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	Wheelchair – User Interface	User
E.g. • Tires (pressure, profile) • Wheelchair mass	E.g. • Hand rim (size, shape) • Seat height	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)

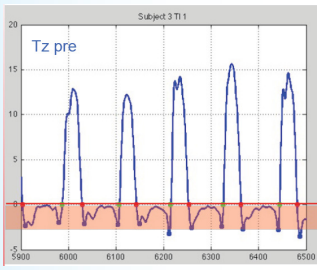
WHEEL-i project

- 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



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)

WHEEL-i project: outcome variables

OptiPush Test Report

Data & Time:	3/18/2011 2:51:15 PM
Description:	3 min op loopband

Client

Name:	EL18032011
Gender:	male
Age:	39
Weight(kg):	80
Height(cm):	180
Wheel Size:	25 in/559mm
Wheel Side:	Right
Comment:	

Results

Number of pushes:	131
Speed(m/s):	1.0
Cadence(push/min):	49
Braking Torque(Nm):	1.3
Distance(m):	1.4
Coast Time(s):	1.0
Peak Force(N):	52
Peak Torque(Nm):	11
Smoothness:	0.6
Contact Angle(deg):	70
Power(W):	5
Impact(N/s):	783

max mobility

"The case"

Client

Name:	EL18032011
Gender:	male
Age:	39
Weight(kg):	80
Height(cm):	180
Wheel Size:	25 in/559mm
Wheel Side:	Right
Comment:	

Lesion level: Th5

Completeness: ASIA A (motor complete)

Re-admittance, followed a wheelchair practice course

3 min. wheelchair propulsion on treadmill

OptiPush Test Report

March 18, 2011

Results

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Peak Torque(Nm):	11
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Contact Angle(deg):	70
Power(W):	5
Impact(N/s):	783

April 13, 2011

Results

Number of pushes:	151
Speed(m/s):	1.0
Cadence(push/min):	52
Braking Torque(Nm):	0.6
Distance(m):	1.3
Coast Time(s):	0.8
Peak Force(N):	40
Peak Torque(Nm):	9
Smoothness:	0.6
Contact Angle(deg):	74
Power(W):	6
Impact(N/s):	662

Dialogue between therapist & researchers

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

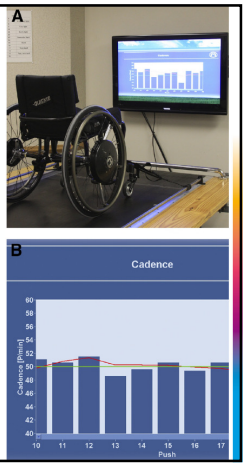
For example:

- What is the effect of tire pressure, tire type and wheelchair mass?
- What is the effect of different caster wheels (size, material) or 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.

-Richter et al. (2011) :
Biofeedback => improved specific aspects of wheelchair propulsion.

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

Discussion

- What brings WHEEL-i?
  - To educate patients about the importance of a proper wheelchair set-up and propulsion technique.
  - To educate therapists.
  - Starting the dialogue between therapists and researchers regarding wheelchair propulsion.
  - The collected data can be used for reference values and research projects.

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!