Nutrition & Supplements in Duchenne Muscular Dystrophy

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Today’s learning objectives

1) To understand why nutrition and nutritional status are important in individuals with DMD

2) To become familiarized with the clinical studies evaluating the effectiveness of specific supplements in individuals with DMD
DMD is caused by mutations in the dystrophin gene

- The dystrophin gene is the largest gene and is highly susceptible to mutations (over 3000 different mutations have been reported!)

- Genetic therapy will ultimately cure the disease….but we are not there yet – for now, we need to focus on keeping patients healthy and strong!

- By tracking nutrition and nutritional status healthcare givers and families can greatly help patients
Dystrophin is important for the function of skeletal, cardiac, and smooth muscles

Very limited research on the role of dystrophin in smooth muscle function!!

Adapted from: http://sniderphysed.blogspot.com/2015/11/smooth-cardiac-skeletal-muscle-image.html
Dystrophic muscles are characterized by many alterations:

- Lack of dystrophin
- Inflammation
- Oxidative stress
- Calcium dysregulation
- Increased fibrosis
- Limited muscle repair
- Membrane instability
- Mitochondrial dysfunction
- Endoplasmic reticulum stress
Why are nutrition and supplements important in DMD?

1) Digestion is likely to be compromised in DMD patients, thus impacting nutritional status even in the presence of a nutritious diet.

2) Glucocorticosteroids side effects include: excessive weight gain, cushingoid features, osteoporosis, impaired growth, glucose intolerance, cataracts, and behavioral changes.

3) Nutritional considerations for patients vary greatly throughout their lifespan.

4) Resting energy expenditure and energy requirement are decreased for patients with DMD.

5) Supplements are commonly used in individuals with DMD.

6) More research is needed!!! Little is known about the relationship between weight status and clinical outcomes.
Overnutrition vs. undernutrition in DMD

Table 1. Overnutrition in patients with neuromuscular diseases (NMDs).

<table>
<thead>
<tr>
<th>Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased caloric needs</td>
</tr>
<tr>
<td>Decreased resting energy expenditure</td>
</tr>
<tr>
<td>Decreased physical activity</td>
</tr>
<tr>
<td>Excessive caloric intake due to increased appetite because of medication</td>
</tr>
<tr>
<td>Lack of caloric restriction by parents</td>
</tr>
</tbody>
</table>

Table 2. Undernutrition in patients with neuromuscular diseases (NMDs).

<table>
<thead>
<tr>
<th>Main Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased muscle strength</td>
</tr>
<tr>
<td>Dysphagia</td>
</tr>
<tr>
<td>Gastrointestinal problems (i.e., constipation, delayed gastric emptying)</td>
</tr>
<tr>
<td>Prolonged mealtime</td>
</tr>
<tr>
<td>Dependent feeding</td>
</tr>
<tr>
<td>Increased energy requirements because of respiratory failure</td>
</tr>
<tr>
<td>Swallowing difficulties</td>
</tr>
</tbody>
</table>

The goal of weight management is to stabilize weight

- It’s better to prevent excessive weight gain than to severely restrict food intake in already obese patients

- Careful monitoring of weight loss is extremely encouraged

- Any recommendations should be done on an individual basis

- Measure height and weight every 6 months
Nutrition care is accomplished with team work!!

Optimal Nutritional Status in DMD

- Physician
- Registered Dietitian
- Individual with DMD
- Caregivers
### Timeframes and key items to be included on nutritional assessment

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Initial diagnosis</th>
<th>Commencing steroids</th>
<th>Yearly review or with weight changes</th>
</tr>
</thead>
</table>
| **Within 6 months of diagnosis** | **Client/family interview**  
- Dietary intake  
- Supplement intake  
- Gastrointestinal symptoms  
- Feeding issues (parent role, child’s responsibility)  
- Activity level  
- Food and nutrition knowledge/skills  
- Resources and support  
- Anthropometric (growth chart review)  
- Biochemical data and tests  
- Food-drug interaction review  
- Nutrition-focused physical findings | **Same as initial with focus on weight status and bone health**                      | **Yearly or when weight charts demonstrate a change in classification (underweight, overweight, obese)** |
| **At clinic visit when steroids begun** |                                                                                  | **Counseling/education of client/caregiver on effect of steroids on:**  
- Nutritional status and potential increase in appetite  
- Strategies for preventing weight gain through food intake and physical activity  
- Bone health  
- Consider calcium and Vitamin D supplementation |                                                                                     |
| **Yearly review or with weight changes** |                                                                                  | **Counseling/education of client/caregiver on effect of steroids on nutritional status:**  
- Strategies for preventing weight gain through food intake and physical activity  
- Bone health  
- Supplement use  
- Consider calcium and Vitamin D supplementation  
- Weight management strategies for over or under weight (including enteral feedings) |                                                                                     |

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Definition: “an alteration of kinetics or dynamics of a drug or a nutritional element, or a compromise in nutritional status as a result of the addition of a drug” (Boullata & Hudson 2012).
## Drug-Nutrient interaction

<table>
<thead>
<tr>
<th>Drug</th>
<th>Interaction with nutrients/foods?</th>
<th>Type of interaction</th>
<th>Suggested approach for interaction</th>
<th>Study evaluating interaction with nutrient in DMD?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucocorticoids</td>
<td>Yes</td>
<td>Decreases calcium absorption</td>
<td>Calcium (750 mg/day) and vitamin D (1000 IU/day) supplementation</td>
<td>None</td>
</tr>
<tr>
<td>Prednisone/</td>
<td>Yes</td>
<td>Decreases calcium absorption</td>
<td>Calcium (750 mg/day) and vitamin D (1000 IU/day) supplementation</td>
<td>None</td>
</tr>
<tr>
<td>Prednisolone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metformin</td>
<td>Yes</td>
<td>Decreases vitamin B12 absorption</td>
<td>Daily vitamin B12 and calcium supplementation</td>
<td>None</td>
</tr>
<tr>
<td>ACE inhibitors</td>
<td>Yes</td>
<td>(1) High-sodium intake might decrease losartan effects</td>
<td>Monitor potassium intake; avoid consumption of grapefruit juice</td>
<td>None</td>
</tr>
<tr>
<td>Losartan</td>
<td></td>
<td>(2) Low sodium intake might potentiate losartan effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captopril</td>
<td>Yes</td>
<td>Decreased absorption if ingested with meal</td>
<td>Should be ingested 1 h before meal</td>
<td>None</td>
</tr>
<tr>
<td>Enalapril</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>None</td>
</tr>
<tr>
<td>Lisinopril</td>
<td>No</td>
<td>NA</td>
<td>NA</td>
<td>None</td>
</tr>
<tr>
<td>Cilazapril</td>
<td>Yes</td>
<td>Small delay in action if ingested with food (degree and duration of ACE inhibition are not affected)</td>
<td>It can be ingested with or without food</td>
<td>None</td>
</tr>
<tr>
<td>Beta-blockers</td>
<td>Propranolol</td>
<td>Bioavailability is decreased if ingested with protein-rich meal; decreases activity of CoQ10-NADH-oxidase</td>
<td>Avoid consumption of protein-rich meal with propranolol; no existing recommendation for interaction with CoQ10-NADH-oxidase</td>
<td>None</td>
</tr>
<tr>
<td>Diazoxide</td>
<td>Yes</td>
<td>Decreases activity of CoQ10-succinoxidase</td>
<td>No existing recommendation for interaction with CoQ10-succinoxidase</td>
<td>None</td>
</tr>
<tr>
<td>Biophosphonates</td>
<td>Yes</td>
<td>Food/metal decreases bisphosphonate absorption; magnesium inhibits bisphosphonate absorption</td>
<td>Avoid ingestion of food/metal and magnesium with bisphosphonates</td>
<td>None</td>
</tr>
</tbody>
</table>

Additional information on nutrition & nutritional status

- Please refer to our book chapter:

Information on:
- Growth assessment, height, weight, and body mass index
- Pediatric nutrition and feeding considerations
- Considerations for weight management
- Energy intake and assessing nutrient intake
- Energy expenditure
- Nutritional implications of steroid therapy
- Etc....
Supplements & DMD

http://thebarbellbattalion.com/tips-safely-buying-supplements-online/

http://gnc.com/creatine
The goal of supplement use is to attenuate secondary alterations that happen due to the lack of dystrophin!
The goal of supplement use is to attenuate secondary alterations that happen due to the lack of dystrophin!
Complementary & alternative medicine are commonly used in the DMD population

- 20% (Canada) and 80% (USA) of DMD patients reported using complementary and alternative therapy in addition to conventional therapy

- Most parents and caregivers believe that complementary and alternative therapy (e.g., supplements) have improved quality of life and/or muscle function of patients…..but this is mostly based on anecdotal evidence

Woodman et al. (2016). "Nutraceuticals and Their Potential to Treat Duchenne Muscular Dystrophy: Separating the Credible from the Conjecture." Nutrients 8.11: 713.
Nabukera et al. (2012). "Use of complementary and alternative medicine by males with Duchenne or Becker muscular dystrophy." J Child Neurol 27.6: 734-740.
Supplement use is common in DMD, but not all supplements have been tested for effectiveness and safety!

- 11 year old boy with DMD
- Deflazacort: 0.9 mg/kg/day
- Supplements:
  - 1) Creatine: 5 g/day
  - 2) Vitamin D: 4000IU/day
  - 3) Multi-vitamin blend: may different components
  - 4) Calcium: 400 IU/day
  - 5) Beet concentrate: 5 g/day
  - 6) L-arginine: 4 capsules/day (not sure the dose)
  - 7) Cocoa powder: planning to start soon
<table>
<thead>
<tr>
<th>Supplement</th>
<th>Dose used in study</th>
<th>Participants</th>
<th>Steroids</th>
<th>Study Duration</th>
<th>Results</th>
<th>Well tolerated</th>
<th>Study</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic Review (Level 1 Evidence)</td>
<td>Characteristics of included studies listed below</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Key et al. (2013)</td>
<td>This study combined all outcomes from the individual trials listed below. Although the average increase is encouraging, there was some variation in the results which means individuals may experience very modest effects from creatine monohydrate.</td>
</tr>
<tr>
<td>Creatine monohydrate</td>
<td>5 g/day</td>
<td>8 boys Average 10 years</td>
<td>No</td>
<td>8 weeks</td>
<td>Modest but significant improvement in muscle strength and daily activities</td>
<td>Yes</td>
<td>Walter et al. (2000)</td>
<td>See above comments. The summary of these studies gives the best indication of evidence for creatine monohydrate.</td>
</tr>
<tr>
<td></td>
<td>0.1 g/kg/day</td>
<td>31 boys Average 10 years</td>
<td>50%</td>
<td>4 months</td>
<td>Decrease in bone breakdown, increased grip strength, and increased fat-free mass</td>
<td>Yes</td>
<td>Tarnopolsky et al. (2004)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 g/day</td>
<td>12 boys Average 11 years</td>
<td>No</td>
<td>3 months</td>
<td>Increase in muscle strength, resistance to fatigue, and bone mineral density</td>
<td>Yes</td>
<td>Louis et al. (2003)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 g/day</td>
<td>33 boys 3-12 years</td>
<td>No</td>
<td>8 weeks</td>
<td>Muscle strength was preserved in short term</td>
<td>Yes</td>
<td>Banerjee et al. (2020)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 g/day</td>
<td>50 boys 4-10 years</td>
<td>No</td>
<td>6 months</td>
<td>No change in muscle strength or function</td>
<td>Yes</td>
<td>Escobar et al. (2005)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.6 g/kg/day</td>
<td>50 boys 4-10 years</td>
<td>No</td>
<td>6 months</td>
<td>No change in muscle strength or function</td>
<td>Yes</td>
<td>Escobar et al. (2005)</td>
<td></td>
</tr>
<tr>
<td>L-Glutamine</td>
<td>0.5 g/kg/day</td>
<td>20 boys 2-10 years</td>
<td>15%</td>
<td>4 months</td>
<td>No differences in muscle mass and protein breakdown were observed; small improvements when used in conjunction with corticosteroids</td>
<td>Yes</td>
<td>Mok et al. (2005)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5 g/kg/day</td>
<td>26 boys 7-15 years</td>
<td>No</td>
<td>10 days</td>
<td>Decrease in whole-body protein degradation</td>
<td>Yes</td>
<td>Mok et al. (2006)</td>
<td></td>
</tr>
<tr>
<td>L-leucine</td>
<td>0.2 g/kg/day</td>
<td>56 boys Average 10 years</td>
<td>No</td>
<td>12 months</td>
<td>Small increase in muscle strength observed in the treatment group.</td>
<td>Yes</td>
<td>Mandell et al. (1984)</td>
<td>The researchers state that the difference may have been due to an unexpected decline in the control group.</td>
</tr>
<tr>
<td>L-Carnitine</td>
<td>0.05 g/kg/day twice a day</td>
<td>20 boys 4-9 years</td>
<td>No</td>
<td>12 months</td>
<td>No effect on muscle function</td>
<td>Yes</td>
<td>Esteban-Cadillo et al. (2013)</td>
<td>Whilst this study was conducted well, there were very few descriptive results presented in the study (e.g., mean function) so</td>
</tr>
</tbody>
</table>

PARENT PROJECT MUSCULAR DYSTROPHY | ENDDUCHENNE.ORG
Creatine Monohydrate

- It functions as an energy buffer in cells
- Individuals with DMD have lower levels of creatine and phosphocreatine

Creatine Phosphate + ADP = ATP → Energy

Creatine Monohydrate

Study: Walter et al. (2000)
- Dose: 5 g/day
- Participants: 8 boys; average 10 years old
- Steroids: No
- Study duration: 8 weeks
- **Results:** Modest but significant improvement in muscle strength and daily-life activities
- Well tolerated: Yes

Study: Tarnopolsky et al. (2004)
- Dose: 0.1 g/kg/day
- Participants: 31 boys; average 10 years old
- Steroids: 50%
- Study duration: 4 months
- **Results:** Decrease bone breakdown, increased grip strength, and increased fat free mass
- Well tolerated: Yes

Creatine Monohydrate

Study: Louis et al. (2003)
- Dose: 3 g/day
- Participants: 12 boys; average 11 years old
- Steroids: No
- Study duration: 3 months
- Results: Increase in muscle strength, resistance to fatigue, and bone mineral density
- Well tolerated: Yes

Study: Escolar et al. (2005)
- Dose: 5 g/day
- Participants: 50 boys; 4-10 years old
- Steroids: no
- Study duration: 6 months
- Results: No change in muscle strength or function
- Well tolerated: Yes

Creatine Monohydrate

Kley et al. (2013): Systematic review of the studies presented on the previous slides using creatine monohydrate

- *This study combined all outcomes from different individual trials. Although the average increase is encouraging, there was some variation in the results which means individuals may experience very modest effects from creatine monohydrate*
L-Glutamine

- Non-essential amino acid that can slow down or inhibit whole body protein breakdown

- Major gluconeogenic precursor which stimulates insulin secretion

L-Glutamine

Study: Escolar et al. (2005)
- Dose: 0.6 g/kg/day
- Participants: 50 boys; 4-10 years old
- Steroids: no
- Study duration: 6 months
- **Results:** No change in muscle strength or function
- Well tolerated: Yes

Study: Mok et al. (2006)
- Dose: 0.5 g/kg/day
- Participants: 26 boys; 7-15 years old
- Steroids: No
- Study duration: 10 days
- **Results:** Decrease in whole-body protein degradation
- Well tolerated: Yes

L-Glutamine

Study: Mok et al. (2009)
- Dose: 0.5 g/kg/day
- Participants: 30 boys; 2-10 years old
- Steroids: 15%
- Study duration: 4 months
- Results: No differences in muscle mass and protein breakdown were observed; small improvements when used in conjunction with steroids
- Well tolerated: Yes

Take home message:

- There is mixed evidence for glutamine. There have been no significant differences found in function after glutamine supplementation. However, the study by Escolar et al. (2005) stated that they could not rule out a positive effect of glutamine because the control group did not decline as much as they expected. The study by Mok et al. (2009) showed potential improvements when glutamine is used together with corticosteroids.

L-Leucine

- Essential amino acid that can stimulate protein synthesis

- Study: Mendell et al. (1984)
- Dose: 0.2 g/kg/day
- Participants: 96 boys; Average 10 years
- Steroids: No
- Study duration: 12 months
- Results: Small increase in muscle strength observed in the treatment group
- Well tolerated: Yes

*The authors stated that the difference may have been due to an unexpected decline in the control group

L-Carnitine

- L-Carnitine is an amino acid that participates in fatty acid metabolism
- DMD patients have an inherent deficiency of L-carnitine levels

Study: Escobar-Cedillo et al. (2013)
- Dose: 0.05 g/kg/day twice a day
- Participants: 20 boys; 4-9 years old
- Steroids: No
- Study duration: 12 months
- Results: No effect in muscle function
- Well tolerated: Yes

*Whilst this study was conducted well, there were very few descriptive results presented in the study (e.g., mean function) so it’s difficult to completely understand these findings

Coenzyme-Q10 (CoQ10)

- Located in the inner membrane of the mitochondria where it accepts electrons for the NADH and SDH complexes
- Might improve mitochondrial function and decrease oxidative stress

- **Study:** Salehi *et al.* (2017)
- **Dose:** 3-5 mg/kg/day
- **Participants:** 25 boys; average 9 years old
- **Steroids:** 95%
- **Study duration:** 12 months
- **Results:** No change in cardiac performance
- **Well tolerated:** Not reported

*This study measured heart outcomes only. Functional/strength outcomes were not measured. There may be some positive effects on strength following CoQ10 supplementation.*

Idebenone

- Idebenone is a synthetic analogue of CoQ10
- It has the potential to protect against mitochondrial chain dysfunction and decrease oxidative stress

Study: Buyse et al. (2011)
- Dose: 450 mg/day (3 x150 mg)
- Participants: 21 boys; 8-16 years of age
- Steroids: 62%
- Study duration: 12 months
- Results: Increase in respiratory strength and trend for improvement of peak systolic radial strain in the left ventricle lateral wall
- Well tolerated: Not reported

- Study: Buyse et al. (2015)
- Dose: 900 mg/day (3 x 300mg)
- Participants: 64 boys; 10-18 years old
- Steroids: 57%
- Study duration: 12 months
- Results: There was less deterioration in respiratory function in the Idebenone group compared to controls.
- Well tolerated: Yes

Omega-3 long chain fatty acids

- Polyunsaturated fatty acids that have been shown to play a role in cardiovascular disease and inflammation

- Study: Rodríguez-Cruz et al. (2017)
- Dose: 2.9 g/day
- Participants: 36 boys; average 8 years old
- Steroids: No
- Study duration: 6 months
- **Results:** Improved markers of inflammation
- Well tolerated: Yes

*Functional / strength outcomes not measured.*

Epicatechin

- 103 studies on Clinicaltrials.gov
- 15 studies currently with open recruitment
- 1 study for BMD and 2 studies for DMD with open recruitment

Epicatechin enhances mitochondrial biogenesis, increases dystrophin and utrophin, increases follistatin while decreasing myostatin, and improves skeletal muscle exercise response in adults with Becker muscular dystrophy (BMD)

C. McDonald *,1, E. Henricson 1, B. Oskarsson 2, C. Aguilar 1, A. Nicorici 1, N. Joyce 1, D. Reddy 1, A. Wagner 1, E. deBie 1, E. Goude 1, R. Abresch 1, F. Villereal 3, G. Perkins 4, Y. Hathout 5, S. Dugar 6, G. Schreiner 6
Many different supplements have been tested in dystrophic mouse models (e.g., *mdx* mice) and have shown beneficial effects.

Although studies in animal models of DMD provide very important information regarding the underlying mechanisms behind disease progression and potential treatments, their findings are somewhat limited.
# Animal studies

## Summary of studies using different supplements in DMD mouse models

<table>
<thead>
<tr>
<th>Supplement</th>
<th>Dose used in study</th>
<th>Results</th>
<th>Study Duration</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) L-Arginine</td>
<td>200 mg/kg/day (5 days/week)</td>
<td>Decrease in skeletal muscle necrosis, and decrease in serum creatine kinase; increase in diaphragm specific force</td>
<td>6 weeks</td>
<td>Voisin et al. (2005)</td>
</tr>
<tr>
<td></td>
<td>200 mg/kg/day</td>
<td>Decrease in markers of skeletal muscle inflammation, increase in centrally nucleated fibers (indirect marker of muscle damage)</td>
<td>2 weeks</td>
<td>Hnia et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>5 mg/mL in drinking water</td>
<td>Increased fibrosis in heart and muscle</td>
<td>17 months</td>
<td>Wehling-Hennicks et al. (2010)</td>
</tr>
<tr>
<td>3) L-Glutamine</td>
<td>500 mg/kg/day</td>
<td>Increase in antioxidant capacity</td>
<td>3 days</td>
<td>Mck et al. (2008)</td>
</tr>
<tr>
<td>4) Taurine</td>
<td>10 % of daily chow</td>
<td>Increase in forelimb strength; improvement in markers of muscle regeneration</td>
<td>4–8 weeks</td>
<td>De Luca et al. (2003)</td>
</tr>
<tr>
<td></td>
<td>1 g/kg/day</td>
<td>Decrease in plasma lactate dehydrogenase</td>
<td>4–8 weeks</td>
<td>Cozzoli et al. (2011)</td>
</tr>
<tr>
<td>6) Green tea extract</td>
<td>0.01–0.05 % of daily chow</td>
<td>Decrease in skeletal muscle necrosis and regenerative cycling</td>
<td>4 weeks</td>
<td>Buettler et al. (2002)</td>
</tr>
<tr>
<td></td>
<td>0.50 % of daily chow</td>
<td>Decrease in serum creatine kinase and increase in voluntary running performance</td>
<td>3 weeks</td>
<td>Call et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>0.25–0.50 % of daily chow</td>
<td>Decrease in the percentage of regenerating fibers</td>
<td>6 weeks</td>
<td>Evans et al. (2010)</td>
</tr>
<tr>
<td>7) Omega-3's</td>
<td>Eicosapentaenoic acid (EPA) only (300 mg/kg/day)</td>
<td>Decrease in the percentage of centrally nucleated fibers; decrease in inflammatory biomarkers</td>
<td>16 days</td>
<td>Machado et al. (2011)</td>
</tr>
<tr>
<td></td>
<td>EPA and docosahexaenoic (DHA) - (300 and 150 mg/kg/day, respectively)</td>
<td>Decrease in the percentage of centrally nucleated fibers; decrease in inflammatory biomarkers; decrease in serum creatine kinase</td>
<td>16 days</td>
<td>Mauricio et al. (2013)</td>
</tr>
<tr>
<td></td>
<td>EPA only (500 mg/kg/day)</td>
<td>Promoted anti-inflammatory M1 to M2 macrophage shift</td>
<td>16 days</td>
<td>de Carvalho et al. (2013)</td>
</tr>
<tr>
<td>8) L-Carnitine</td>
<td>75 mg/kg/day</td>
<td>Decrease in serum creatine kinase</td>
<td>6 weeks</td>
<td>Oh et al. (2005)</td>
</tr>
<tr>
<td>9) Resveratrol</td>
<td>100 mg/kg/day</td>
<td>Decrease in the percentage of centrally nucleated fibers and oxidative stress in skeletal muscle; increase in skeletal muscle strength; no change in inflammatory biomarkers</td>
<td>8 weeks</td>
<td>Gordon et al. (2014)</td>
</tr>
<tr>
<td></td>
<td>100 mg/kg/day</td>
<td>8 week treatment increased skeletal muscle strength but not fatigue resistance</td>
<td>10 day or 8 weeks</td>
<td>Kostek et al. (2011)</td>
</tr>
<tr>
<td></td>
<td>4 g/kg/day</td>
<td>Decrease in skeletal muscle oxidative stress and fibrosis; decrease in maintained muscle mass</td>
<td>32 weeks</td>
<td>Hori et al. (2011)</td>
</tr>
<tr>
<td>10) N-acetylcysteine</td>
<td>1 % of drinking water (60 mM)</td>
<td>Improved in various markers of cardiac pathology; decrease in centrally nucleated fibers and NF-kB; increase in ubiquitin levels</td>
<td>6 weeks</td>
<td>Whitehead et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>150 mg/kg/day</td>
<td>Decrease in inflammatory areas in muscle and TNF-α in the diaphragm muscle</td>
<td>2 weeks</td>
<td>Pinto et al. (2013)</td>
</tr>
<tr>
<td>11) Idebenone</td>
<td>200 mg/kg/day</td>
<td>Decrease in cardiac fibrosis, and inflammation; increase in voluntary running; prevention of cardiac dysfunction</td>
<td>9 months</td>
<td>Buese et al. (2009)</td>
</tr>
<tr>
<td>12) Protandim</td>
<td>457 mg/m2</td>
<td>Improves some markers of oxidative stress, but did not improve motor function</td>
<td>6 weeks</td>
<td>Qureshi et al. (2010)</td>
</tr>
</tbody>
</table>
High protein diet might further impair autophagy in dystrophic muscles

Considerations when using supplements

- Because something worked on an animal study, doesn’t necessarily mean that it will work on humans. Instruct individuals to carefully interpret results from animal studies.

- Remember to recommend families and DMD patients to seek advice from experts – i.e. dietitian/doctor.

- Supplements are expensive!
Take home message

- Individuals with DMD have nutritional deficits and need an optimized diet – again, this needs to be done on a case by case basis!

- Optimal nutrition has yet to be determined for individuals with DMD

- Supplements are commonly used, but not all have shown positive results in clinical studies (maybe due to the variability in disease phenotype between patients?)
Remember that you can find useful information regarding nutrition/supplements for DMD in the literature!!


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