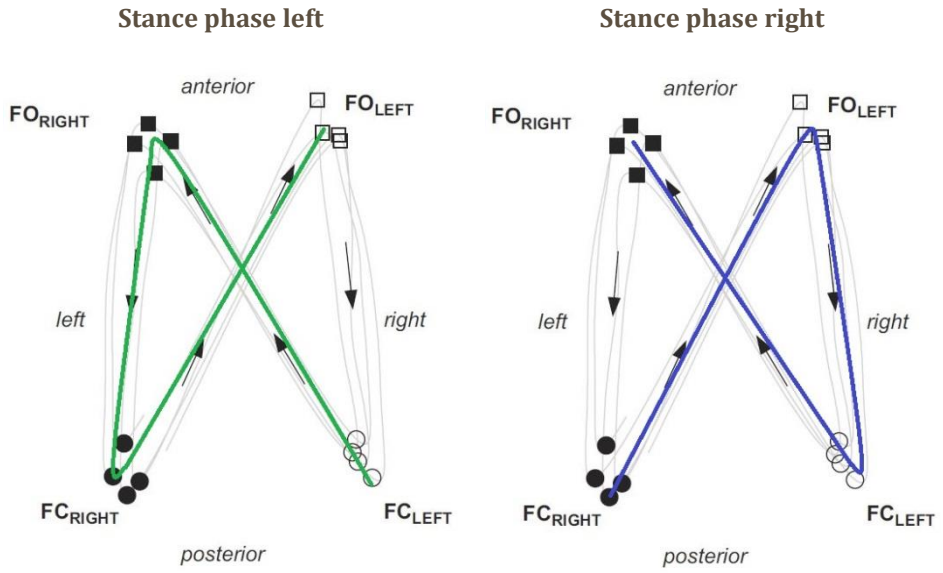


Figure 18: view of the stance phases. Stance phase left (green) order of interpretation: FCleft – FOright – FCright – FOleft. Stance phase right (blue): FCright – FOleft – FCleft – FOright. Figure from Roerdink et al. (2008).

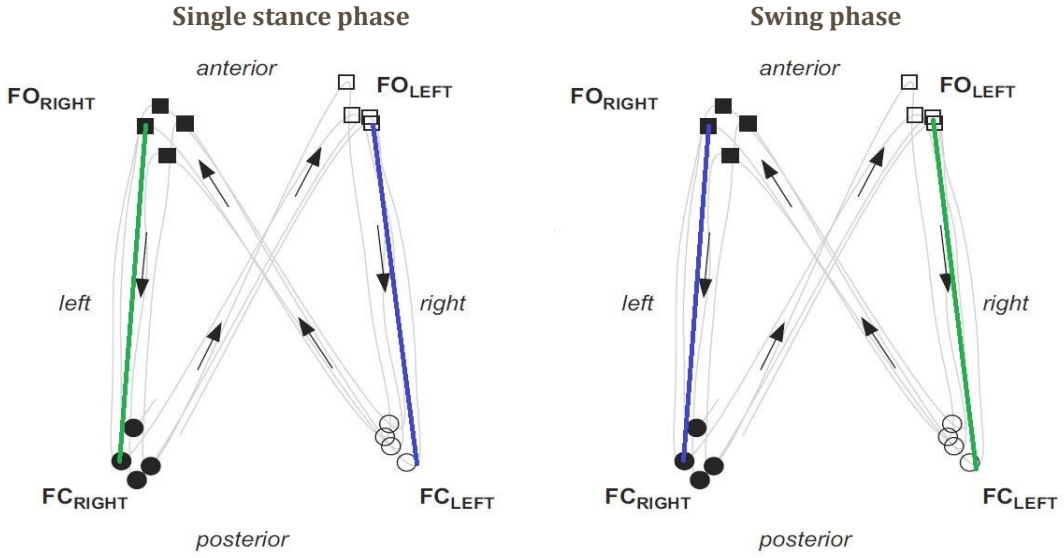


Figure 19: single stance phase left (left figure): green line from FOright to FCright. Single stance phase right (left figure): blue line from FOleft to FCleft. Swing phase left (right figure): green line from FOleft to FCleft. Swing phase right (right figure): blue line from FOright to FCright. Figure from Roerdink et al. (2008).

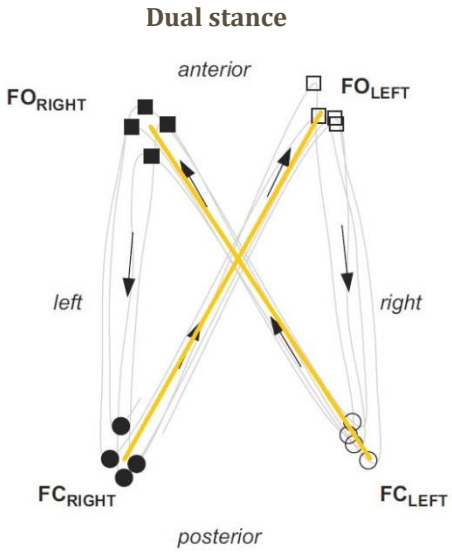


Figure 20: dual stance: orange line from FCright to FOleft and from FCleft to FOright. Figure from Roerdink et al. (2008).

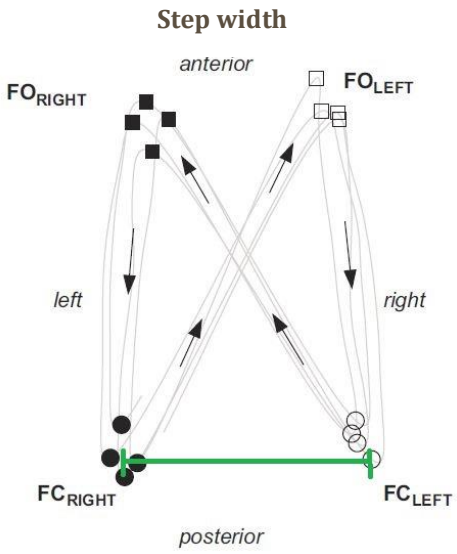
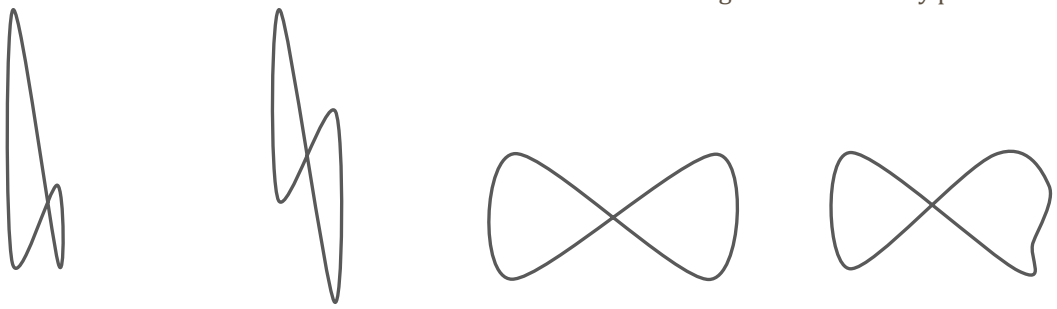


Figure 21: step width: green line. The distance between FCright and FCleft shows the step width. Figure from Roerdink et al. (2008).

Figure 22 shows some examples of deviating CoP profiles relative to the CoP profile of a healthy person. While keeping in mind the CoP trajectory of a healthy subject, gait deviations can be indicated quickly. Figure 22 shows some examples of a deviating CoP profile. These deviations arise from:

1. Asymmetric step time: step time left is bigger than step time right.
2. Asymmetric gait pattern: left step occurs constantly in front of the right step.
3. Wide gait pattern.
4. Disturbed balance during stance phase.

Consult the literature in the reference list for more information concerning the CoP butterfly profile.



1: Asymmetric step time 2: Asymmetric gait pattern **3: Wide gait pattern** **4: Disturbed balance right stance phase**

Figure 22: example of CoP profiles different from a healthy person. 1: stance time left is bigger than right. 2: asymmetric gait with FOR constantly in front of FOL. 3: a wide gait pattern. 4: disturbed balance during right stance phase.

Hogehilweg 18-C | 1101 CD | Amsterdam | The Netherlands
T: +31(0) 20 301 3020 | www.motekforcelink.com