IMPROVE HUMAN PERFORMANCE

C-MILL & BWS TRAINING
Click here to open the video on YouTube
Effective functional gait therapy
(Heeren et al. 2013)

Incorporate motor learning principles
(Papegaaij et al. 2017)

Fun and motivative therapy in a safe environment
(Houdijk et al. 2012)

Objective balance and gait assessment results
(Roerdink et al. 2014)

Monitor progression over time
PROGRAM C-MILL TRAINING

1. Hardware C-Mill
2. Safety C-Mill & BWS
3. Prepare C-Mill session
4. C-Mill Therapy Workflow
5. Assessment & Training
6. Patient Session
7. Manual control & Make your own protocol
8. Advanced Items

End Training +/- [TIME]
C-Mill hardware
C-MILL VR+ AND BWS

Safety portal
Front display
BWS
Floor projector
Handrail
Videocamera
Videocamera
Control panel
Treadmill + forceplate
E-Stop

IMPROVE HUMAN PERFORMANCE
C-MILL FORCE PLATE

Centre of Pressure (CoP)

Balance measurement

Gait measurement

Force plate
Safety C-Mill

- Preventive measures
- Passive safety $\rightarrow$ Harness + Safety line + Support bars
- Active safety $\rightarrow$ E-stop 2x + Light Gate
<table>
<thead>
<tr>
<th>Safety BWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Standalone Hardware system</td>
</tr>
<tr>
<td>- Passive safety → BWS harness + connection to BWS</td>
</tr>
<tr>
<td>- Active safety → E-stop 1x</td>
</tr>
</tbody>
</table>
Prepare C-Mill Session
C-Mill Therapy Workflow
THERAPY WORKFLOW

- Referral
- Intake
- Assessment
- Training
- Re-Assessment
- Evaluation

Indication/Contraindications?
Start level patient?
Baseline level patient?
Treatment goals?
Effect training?
Patient improved in performance?
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 operator.
- More than 135 kg total bodyweight or less than 25 kg
- 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

FAC: functional ambulation categories
**Contraindications C-Mill**

- A severe cognitive, visual or hearing impairment where the patient is not able to follow the instructions of the operator.
- More than 135 kg total bodyweight or less than 25 kg
- More than 2.00 meter body height
- Open skin lesion or bandage in the area of harness contact.
- Running < 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

**FAC: functional ambulation categories**

<table>
<thead>
<tr>
<th>FAC</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Independent</td>
</tr>
<tr>
<td>1</td>
<td>Assisted</td>
</tr>
<tr>
<td>2</td>
<td>Walking</td>
</tr>
<tr>
<td>3</td>
<td>Stepping</td>
</tr>
<tr>
<td>4</td>
<td>Sitting</td>
</tr>
<tr>
<td>5</td>
<td>Draping</td>
</tr>
</tbody>
</table>
### Indication

<table>
<thead>
<tr>
<th>Action</th>
<th>FAC level ≥ 1 (with BWS)</th>
<th>FAC level ≥ 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand</td>
<td>- Dynamic balance</td>
<td>- Weight shifting</td>
</tr>
<tr>
<td>Step</td>
<td>- Stepping balance</td>
<td>- One leg stance</td>
</tr>
<tr>
<td>Walk</td>
<td>- Gait</td>
<td>- Gait adaptability</td>
</tr>
</tbody>
</table>

### Training goals

- Dynamic balance
- Weight shifting
- Stepping balance
- One leg stance
- Gait
- Gait adaptability

FAC: functional ambulation categories

0 1 2 3 4 5
## ASSESSMENT

### STAND

<table>
<thead>
<tr>
<th>Goal</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static balance</td>
<td>Postural control</td>
</tr>
<tr>
<td>Dynamic balance</td>
<td>Limits of Stability</td>
</tr>
</tbody>
</table>
## ASSESSMENT

<table>
<thead>
<tr>
<th>Referral</th>
<th>Intake</th>
<th>Assessment</th>
<th>Training</th>
<th>Re-Assessment</th>
<th>Evaluation</th>
</tr>
</thead>
</table>

### WALK

<table>
<thead>
<tr>
<th>Goal</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk pattern</td>
<td>Gait Assessment</td>
</tr>
<tr>
<td>Gait Adaptability</td>
<td>C-Gait</td>
</tr>
</tbody>
</table>
TRAINING

Referral  Intake  Assessment  Training  Re-Assessment  Evaluation

Virtual Reality
Augmented Reality
MOTOR LEARNING PRINCIPLES

- Training intensity
- Variable practice
- External focus of attention
- Implicit learning
- Task-specific
- Feedback
RE-ASSESSMENT

Assessment → Training

T0

T1
Assessments & Training
THERAPY WORKFLOW

- Referral
- Intake
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- Evaluation

Indication/Contraindications?
Start level patient?
Baseline level patient?
Treatment goals?
Effect training?
Patient improved in performance?
**GOAL**: measures static postural control in 4 different postures.

- Eyes open
- Eyes closed
- Tandem stance
- One-leg stance

**OUTCOME**: Center of Pressure (CoP) velocity in cm/s

- Low CoP velocity = Better postural control
LIMIT OF STABILITY

- **GOAL**: measures the dynamic stability without moving the BOS
- **OUTCOME**: Medio-lateral and Anterior-posterior CoP displacement in cm

- **Higher CoP displacement = Better stability**
GAIT ANALYSIS

- Step length
- Stride length
- Step width
- Distance

**Spatial parameters (distance)**

- Left step length (m)
- Right step length (m)
- Step width (m)
- Stride length (m) = right step length + left step length
GAIT ANALYSIS

- Total stance time
- Unipedal stance time
- Bipedal stance time
- Cadence

**Temporal parameters (time)**

- Right stance phase 60%
- Right swing phase 40%
- Left swing phase 40%
- Left stance phase 60%
- Single-limb support on right 40%
- Double-limb support 10%
- Single-limb support on left 40%
- Double-limb support 10%
BUTTERFLY (COP GAITOGRAM)

Top view COP trajectory

Walking direction ----->

FO left: Foot Off left
FO right: Foot Off right
FC left: Foot Contact left
FC right: Foot Contact left
BUTTERFLY (COP GAITOGRAM)

FO left: Foot Off left
FO right: Foot Off right
FC left: Foot contact left
FC right: Foot contact left
C-GAIT (GAIT ADAPTATION OUTCOME)

<table>
<thead>
<tr>
<th>C-Gait assessment</th>
<th>Time</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiarization on the treadmill</td>
<td>±3 min</td>
<td>Determine comfortable walking speed</td>
</tr>
<tr>
<td>Gait adaptability assessment</td>
<td>±10 min</td>
<td>1.5 min: visually guided stepping</td>
</tr>
<tr>
<td>Low difficulty level</td>
<td></td>
<td>2 min: obstacle avoidance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 min: slalom walking</td>
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<tr>
<td></td>
<td></td>
<td>2 min: speed adaptations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 min: tandem walking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 min: reaction to unexpected situations</td>
</tr>
<tr>
<td>Assessment of cognitive dual task</td>
<td>±1 min</td>
<td>Walking while performing an auditory Stroop task</td>
</tr>
<tr>
<td>Gait adaptability assessment</td>
<td>±10 min</td>
<td>1.5 min: visually guided stepping</td>
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THERAPY WORKFLOW

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## Training

### Category: Walk

<table>
<thead>
<tr>
<th>Treatment goals</th>
<th>Walking symmetry</th>
<th>Increase stance time</th>
<th>Increase step length</th>
<th>Improve gait stability</th>
<th>Change step width</th>
<th>Improve gait adaptability</th>
<th>Improve walking accelerations</th>
<th>Train double task</th>
</tr>
</thead>
<tbody>
<tr>
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### Category: Step

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<thead>
<tr>
<th>Treatment Goals</th>
<th>Improve weight distribution</th>
<th>Improve weight shifting</th>
<th>Improve single leg stance</th>
<th>Improve stepping sideways</th>
<th>Improve walking duration</th>
<th>Improve gait stability</th>
<th>Improve step length</th>
<th>Improve walking symmetry</th>
<th>Improve gait adaptability</th>
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### Category: Stand

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Manual control & Make your own protocol
Advanced Items
CONFIGURATION MENU

- Admin account
- Belt projection
- Create new users
TROUBLESHOOT C-MILL

- Cue Display
- Update CueFors
- Logfiles
- Support/ Clinical Applications contact
Virtual/Augmented reality is a powerful tool for rehabilitation: optimizing therapy outcome by following the motor learning principles.