From Rehabilitation to Paralympics: technological innovations to improve clinical outcome and sports performance

Prof.dr. Thomas W.J. Janssen

Amsterdam Institute of Sport Science
Center for Adapted Sports Amsterdam | Reade
Vrije Universiteit Amsterdam, Human Movement Sciences
From Rehabilitation to Paralympics

• Exercise and sport important, from rehab to Paralympics
Research

• Several exercise forms and sports available for people with disabilities
• Research in The Netherlands into several forms
• Prominent place in Dutch Research Agenda Sport
• Selection based on history and strength: focus on wheelchair propulsion and sports
Wheelchair, Individual and Interface determine Performance (Sport and ADL)

Wheelchair/Handbike
- Material
- Resistance
- Toe-in/toe-out
- Maintenance

Interface
- Sitting position
- Propulsion mechanism
- Gearing (rims)

Individual
- Physical/mental,
- Training,
- Technique/Tactics

Figure Riemer Vegter
From Rehabilitation to Paralympics
• Netherlands has contributed significantly
Approach in Netherlands

• Multidisciplinary
  – Biomechanics, exercise physiology, motor control, perception-action, sport psychology
  – Technology, modelling

• Multicenter
  – Amsterdam, Groningen, Delft, The Hague, and others
Evaluate and Improve Performance

Part of Dutch Research Agenda Sports
POWER BALANCE:

\[ P_0 = (F_{\text{roll}} + F_{\text{int}} + F_{\text{air}} + F_{\text{incl}} + ma) \cdot V \]

\[ = F_{\text{drag}} \cdot V \]

\[ = A \cdot f \]

\[ = 2f \cdot \Sigma M \Delta Q \]

Gross ME = \( \frac{P_0}{E_n} \)
Biomechanics & Physiology & Motor Control

\[ \text{PO} = M \cdot V_w \cdot r_w^{-1} (W) \]

\[ F_{\text{tot}} = \sqrt{(F_x)^2 + (F_y)^2 + (F_z)^2} \text{(N)} \]

\[ F_m = M \cdot r^{-1} \text{(N)} \]

\[ \text{FEF} = (F_m \cdot F_{\text{tot}}^{-1}) \cdot 100(\%) \]

\[ \text{ME} = (\text{PO} \cdot \text{En}^{-1}) \cdot 100(\%) \]
Data analysis
Propulsion technique out of torque and velocity signals

Push frequency
Push time
Power loss before push
Power loss after push
POpeak during push
POmean during push
Overall mean speed

Vegter et al., 2013
Model applications in wheelchair propulsion

- Delft Shoulder Model (Delft, Amsterdam)
- Estimation of overload risk
- Optimization of wheelchair geometry

Veeger, Van der Helm
Improving WC Performance for rehabilitation, ADL & Sports
Ex1. Biomechanics & Physiology

Effect of seat position

- Rehab, ADL, and sports
- More parameters studied: rim diameter, for-aft position, etc.

Van der Woude et al. 80-90ies
Wheelchair tennis vs. other wheelchair sports:
-> different propulsion

Optimize propulsion in wheelchair tennis ->
important to study the effect of holding a racket on propulsion technique
### Propulsion technique vs. Racket side vs. non-racket side

<table>
<thead>
<tr>
<th>Propulsion technique</th>
<th>Racket side vs. non-racket side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push frequency</td>
<td>=</td>
</tr>
<tr>
<td>Push time</td>
<td>↓</td>
</tr>
<tr>
<td>Power loss before push</td>
<td>↑</td>
</tr>
<tr>
<td>Power loss after push</td>
<td>↑</td>
</tr>
<tr>
<td>POpeak during push</td>
<td>↑</td>
</tr>
<tr>
<td>POmean during push</td>
<td>↑</td>
</tr>
<tr>
<td>Overall mean speed</td>
<td>↓</td>
</tr>
</tbody>
</table>

#### Questions to be solved
- How to avoid high power loss when coupling the hand/racket to the rim?
- To what extent increases high peak power shoulder load? (modelling)
- Injury prevention?
Ex3. Biomech.-Physiol

Kneesit vs. Recumbent handbike

- Recumbent is 20-30% more efficient
- Knee-sit
  - 17% more power; 46% higher VO2peak
- Which one is better?

![Graph showing efficiency by angle change](image1)

![Graph showing maximal power output](image2)
Ex4. Motor control and Learning

Learning wheelchair propulsion

- Feedback on the right side only.
- Feedback group did not know what the bar represented.
- Also feedback of the velocity (for all groups).

De Groot et al. 2001
Fraction Effective Force

- **Control**
- **Feedback**
- **No Feedback**

*De Groot et al. 2001*
Authors’ conclusions:

- Feedback program of a biomechanical variable is successful
- Increasing FEF does not necessarily improve performance;
- Efficiency can improve without a change in FEF
Ex5. Perception-Action

Training Visual Attention

- Previous research basketball shooting
- Looking late necessary and sufficient
- Looking late leads to successful shooting
- Experts pick up relevant info as late as possible

Training Visual Attention

- junior players national level
- two months shooting drill screen (2xpw)

<table>
<thead>
<tr>
<th>period</th>
<th>before</th>
<th>during</th>
<th>after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>46.1</td>
<td>54.2</td>
<td>60.6</td>
</tr>
<tr>
<td>3p%</td>
<td>35.2</td>
<td>46.5</td>
<td>53.9</td>
</tr>
</tbody>
</table>

Oudejans et al. (2005)
Same Results in WC Basketball?

- Nat. WC basketball team
- Regular training facilities
- 2 pushes, pass screen, shoot ASAP 25 shots
- Control: same, but no screen
- Shot percentage calculated
And? Did it work?

- Conclusion: it works!
- These methodes could be used in many more sports

Oudejans et al. (2012)
Ex.6 Technology

Recording wheelchair – user interaction during matches

Raak Project “The Perfect Wheelchair”

Slide: Berger & Vd Slikke
Aimed outcome

• Optimal tuning wheelchair - user
  – Competition level
  – Classification
  – Field position

• Optimisation of team composition
  – Field positions
  – Opponent strategy
Match results

- Differences by classification
  - Competition level (National Male NM; International Male IM; International Female IF)
  - Classification (< 3 vs. 3+)

- Forward speed (m/s) & acceleration (m/s²)

- Rotational speed (°/s)

- Rot. acc. (°/s²)

- Avg. speed
- Best speed
- Avg. Acceleration

- Rot. speed turn
- Rot. sp. curve
- Best rot. speed

- Avg. rot. acc.
Promoting Active Lifestyle
*From Rehabilitation to End of Life*

- Important research line in the Netherlands
  - Dutch Research Agenda Sport
- Activate inactive individuals with a disability
- Activate inactive muscles (non-paralyzed and paralyzed muscles): exercise and sports
Ex1. Handbike Battle: more than a race
Outcomes

- Improved fitness
- Improved health
- Improved psychosocial functioning
- Improved QoL
- More than a Race!

*Slide info: Sonja de Groot*
Ex.2 FES-exercise after spinal cord injury

- Arm exercise: small muscle mass, no training of legs
- Electrical stimulation-induced exercise (strength training, cycling) of paralyzed muscles is beneficial (muscle, circulation, body comp., etc)
Hybrid cycling (BerkelBike)

- Cycling using electrical stimulation combined with voluntary handcycling
Upper-body vs Total-body Exercise

- Allrisc study (national study): 16-wk training on Handbike (HB) or Berkelbike (BB)
- Inactive people with long-standing SCI
- Parameters: a.o. body comp; bone density, muscle and fat mass, immune system, CVD risk factors
Effect on CVD Risk Factors

- WC post vs. WC pre
- HOMA-IR post vs. CRP pre
- CRP post vs. CRP pre
- IL-6 post vs. IL-6 pre
- IL-6/IL-10 ratio post vs. IL-6/IL-10 ratio pre
Keep Exercising

• Start early, asap after injury during rehab
• Keep doing this after rehab; rest of life!
• Research: effects, cost-effectiveness, improved outcome
Collaboration

- Several possibilities for research on adapted sports, active and healthy living, and Paralympic sports
- Proposed project:
  - e-Health for healthy lifestyle in wheelchair users with spinal cord injury or amputation
  - Develop exercise and dietary advise
  - Platform with apps; adapt for WC users; online lifestyle intervention
  - Monitoring lifestyle changes; data science
Virtuagym Fitness - Home & Gym

Biedt in-app-aankopen

Deze app is compatibel met een aantal van je apparaten.
DIGIFiT Cardio GPS

Virtuagym  Gezondheid en fitness

Niet geclassificeerd

Deze app is compatibel met al je apparaten.
Visão geral da dieta

Plano de nutrição "Duradouro"
Esta dieta ajuda a perder peso com resultados duradouros, permitindo emagrecer gradualmente enquanto obtém todos os nutrientes necessários. Esta dieta baseia-se em alimentos equilibrados e saudáveis combinados com um baixo consumo de energia e gorduras.

Meta: 76 kg (-4 kg)
Data da meta: 26 April 2016

Seu IMC (taxa de queima em repouso): 1806 Kcal
Mínimo de calorias de que precisa: 2541 Kcal
Diferença de calorias por dia: -500 Kcal

Conselho energético diário: 2041 Kcal

Novo plano de nutrição
Monitorar sua alimentação
Pesquisar produtos

Toddy
400 calorias, 95 g. hidratos de carbono, 0 g. gorduras em 0 g. proteínas.
Não validado

Sorvete de Flocos
200 calorias, 26 g. hidratos de carbono, 9 g. gorduras em 2 g. proteínas.
Não validado

Sonho de Valsa
738 calorias, 85 g. hidratos de carbono, 20 g. gorduras em 100 g. proteínas.
Não validado
• T.janssen@reade.nl
• @Janssen_Thomas1