Role of the physiotherapist in McArdle disease and related disorders

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Overview

- Aims of physiotherapy
- Outcome measures
- Aerobic exercise
- Strength training
- Management strategies
Energy systems

![Graph showing energy systems](image)

- **Phosphagen**
- **Glycolytic**
- **Oxidative**

Percent of total energy vs. Time (seconds)
Aims of physiotherapy

- Assessment and outcome measures
- Aerobic conditioning
- Strengthening exercise programme
- Prevention of secondary musculoskeletal problems (e.g., back pain)
- Patient education
- Liaison with other healthcare professionals
  - Occupational Therapists for adaptive equipment and assessment of ADLs
  - Orthotics service for provision of orthoses as indicated
Physical Assessments

- Strength
- Range of movement
- Functional ability
  - Will determine how they can exercise
- Fatigue
- Pain
- Cardiovascular fitness
Outcome Measures

- Balance
- 10m Timed walk
  - self selected speed and fast
- 6 minute walk test / 12 minute walk test
  - Can help identify subtle gait changes (eg mild foot drop)
- TUG
- Borg (rates of perceived exertion / pain)
  - For self-monitoring exercise intensity / pain
- Walk 12 – qualitative
  - Validated for neuropathy; good for muscle patients
- Physical activity questionnaires (eg: IPAQ)
- Manual muscle testing, Hand held dynamometry
12 Minute Walk Test (12MWT)

- Routinely used in the McArdle Clinic at NHNN to identify the second wind phenomenon and measure physical function in this patient group (Buckley et al, 2014).
  - The furthest distance covered in 12 minutes
  - Treadmill or gym floor
  - Heart rate monitor
  - Pain scale

- Used as an outcome measure in other health conditions, for example stroke (Eng et al, 2002) and respiratory disease (Butland et al, 1982).

- Shown to correlate to the 6 minute walk test in these patient groups
<table>
<thead>
<tr>
<th>Borg’s RPE Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No exertion at all</td>
</tr>
<tr>
<td>7</td>
<td>Extremely light</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>9</td>
<td>Light</td>
</tr>
<tr>
<td>10</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>11</td>
<td>Hard (Heavy)</td>
</tr>
<tr>
<td>12</td>
<td>Very hard</td>
</tr>
<tr>
<td>13</td>
<td>Extremely hard</td>
</tr>
<tr>
<td>14</td>
<td>Maximal exertion</td>
</tr>
</tbody>
</table>

0  Nothing at all          "No P"
0.3 Extremely weak         Just noticeable
0.5 Very weak              Light
1  Moderate                 Heavy
1.5 Weak                    Light
2  Strong                   Heavy
2.5 Very strong
3
4
5
6
7
8
9
10 Extremely strong "Max P"
11 Absolute maximum
11

Borg CR10 scale

University College London Hospitals
Second wind

- During the ~10 minutes before second wind, need to pace activity to ensure the muscles do not run out of energy (ATP)

- Less intense effort = slower depletion, allowing for ATP to be ‘topped up’

- Around 7-10 minutes 2\textsuperscript{nd} pathway is activated – fatty acid oxidation

- Muscles start to burn free fatty acids

- Continue aerobic exercise without pain
### 12MWT and second wind

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Walking speed (kph)</th>
<th>Distance (m)</th>
<th>RPP</th>
<th>Heart Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.2</td>
<td>70</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td>2</td>
<td>4.2</td>
<td>140</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>4.2</td>
<td>210</td>
<td>3</td>
<td>111</td>
</tr>
<tr>
<td>4</td>
<td>3.6</td>
<td>270</td>
<td>2</td>
<td>117</td>
</tr>
<tr>
<td>5</td>
<td>3.9</td>
<td>330</td>
<td>2</td>
<td>120</td>
</tr>
<tr>
<td>6</td>
<td>4.2</td>
<td>400</td>
<td>2</td>
<td>123</td>
</tr>
<tr>
<td>7</td>
<td>4.2</td>
<td>470</td>
<td>1.5</td>
<td>120</td>
</tr>
<tr>
<td>8</td>
<td>4.2</td>
<td>540</td>
<td>0</td>
<td>121</td>
</tr>
<tr>
<td>9</td>
<td>4.8</td>
<td>620</td>
<td>0</td>
<td>115</td>
</tr>
<tr>
<td>10</td>
<td>4.8</td>
<td>700</td>
<td>0</td>
<td>107</td>
</tr>
<tr>
<td>11</td>
<td>4.8</td>
<td>780</td>
<td>0</td>
<td>108</td>
</tr>
<tr>
<td>12</td>
<td>4.8</td>
<td>860</td>
<td>0</td>
<td>107</td>
</tr>
</tbody>
</table>
Treadmill vs Over-ground

Treadmill

- Provides feedback as encouragement to increase walking distance
- Constant walking speed
- Pace not necessarily controlled by patient
- Opportunity to hold on for balance as needed

Overground

- All abilities are able to use this
- Mimics more “real life” activity
- Pace is controlled by the patient
12MWT trial

Chatfield et al, unpublished
12MWT predictors in McArdle disease

- Retrospective study to identify the predictors of walking distance on the 12MWT for a large sample of patients with McArdle disease (Pattni et al, in press)

- 146 patients with McArdle disease completed the 12MWT on each clinic visit (2011-2017).

- Data collected included age, gender, height, body mass, overall distance covered, and heart rate and rating of perceived pain.
Maximal exercise testing - $\text{VO}_2\text{max}$

- $\text{VO}_2\text{max}$ is also known as maximal oxygen uptake
  - Time limited
  - $\text{VO}_2\text{peak}$ is used in McArdle disease (longer test duration to accommodate second wind)

- Indirect measure of
  - Aerobic power
  - General endurance
  - Functional capacity
Cycle test protocol – McArdle disease

- Use of a cycle ergometer and cardiopulmonary exercise test system

- Protocol
  - Cycle at a constant workload (60-70% of VO2 max or predicted maximal heart rate) for 15 minutes in order for 2\textsuperscript{nd} wind to be achieved
  - Workload increased by 5W every minute after the 15\textsuperscript{th} minute until exhaustion
  - Every minute Borg RPE and heart rate are measured

Vissing & Haller 2003
Maximal exercise testing

- Fifteen minutes of cycling at a constant workload of approximately 40 watts consistently resulted in a marked second wind in all 24 McArdle’s disease patients, with a decrease in heart rate of 35bpm (Vissing & Haller, 2003).

- $\text{VO}_{2\text{max}}$ and $\text{VCO}_{2\text{max}}$ were significantly lower in patients ($p<0.05$) compared to controls (Ricci et al, 2015).

- RER value was constant and $< 1$ in patients, while increased progressively to 1 in controls. This indicates the inability to use glycogen by muscle during sustained exercise in McArdle disease (Ricci et al, 2015).
\( \text{VO}_{2\text{max}} \) cycle test

Heart rate monitoring during cycle ergometer exercise test

- Patients 1-4 (curve a)
- Controls (curve b)
- Patient 5 (curve c)

Costant load

Incremental load

Second wind

Ricci et al, 2015
**VO_{2}\text{max}** Tests

Able to measure oxygen uptake during exercise.

Able to accurately quantify the amount of exercise the person is doing.

Equipment is expensive.

Time consuming.

May result in premature leg muscle fatigue if cycling is an unfamiliar form of exercise.
Sub-maximal exercise testing

- Record heart rate and perceived exertion during a sustained activity (e.g., walking test; cycle test).
- Test should be terminated when patient reaches 70% heart rate reserve (85% of age-predicted HRmax), or unable to keep up with test protocol.

- Astrand-Ryhming cycle ergometer test
  - Single stage test lasting 6 mins.
  - This will need to be adjusted to accommodate second wind in McArdle disease.
Physical Activity Questionnaires (self-reported)

- Cost effectiveness
- Ease of use
- Discrete categories (low, moderate, high)
- Provides information about physical activity

- Relies on patient’s ability to recall
- Physical activity is often overestimated
- Interpretation of vigorous vs moderate vs walking exercise
International Physical Activity Questionnaire (IPAQ)

- The IPAQ is a self-reported questionnaire designed to obtain internationally comparable data on health-related physical activity.
- It has 4 domains:
  - Job-related physical activity
  - Transportation physical activity
  - Housework, house maintenance and caring for family
  - Recreation, sport and leisure-time physical activity
### IPAQ and 12MWT

<table>
<thead>
<tr>
<th>IPAQ Category</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>9</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Expected 12MWT distance</td>
<td>More than 800m</td>
<td>500m – 800m</td>
<td>Less than 500m</td>
</tr>
<tr>
<td>Actual 12MWT distance (range)</td>
<td>680m – 1280m</td>
<td>670m – 1050m</td>
<td>760m – 910m</td>
</tr>
</tbody>
</table>
Exercise Prescription

I need some exercise!
# Aims of exercise in Glycogen Storage Disorders

## Specific Impairment

<table>
<thead>
<tr>
<th>Specific Impairment</th>
<th>General Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>To prevent disuse atrophy &amp; secondary muscle weakness</td>
<td>To improve or maintain function; reduce effort &amp; improve performance of ADLs</td>
</tr>
<tr>
<td>To keep unaffected muscles strong &amp; maintain endurance</td>
<td>To reduce disease risk &amp; promote healthy lifestyle</td>
</tr>
<tr>
<td>Optimise cardiorespiratory fitness; prevent or reverse physical de-conditioning</td>
<td>Reduce fatigue</td>
</tr>
<tr>
<td>Reduce pain</td>
<td>Improve bone density</td>
</tr>
<tr>
<td>Maintain/improve ROM</td>
<td>To assist in weight management</td>
</tr>
<tr>
<td>Improve balance &amp; co-ordination</td>
<td>Improve mental health wellbeing</td>
</tr>
<tr>
<td>Improve efficiency of getting into second wind (McArdle disease)</td>
<td></td>
</tr>
</tbody>
</table>
Pain after exercise that everyone experiences

- In the first 24-72 hours after new / unaccustomed exercise
  - Stiffness and mild pain (feels like bruising) known as DOMS (delayed onset muscle soreness).

- DOMS occurs because all exercise causes microscopic damage to muscle.

- DOMS is the result of accumulation of enough of these to cause a mild inflammatory response.
## Preliminary data: McArdle vs DOMS pain

<table>
<thead>
<tr>
<th>McArdle Pain Description</th>
<th>Number of participants</th>
<th>DOMS Description</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ache</td>
<td>5</td>
<td>Ache</td>
<td>7</td>
</tr>
<tr>
<td>Muscle tightness, stiffness</td>
<td>5</td>
<td>Muscle stiffness</td>
<td>4</td>
</tr>
<tr>
<td>Intensity (sharp, severe, acidic)</td>
<td>7</td>
<td>Intensity (sharp, burning)</td>
<td>2</td>
</tr>
<tr>
<td>Duration (quick onset, constant)</td>
<td>4</td>
<td>Duration (arrives later, lasts a couple of days)</td>
<td>2</td>
</tr>
<tr>
<td>Fatigue, exhaustion, heaviness</td>
<td>9</td>
<td>Fatigue, tiredness</td>
<td>1</td>
</tr>
<tr>
<td>Numbness</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flu symptoms / nausea</td>
<td>2</td>
<td>No answer / not experienced DOMS</td>
<td>9</td>
</tr>
<tr>
<td>Cramping / spasm</td>
<td>3</td>
<td>Cramping</td>
<td>3</td>
</tr>
</tbody>
</table>
General considerations for exercise prescription

- Cardiorespiratory (aerobic) fitness
- Muscular strength and endurance
- Flexibility

- Reduction in time spent in sedentary activities in addition to regular exercise is important for health
General considerations for exercise prescription

- **Frequency**
  - Number of days per week
- **Intensity**
  - How hard to exercise
  - Use of HR, perceived exertion, rating of perceived pain
- **Time**
  - Duration
- **Type**
  - Mode of exercise (aerobic, strengthening, stretches)
Aerobic exercise in McArdle disease

8 people with McArdle disease cycled for 30-40 minutes, 4 days per week for 14 weeks at 60-70% of maximal heart rate.

Results:
- Improved work capacity (36%), oxygen uptake (14%) and cardiac output (15%) without causing pain or cramping.
Aerobic exercise in McArdle disease

Favorable Responses to Acute and Chronic Exercise in McArdle Patients

José L. Maté-Muñoz, MSc,* María Moran, PhD,† Margarita Pérez, MD, PhD,* Carolina Chamorro-Viña, MSc,* Félix Gómez-Gallego, PhD,* Catalina Santiago, PhD,* Luis Chicharro, BSc,* Carl Foster, PhD,‡ Gisela Nogales-Gadea, MSc,§ Juan C. Rubio, MSc,†|| Antoni L. Andreu, MD, PhD,§ Miguel A. Martín, PhD,†|| Joaquín Arenas, PhD,†|| and Alejandro Lucia, MD, PhD*

- 9 people with McArdle disease cycled or walked 5 times per week for no longer than 60 minutes for 8 months at 60% of peak heart rate
- Results:
  - 44 % increase in VO$_{2peak}$ (peak oxygen uptake)
  - Increase in peak power output by 25%
Recommendations: Aerobic exercise

- All adults should participate in moderate intensity aerobic exercise for 150 minutes each week, in bursts of at least 10 minutes (Department of Health, 2011; American College of Sports Medicine, 2013).

- McArdle disease: aim for bouts of at least 20 – 30 minutes to accommodate second wind.

- Aiming for a heart rate between 60 – 70% of predicted maximum heart rate (220 – age) during exercise once in second wind.
## Guidelines – NMDs (MDUK, 2015)

<table>
<thead>
<tr>
<th>Type of exercise</th>
<th>Frequency</th>
<th>Intensity</th>
<th>Duration</th>
<th>Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aerobic exercise</strong> E.g. walking to work, wheeling your wheelchair, activities of daily living, cycling, swimming or static bike</td>
<td>Try and make being active part of your daily routine or try to be active in these ways at least five times a week</td>
<td>Comfortably out of breath but still able to talk; Borg scale 3 to 5</td>
<td>30 minutes / intermittent bouts aiming for at least 10 minutes</td>
<td>Do not exercise to exhaustion</td>
</tr>
</tbody>
</table>
22.6% reported low back pain

3/10 – 10/10 on VAS (mean 6.9)

Mean BMI of 32.1 (range: 22.6-43.6)

Mean age: 52.2 years (34-68 years)

Mean distance walked on 12MWT: 602m
Back pain and McArdle disease

Sales

- No regular exercise (58.3%)
- Light to moderate exercise (walking) on at least 3 days per week (33.3%)
- Moderate activity (badminton and cricket coaching) (8.3%)
Strength training

- Benefits of strength training include:
  - Increase in bone density
  - Improvement of cardiac function
  - Increased motor unit recruitment, firing rate and synchronization resulting in muscle strength improvement
  - Increased muscle cross sectional area (hypertrophy)
  - Increased upregulation in muscle growth hormone
  - Increased number of capillaries and mitochondria which improve oxygenation and blood flow to working skeletal muscles
  - Improved muscle strength has a carry over to everyday life activities making them easier to perform.

Wagner, 2014
Strength training in McArdle disease

- In addition to glycogen, a second short burst of energy for high intensity exercise can be obtained via the phosphagen pathway (ATP-phosphocreatine system).

- This allows anaerobic activities lasting up to 10 seconds at maximal exercise.

- It takes at least 30 seconds to partly resynthesize this energy source and around 3 minutes to fully replenish, depending on the intensity of performed exercise.
Strength training in McArdle disease

- 7 people with McArdle disease followed a twice weekly supervised strength training programme for 4 months.
- Results: Significant increase in total body lean mass; bench press and half squat performance improved, improved muscle strength.
Strength training in McArdle disease

Case Report

Resistance Exercise Training in McArdle Disease: Myth or Reality?

Aleksandra Pietrusz, Renata S. Scalco, and Ros Quinlivan

- Case reports of 2 people with McArdle disease who performed weight training at local gyms.
- A single set of repetitions lasted for maximum 10 seconds with minimum of 30 seconds rest in between sets of exercises.
- Benefits of this type of training included improvement in quality of life and reduction of McArdle disease symptoms.
Muscle weakness

- 15 of the cohort of 80 patients in France were found to have fixed muscle weakness (Nadaj-Pakleza et al 2009)
  - Mean age of onset was 46 years
  - Weakness was predominantly proximal
  - Trunk muscles were severely affected in most of the cases

- This has also been observed in the UK McArdle population.

- Manual muscle testing can be carried out as indicated.
Strength training: General guidelines for McArdle disease

- Ensure all muscle to be trained are in second wind (upper and lower limbs)
- Low repetitions (3 – 5 repetitions)
- 2 – 3 minute rest between sets of exercises
- Stretches after exercising
- At least 24 – 48 rest between training sessions (not consecutive days)
# Guidelines – Neuromuscular disease (MDUK, 2015)

<table>
<thead>
<tr>
<th>Type of exercise</th>
<th>Frequency</th>
<th>Intensity</th>
<th>Duration</th>
<th>Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengthening exercises</strong> E.g. exercise bands, small weights or Pilates</td>
<td>2-3 times a week</td>
<td>Stop before fatigue</td>
<td>One set of 8-12 repetitions for each muscle group identified</td>
<td>Low / moderate weights; increase number of repetitions rather than weight</td>
</tr>
<tr>
<td>Individual programme: seek advice about which muscles to strengthen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Guidelines – Neuromuscular disease (MDUK, 2015)

<table>
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<th>Frequency</th>
<th>Intensity</th>
<th>Duration</th>
<th>Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flexibility</strong></td>
<td>E.g. stretches (seated or standing), yoga</td>
<td>Try to do this as part of your daily routine or at least two/three times a week</td>
<td>Stretching sensation but not pain</td>
<td>Two to four times</td>
</tr>
<tr>
<td>Static or passive stretch</td>
<td></td>
<td></td>
<td></td>
<td>Do not ‘bounce’</td>
</tr>
</tbody>
</table>
Specific management considerations for all Glycogen Storage Disorders

- Exercises should be paced
  - Consider energy requirements for function
  - Is the patient too weak or fatigued to add extra into their day?
  - Incorporate exercise into daily tasks

- Muscle imbalance / compensations

- Myoglobinuria / rhabdomyolysis
Barriers to exercise

- Most common barriers identified by people with NMDs:
  - Lack of energy
  - Lack of motivation
  - Feeling self-conscious
  - Boring
  - Cost

Phillips et al 2009
Management Strategies at NHNN

- Management Clinics
- Modified Pilates classes
- Liaising with physiotherapists locally
- Telephone reviews
- Individual physiotherapy sessions
- Aiming to use accelerometers for feedback
- NMD Bridges Project
- Yearly clinic reviews
NMD Bridges Project

Objectives:

- Co-design a unique self-management digital and paper based support package for people living with NMD and their families, using Bridges methodology.

- Pilot training for staff and implementation of Neuromuscular Bridges SM programme at the MRC Centre for Neuromuscular Diseases, London.
Community resources

- Activity Alliance (previously English Federation of Disability Sport)
  - [http://www.activityalliance.org.uk/](http://www.activityalliance.org.uk/)
  - Includes Inclusive Fitness Initiative (IFI) which are inclusive fitness gyms that have more accessible environments for disabled people

- Exercise prescription schemes
Acknowledgements

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  - Jatin Pattni
  - Richard Godfrey

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References

References