Part 1:
Exercise physiology and exercise tests in children and adolescents with cerebral palsy

Program
- What happens during exercise?
- Exercise physiology and development
  - Aerobic capacity
  - Anaerobic capacity
  - Muscle strength
- Training
  - Training principles
  - Training in children
- Testing and training in children with CP
  - Practical considerations

What happens during exercise?????

Changes during exercise
- RESPIRATION
  Ventilation ↑ (volume and frequency)
- CENTRAL CIRCULATION
  Heart minute volume ↑
  Arterial blood pressure ↑
- PERIPHERAL CIRCULATION
  Blood flow to not active regions ↓
- BODY TEMPERATURE
  ↑
- Aerobic capacity
- Muscle strength
  Part 2
- Anaerobic capacity

God morgen
**Aerobic Capacity**

**VO2MAX**

**VO2max and age**

Robinson (1938) Experimental studies of physical fitness in relation to age. Arbeitsphysiologie 10, 237-239

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**Development and VO2max**


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**STATEMENT**

- Maximum Heart Rate in children can be calculated using the Formula 220-age.
  - TRUE
  - FALSE

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**Maximal Heart Rate in typically developing children**

*Cycle-ergometry*

Mean HRmax 193

Van Leeuwen et al 2004 Geneeskunde & Sport
**220-age Formula**

![Image of 220-age Formula graph]

220-age = FALSE

Robergs R.A. & Landwehr R. Journal of Exercise Physiology, 2002

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**Anaerobic Capacity**

![Image of Anaerobic Capacity]

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**Muscle biopsy**

![Image of Muscle biopsy]

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**ATP, CP and Glycogen concentrations in the muscle**

Eriksson & Saltin Acta Paed Belgica 1972

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**Anaerobic Capacity and Development**

![Image of Anaerobic Capacity and Development]

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**Recovery in HR after repeated anaerobic exercise**

![Image of Recovery in HR after repeated anaerobic exercise]
Conclusion Aerobic and Anaerobic Capacity

- Big increase in anaerobic capacity in children (> aerobic capacity)
- Children recover faster after (repeated) exercise

Training in children

Training

- **Physical training:**
  The process whereby repeated “systematic” exercise leads to functional and morphological adaptations in the body.

“Training principles”

- The PRINCIPLES of TRAINING are the rules to follow when using physical activity programs:
  - Specificity
  - Reversibility
  - Adaptation/Supercompensation

Specificity

- In order for a training program to be beneficial, it must improve the specific physiological capabilities required to perform a given sport or activity.

- Example, a goalkeeper needs to focus on reaction work in their training, in comparison to a midfielder who should focus on agility, stamina, speed etc.

- A runner who wants to improve his leg strength, should train differently to a cyclist. Both would need muscular endurance but the training method should be different !!
Reversibility

• “Use it or lose it.”
• When you stop training, the training effects can be reversed – so don’t quit!
• The training history will be an important factor. The longer you have trained the longer the effects will be present.

Adaptation/Supercompensation

• In order to improve through training we need to apply greater demands on our body. This is the principle of OVERLOAD.
• The body will adapt to the new norm.

Conclusion

• Children are not just “small” adults!!
• Children develop in VO$_{2\text{max}}$, anaerobic power and muscle strength

Is it possible to train children?

![Graph showing improvement after training in typically developing children compared to adults]


Training in typically developing children

• Little progression after training compared to adults (5-8% vs. 10-15%)
• Program: “carefully adapted to each individual’s potential”

The three most important aspects of training

1. FUN
2. FUN
3. FUN

Fitnesstests in children with Cerebral Palsy

Evaluation

Fieldtests in children who are able to WALK

- Nonthreatening, inexpensive, easy to administer in a nonresearch setting.
- Reliable and valid
- To evaluate a training(period)
- Specific (= functional !!)
  Every test result is specific for the movement pattern that was used.
  Child able to walk → test must be related to walking

Research Question

- What measures are reliable and valid for children with CP?

STATEMENT

- The 6 minute walk test is suitable to measure Aerobic Capacity in children with CP.
  - TRUE
  - FALSE
Research group

- 26 children diagnosed with CP
- GMFCS I or II
- Age: 7-18 years
- 8 Pediatric Physical Therapists
- 2 Exercise Physiologists

Often used aerobic tests

skill: Walking

- 20-meter shuttle run test (beep test)
  - Problematic due to the high starting speed and increasing speed.

- Treadmill (1/2) Bruce and Balke protocol
  - Many protocols are not suitable due to the high starting speed, inclining floor and/or increasing speed.

New CP-Treadmill test

Demand: To exhaustion (and HR>180) between 6 and 18 minutes

- GMFCS level 1
  - Slope 2%
  - Starting speed 5 km/hr
  - per minute +0.25 km/hr

- GMFCS level 2
  - Slope 2%
  - Starting speed 2 km/hr
  - per minute +0.25 km/hr

10-meter Shuttle Run Test

- Beep test. Sound (beeps) on CD
- 10 meter (Gym)
- Increasing speed
- VO2-max related to achieved level

10-m Shuttle Run Test

GMFCS 1

- start: 5 km/hr
- each minute +0.25 km/hr

GMFCS 2

- start: 2 km/hr
- each minute +0.25 km/hr
Research

- **Treadmill**
  - 1x VO$_{2\text{peak}}$ and HR$_{\text{max}}$ measurement

- **10-m Shuttle Run Test**
  - 1x VO$_{2\text{peak}}$ and HR$_{\text{max}}$ measurement
  - 1x HR$_{\text{max}}$ measurement

Video example

**10 meter Shuttle Run Test**

- M. (boy)
- 15 years of age
- GMFCS level II

STATEMENT

- The HR$_{\text{max}}$ during the final level of the SRT-II test in this video is >180 beats/min.
  - TRUE
  - FALSE

Validity

- 10-m Shuttle Run Test vs Treadmill:
  - VO$_2$ (l/min)
  - R=0.96

Reliability

- Shuttle Run Test 1 vs Shuttle Run Test 2:
  - Achieved level (in minutes)
  - ICC=0.97
Reference values GMFCS level I

Reference values GMFCS level II

Conclusion

• Both 10-m shuttle run tests:
  – Are valid
  – Are reliable
  – Can be used for children with CP (classified at GMFCS level I or II) and have advantages over a treadmill.

STATEMENT

• The 10x5 meter sprint test is suitable to measure Anaerobic Capacity in children with CP.
  • TRUE
  • FALSE

Useful anaerobic tests

skill: walking

• 10x5 meter sprint test

• MPST (Muscle Power Sprint Test)

10x5 meter sprint test

• > 5 meter
• stopwatch
• Register time on a score form
Video example
10x5 meter sprint test

- M (girl)
- 14 years of age
- GMFCS level II

Reliability

ICC=1.00

Reliability

ICC=0.97

Reference values GMFCS level I

Reference values GMFCS level II
MPST
Muscle Power Sprint Test

• 6 15 meter sprints at a maximum pace
• 10-second rest between sprints

MPST
Muscle Power Sprint Test

• Power output can be calculated based on times, body mass and distance (15 meter):
  – Peak en mean power

Velocity (m/sec) = 15 meter/Time
Acceleration (m/sec²) = Velocity/Time
Force (kgm/sec²) = Body mass x Acceleration
Power (Watts) = Force x Velocity

Video example
Muscle Power Sprint Test

• T. (boy)
• 15 years of age
• GMFCS level I

Reliability

ICC=0.98

www.netchild.nl
**Muscle Power Sprint Test (Mean power)**

**Test-retest reliability**

$ICC = 0.99$

### Reference values GMFCS level I

### Reference values GMFCS level II

### Conclusion anaerobic tests

- Both sprint tests:
  - Are reliable
  - Measure different aspects of anaerobic capacity
  - Can be used for children with CP (classified at GMFCS level I or II)

### Conclusion anaerobic tests

- $10\times5$ meter sprint test
  - Measures the ability to change the direction of the body abruptly (agility)

- MPST (anaerobic sprint test)
  - Measures the ability to exert strength quickly = anaerobic capacity (power)
How to develop a fitness training?

Fitness levels in children with CP
- Muscle strength (HHD)
  - Low compared to typically developing peers
    - Damiano et al., 1998

Fitness levels in children with CP
- Aerobic capacity
  - Lundberg A, 1984

Muscle strength (HHD)

Fitness levels in children with CP
- Aerobic capacity
  - Verschuren et al., 2008 (submitted)
Fitness levels in children with CP

• Anaerobic capacity
  – Bar-Or et al 1996; Parker et al 1992

Fitness training guidelines

Frequency: 2 days per week
Intensity: 60 - 80% max. HR
Duration: 45 minutes
Activity: Rest: 1:1

Conclusion

Low fitness
Cerebral Palsy

High fitness

Part 2
Cerebral palsy
GMFCS level I and II
Schools for special education ≤ 20 years of age

Aerobic capacity
Muscle Strength

Training is effective

Aerobic capacity
Muscle Strength

Training is effective

Part 2

Conclusion

Low fitness
Cerebral Palsy

High fitness

Part 2

Aerobic capacity

Part 2

Aerobic capacity

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Part 2
**FITNESS TRAINING GUIDELINES**

- **Frequency:** 2 days per week
- **Intensity:** maximal
- **Duration:** 30 - 45 minutes
- **Activity:** Rest: 1:3 1:5

**STATEMENT**

- **True**
- **False**

**FUNCTIONAL FITNESS**

- **Aerobic Capacity**
- **Muscle Strength**
- **Anaerobic Capacity**

**RANDOMIZED CLINICAL TRIAL**

- **Goes**
- **Zwolle**
- **Breda**
- **Utrecht**

- **N = 86**

- **Experimental Group:**
  - **N = 32**

- **Control Group:**
  - **N = 33**

**Fitness Program**

- **8 months**
- **2 times a week for 45 minutes**
- **2 physical therapists**
- **2 groups**
  1. 7 - 12 year
  2. 13 - 20 year
Trainingsscheme

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Months 1</th>
<th>Months 2</th>
<th>Months 3</th>
<th>Months 4</th>
<th>Months 5</th>
<th>Months 6</th>
<th>Months 7</th>
<th>Months 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
</tr>
<tr>
<td>Anaerobic</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
<td>80-90%</td>
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<td>80-90%</td>
</tr>
</tbody>
</table>

- **Training intensity is programmed following this scheme.**

### Ingredients for training

- In the training we used 8 standardized TASK-SPECIFIC aerobic and anaerobic exercises, which were based on walking activities, such as:
  - Running / Walking fast
  - Step up and down
  - Stepping over
  - Bending
  - Turning
  - Getting up from the floor

### The exercises

#### Aerobic exercises
- 8 standardized exercises

#### Anaerobic exercises
- 8 standardized exercises

### Training

1. **Introduction**
   - Explain purpose of training and give children heart rate monitor

2. **Warming-up**

3. **Training focus**
   - In circuit format (with 2 children in each group) for aerobic part (month 1-3)
   - In group format for anaerobic part (month 4-8)

4. **Closure of the training**
FUNCTIONAL FITNESS

Aerobic capacity
Muscle strength
Anaerobic capacity

Randomization

- Experimental group (n=32)
  - GMFCS I n=23
  - GMFCS II n=9
  - 11.6 (2.5) years
  - Boys/girls 18/14

- Control group (n=33)
  - GMFCS I n=22
  - GMFCS II n=11
  - 12.7 (2.7) years
  - Boys/girls 23/10

Objectives

- Primary objective: Study the effects on:
  - aerobic capacity (10-m Shuttle Run Test)
  - anaerobic capacity (Muscle Power Sprint Test)

- Secondary objective: Study the effects on:
  - Functional muscle strength
  - Agility
  - Participation
  - HRQoL

Baseline 8 months 4 months 8 months Follow-up:12 months

Results

For info 10-m SRT: Olaf Verschuren et al. Physical Therapy 2006;86(6): 1107-1117

P-values: group(2) x time(3) interaction of repeated-measures analysis of variance
Body Function and Structure

Functional muscle strength

Agility

P-values: group(2) x time(3) interaction of repeated-measures analysis of variance

Participation

Children’s Assessment of Participation and Enjoyment (CAPE)

Intensity

Participation (intensity)

- Children’s Assessment of Participation and Enjoyment (CAPE).

<table>
<thead>
<tr>
<th>Significant (p&lt;0.05)</th>
<th>Not significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill-based activities (+20%)</td>
<td>Recreational activities (+10%)</td>
</tr>
<tr>
<td>Physical activities (+24%)</td>
<td>Social activities (+0%)</td>
</tr>
<tr>
<td>Overall activities (+27%)</td>
<td>Self-improvement activities (+6%)</td>
</tr>
</tbody>
</table>

P-values: group(2) x time(3) interaction of repeated-measures analysis of variance

Health-related Quality of Life

- TACQOL-PF

<table>
<thead>
<tr>
<th>Significant (p&lt;0.05)</th>
<th>Not significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic motor functioning (+19%)</td>
<td>Pain and symptoms (+4%)</td>
</tr>
<tr>
<td>Autonomy (+4%)</td>
<td>Social functioning (+2%)</td>
</tr>
<tr>
<td>Cognitive functioning (+4%)</td>
<td>Global positive emotions (+2%)</td>
</tr>
<tr>
<td>Global positive emotions (+2%)</td>
<td>Global negative emotions (+2%)</td>
</tr>
</tbody>
</table>

P-values: group(2) x time(3) interaction of repeated-measures analysis of variance

Conclusion

Aerobic and anaerobic capacity

Follow-up
Follow-up
Muscle strength and agility

Follow-up
Participation

• “Use it or lose it.”

Take home assignment
• Keep children with CP and their parents involved in physical activity?