WHEEL-i: The development of a wheelchair propulsion lab for rehabilitation and sports

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Introduction
- Wheelchair => important for mobility for many people
- Wheelchair dependent: e.g. 80% of people with SCI
- Overuse problems of the upper extremities very common
  - 30-40% shoulder pain during and after SCI rehabilitation
- Optimization of wheelchair propulsion!

How can we optimize propulsion?
- What can be optimized?
  - Wheelchair
    - E.g.
      - Tires (pressure, profile)
      - Wheelchair mass
  - Wheelchair – User Interface
    - E.g.
      - Hand rim (size, shape)
      - Seat height
  - User
    - E.g.
      - Skill learning
      - Fitness
- Much experience with these aspect in research
=> Time for implementation in rehabilitation & sports!

How can we evaluate this?
- WHEEL-i: Wheelchair Expert Evaluation Laboratory – Implementation
  - A wheelchair lab similar to a gait analysis lab:
    - to measure force, EMG, kinematics, heart rate, oxygen uptake
  - Instead of a force platform -> measurement wheels (3D forces and torques)
  - Smartwheel
  - Optipush

WHEEL-i project
- Measurements
  - Tests
    - Wheelchair skills
    - Questionnaires
    - Steady-state wheelchair propulsion with Optipush
  - Pre/Post intervention
    - E.g. learning period of user (long term: weeks)
    - E.g. changes wheelchair / interface (short term: days)

- Standardized tests
  - Wheelchair skill test (8 tests)
    - Figure of 8
    - Crossing a doorstep (4 cm)
    - Mounting a platform (10 cm)
    - 15 m sprint
    - 3% slope
    - 6% slope
    - 3 min. wheelchair propulsion transfer
  - 2 questionnaires:
    - Wheelchair User Shoulder Pain Index (WUSPI)
    - Self-efficacy in wheelchair exercise
**WHEEL-i project**

Optipush measurement:

- forces and torques => to analyze propulsion technique

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**WHEEL-i project: Outcome variables**

- **Consortium for Spinal Cord Medicine**
  - Minimize:
    - Cadence
    - Force

- **SmartWheel User Group**
  - Most clinically important and relevant information:
    - minimum velocity of 1.06 m/s (for crossing intersection)
  - And, as above, minimize:
    - Force
    - Cadence
  - And thus longer strokes (high contact angle)

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**WHEEL-i project: Outcome variables**

- **Client**
  - Name: EL18032011
  - Gender: male
  - Age: 36
  - Weight(kg): 90
  - Height(cm): 180
  - Wheel Size: 25 in/559mm
  - Wheel Side: Left
  - Comment:
    - Re-admittance, followed a wheelchair practice course

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**“The case”**

- Lesion level: Th5

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**3 min. wheelchair propulsion on treadmill**

**March 18, 2011**

- Number of pushes: 131
- Speed(m/s): 1.0
- Cadence/force(min): 1.2
- Braking Torque(Nm): 0.3
- Distance(m): 1.8
- Peak Force(N): 17
- Smoothness: 0.6
- Contact Angle(deg): 70
- Power(W): 6
- Impact(Na): 783

**April 13, 2011**

- Number of pushes: 151
- Speed(m/s): 1.0
- Cadence/force(min): 0.6
- Braking Torque(Nm): 0.0
- Distance(m): 1.8
- Peak Force(N): 48
- Smoothness: 0.6
- Contact Angle(deg): 74
- Power(W): 6
- Impact(Na): 662

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**Dialogue between therapist & researchers**

- Using this equipment in the clinic leads to interaction between researchers and therapists and:
  - New (research) questions!

- For example:
  - What is the effect of tire pressure, tire type and wheelchair mass?
  - What is the effect of different caster wheels (size, material) and wheel size?
  - Can we educate the patients with help of the outcome measures?
  - Or give them feedback during propulsion?
**Tire pressure, tire type, wheelchair mass**

- **Tire pressure**
  - Higher -> Lower power output and subsequently oxygen uptake
  - Lower push frequency / Higher contact angle

- **Tire type**
  - Solid tires -> higher power output and oxygen uptake, heart rate than pneumatic tires

- **Wheelchair mass**
  - No effect on physical strain or propulsion technique during steady-state wheelchair propulsion
  - Probably an effect when accelerating
  - Important for transferring the wheelchair to the car

**Feedback application**

- Training/Education:
  - Feedback
    - Cadence,
    - Force,
    - Contact angle
    - etc.


**Discussion**

- Difficulties regarding implementation:
  - Therapist have to become experienced with tests and outcomes (it’s all new and not much time)
  - Measuring individuals instead of groups

**Conclusion**

- Based on the pilot results of WHEEL-i:
  
  Instrumented measurement wheels can help support the systematic monitoring of the individual wheelchair optimization process and the underlying process of learning.

**Thank you for your attention!**