Alcohol & Exercise:  
A popular cocktail, but do they mix?  
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Overview  
- Alcohol use and physical activity  
- Alcohol’s effect on performance  
  - Exercise during “intoxication”  
  - Exercise after “intoxication”  
  - Alcohol “intoxication” after exercise  
- Acute effects of alcohol on physiology
### Alcohol Use & Physical Activity

<table>
<thead>
<tr>
<th>Measures</th>
<th>Infrequent (0-2 days)</th>
<th>Regular (3-4 days)</th>
<th>Frequent (5-7 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of consumption</td>
<td>6.8</td>
<td>7.5</td>
<td>8.0**</td>
</tr>
<tr>
<td>Amount consumed</td>
<td>5.4</td>
<td>6.1</td>
<td>6.6**</td>
</tr>
<tr>
<td>Drinking heavily</td>
<td>4.5</td>
<td>5.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Smoking cigarettes</td>
<td>2.9</td>
<td>2.6</td>
<td>1.9***</td>
</tr>
</tbody>
</table>

Infrequent vs. frequent exercisers: *P = 0.05, **P < 0.01

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### Alcohol Use & Physical Activity (BRFSS)

<table>
<thead>
<tr>
<th>Alcohol use</th>
<th>Women (n=140,925)</th>
<th>Abstaining</th>
<th>Light</th>
<th>Moderate</th>
<th>Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly min of total PA**</td>
<td>70</td>
<td>78</td>
<td>85</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Weekly min of vigorous PA**</td>
<td>22</td>
<td>28</td>
<td>33</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Any vigorous PA (%)**</td>
<td>34</td>
<td>52</td>
<td>59</td>
<td>55</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alcohol use</th>
<th>Men (n=159,311)</th>
<th>Abstaining</th>
<th>Light</th>
<th>Moderate</th>
<th>Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly min of total PA**</td>
<td>96</td>
<td>101</td>
<td>111</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>Weekly min of vigorous PA**</td>
<td>38</td>
<td>43</td>
<td>46</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Any vigorous PA (%)**</td>
<td>52</td>
<td>65</td>
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<td></td>
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</table>

**P<0.01 across alcohol use categories

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*French et al., 2009*
Alcohol Use: NCAA Athletes

- Slightly higher use among men
- High use across all sports
- Many (~40%) engage in Binge drinking
- ~80% had initial use before entering college

NCAA, 2006, 2014

Alcohol Use & Physical Activity

- Summary on alcohol use:
  - High use among athletes
    - At least as high as for non-athlete peers
  - Physically active vs. sedentary adults
    - Greater frequency
    - Greater amount consumed

Alcohol & Performance

Exercise during “intoxication”
Early Research: During “Intoxication”

Performance Time for 350 Revolutions (0.86 kg).

<table>
<thead>
<tr>
<th>Subjects (men)</th>
<th>Alcohol concentration in Blood [0.06-0.10 g·dl⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Α</td>
<td>0.1-0.3 %   0.3-0.6 %   0.6-1.0 %</td>
</tr>
<tr>
<td>Β</td>
<td>5.0% min    5.0% min    5.0% min    5.0% min</td>
</tr>
<tr>
<td>Ε</td>
<td>4.9%        4.7%        4.7%        4.7%</td>
</tr>
<tr>
<td>Ζ</td>
<td>4.6%        4.6%        4.6%        4.6%</td>
</tr>
<tr>
<td>BAC</td>
<td>(4.9%)      (4.9%)      (4.9%)      (4.9%)</td>
</tr>
</tbody>
</table>

Lecoultre & Schutz, 2009

Endurance: During “Intoxication”

- Cycling (men)
  - 60 min time trial
- Alcohol: 0.5 ml/kg FFM
  - BAC 0.02% (@20min)

- Effect of Alcohol:
  - 3.9% performance
  - Glucose oxidation rate
  - Blood glucose

Poulsen et al., 2007

Strength: During “Intoxication”

- Men and women
- Alcohol: 1.5 g·kg⁻¹
- Knee extensions
  - Maximal isokinetic & isometric strength

Poulsen et al., 2007
**Strength: During “Intoxication”**

No effect of alcohol

- **BAC**: 0.14 g/dl
- **Knee extensions**
  - Voluntary & evoked

Poulsen et al., 2007

**Exercise During “Intoxication”**

- **Summary on effect of alcohol:**
  - ↓ Performance in cycling time trials lasting ~5-60 min
  - ↔ Isokinetic or isometric strength

**Alcohol & Performance**

Exercise after alcohol “intoxication” (during “hangover”)
Time trial: During Hangover

- Alcohol: 1.7 g·kg⁻¹ (1.0-2.4 g·kg⁻¹)
  - ~13 drinks
  - ~1/3 participants had severe hangover
- 5 min @ 245 W on morning after

Effect of “Hangover”
- ↓ Completion: 9/27 vs. 15/27
- ↓ Work performed
- ↑ HR during exercise

Karvinen et al., 1961

During Hangover

No effect of alcohol

<table>
<thead>
<tr>
<th>Strength</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand Grip</td>
<td>Vertical Jump</td>
</tr>
<tr>
<td>Back/leg Pull</td>
<td></td>
</tr>
</tbody>
</table>

Karvinen et al., 1961

Exercise after alcohol “intoxication” (During “hangover”)

- Summary on effect of alcohol:
  - ↓ Performance in cycling time trial: 5 min
  - ↔ Isometric strength
  - ↔ Maximal explosive power
Alcohol & Performance

Alcohol “intoxication” after exercise (during recovery)

Strength: Alcohol During Recovery

Alcohol delayed recovery

Men
• 300 max eccentric leg extensions
• 1 g·kg⁻¹ (8 ± 2.8 drinks)

- Effect of alcohol
  - ↓ Eccentric (Torque)
  - ↓ Isometric (Torque)
  - ↓ Concentric (Torque)
  - ↔ Creatine kinase
  - ↔ w. 0.5 g·kg⁻¹

Barnes et al., 2009, 2010, 2011

Strength: Alcohol During Recovery

Alcohol enhanced recovery

Women (preliminary results; n=10)
• 300 max eccentric leg extensions
• 1.09 g·kg⁻¹ FFM
• BAC: ~0.12 g·dl⁻¹

- Effect of alcohol
  - ↑ Concentric (Torque)
  - ↔ Eccentric (Torque)
  - ↔ Isometric (Torque)
  - ↔ No-exercise leg

Levitt & Vingren
Strength: Alcohol During Recovery

Alcohol delayed recovery

Men and women
- Squat, leg press, and knee extension
- Drink: 60 min post exercise

Haugvad et al., 2014

Power: Alcohol During Recovery

No effect of alcohol

- Squats (men)
  - 6 sets of 10 reps @ 80% 1RM
- Power tests
  - High pull (HP)
  - Vertical jump (VJ)
- Noon (Pre) & 7am (AM)
- BAC: ~0.11 g·dl⁻¹
- Only slight soreness

Idemudia and Vingren., 2012

Alcohol “intoxication” after exercise (during recovery)

- Summary on effect of alcohol:
  - ↓ Strength only when muscle damage is present in men
  - ↔ Strength and power w. limited muscle damage
  - Alcohol might affect muscle recovery
    - Gender difference appear to exist
    - Alcohol dose appears important
    - Extent of muscle damage appears important
Acute Physiological Effects of Alcohol

Does alcohol impact processes important to exercise recovery?

• ↓ Protein synthesis
  - ↓ Leucine stimulation
• ↔ Protein degradation
• Alcohol likely affects signals for protein synthesis and NOT degradation

Vary et al., 2008

Acute effect of alcohol (no exercise)

• ↓ Protein synthesis
  - ↓ Leucine stimulation
• ↔ Protein degradation

Myofibrillar fractional synthetic rate (Endurance + resistance exercise)

Men
- Leg extensions (5x8)
- Cycling:
  - 30 min @ 63% VO\textsubscript{max}
  - Sprints (10x30s)
- Whey protein (25 g)
- Alcohol (1.5 g·kg\textsuperscript{-1}) over 2 hr

From 2 to 8 hr after exercise

Parr et al., 2014
Acute effect of alcohol (no exercise)

Signals for Protein Synthesis
- Testosterone
  - ↑ in men
  - ↔ in women
  - dose dependent
- Androgen receptor
  - Unknown
- ↓ Protein synthesis

Acute effect of resistance exercise (no alcohol)

Signals for Protein Synthesis
- Testosterone
  - ↑ in men
  - ↔ in women
- Androgen receptor
  - ↑ in men (3hr)
  - ↔ in women (1hr)
- All are time dependent
- ↑ Protein synthesis
What are the combined effects? (Alcohol + RE)

Signals for Protein Synthesis

- AlCOHOL
- RE
- AMPK
- Akt
- TSC1/2
- mTOR
- S6K1
- 4E-BP1

Translation initiation, peptide elongation, Protein synthesis

Acute Effects of Alcohol: mTOR signaling

Men and Women
- 6x10 squats
  - 80% 1RM
- Alcohol (1.09 g·kg⁻¹)
  - BAC: ~0.11 g·dl⁻¹
- ↔ 4E-BP1

MEN WOMEN

Duplanty & Vingren, in Press

Acute Effects of Alcohol: mTOR signaling

Men
- Leg extension (5x8)
- Cycling:
  - 30 min @ 63% VO₂max
  - Sprints (10x30s)
- Whey protein (25 g)
- Alcohol (1.5 g/kg) over 2 hr
- ↔ 4E-BP1
- ↓ Protein synthesis

Parr et al., 2014
Acute Effects of Alcohol: Testosterone response

**Men**
- 6x10 squats
- 80% 1RM
- BAC: 0.09 g/dl
- Alcohol (1.09 g/kg)
- Effect of alcohol
  - ↑ Testosterone (total & free)
  - ↔ Estradiol or SHBG
  - ↑ Testosterone could be due to change in androgen receptor

Vingren et al., 2013

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Acute Effects of Alcohol: Testosterone response

**Preliminary results (n=6)**

**Women**
- 6x10 squats
- 80% 1RM
- BAC: ~0.11 g/dl
- Alcohol (1.09 g/kg)
- Effect of alcohol
  - ↑ Total Testosterone
  - Could be due to change in androgen receptor

Budnar & Vingren

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Acute Effects of Alcohol: Androgen Receptor Response

**Men and women**
- 6x10 squats
- 80% 1RM
- BAC: ~0.11 g/dl
- Alcohol (1.09 g/kg)

Vingren et al.
Acute Effects: LPS Stim. Cytokines

Men and women
- 6x10 squats
- BAC: ~0.11 g/dl
- Alcohol (1.09 g/kg)

IL-6 (pro-inflammatory)

(\text{con x time}) \eta_p^2 = 0.164

IL-8 (chemokine)

(\text{con x time}) \eta_p^2 = 0.295

Levitt & Vingren, 2016

Summary: Acute Effects of Alcohol

- Without exercise (males and females):
  - ↓ Protein synthesis
  - ↔ Protein degradation
  - ↓ Signals that promote protein synthesis
  - ↑ Signals that inhibit protein synthesis

- On resistance exercise-induced responses:
  - ↓ Protein synthesis (men, combined RE and cycling)
  - ↓ mTOR pathway signaling (men but not women)
  - ↑ Testosterone late in recovery (men, maybe women)
  - ↓ AR response (men, maybe women)
  - ↓ IL-6 & IL-8 (men and women)

Could alcohol impact long-term training adaptations?
Chronic Effects: Muscle size

- Myopathy (muscle wasting)
  - Specific to type II fibers
  - Likely due to ↓ protein synthesis
  - Not caused by inactivity
  - Not caused by diet (other than alcohol)

Preedy et al., 2003

Acute effect of alcohol (no exercise)

- Protein synthesis signals
  - In males
  - Not clear in females
- Mediation by resistance training is unknown

Vingren et al., 2005

Chronic Effects of Alcohol: Resistance Training & AR

Male rats
- squat
- 6-week training program
- 3 sessions per week
  - Alcohol: 35% of total kcal

Vingren et al., 2005
Chronic Effects of Alcohol: Androgen Receptor

Summary: Chronic Effects of Alcohol

- Without exercise (males only)
  - ↓ Protein synthesis (no exercise)
  - ↓ Signals that promote protein synthesis
  - ↑ Signals that inhibit protein synthesis
- Resistance training
  - ↓ Androgen receptor (males)
- Effects are mainly type II fiber specific

Future Questions: Alcohol & Exercise

- Mechanisms for gender differences
- Dose effects
- Protein synthesis and signaling after exercise
  - Mechanisms for effect on neuromuscular and endocrine system
- Mode of exercise
- Benefits of exercise training
Summary: Alcohol & Exercise

• High(er) use in physically active (men and women)
• Effect on performance:
  – Exercise during "intoxication"
    • ↓ Endurance type exercise
    • ↔ Strength
  – Exercise during "hangover"
    • ↓ Endurance type exercise
    • ↔ Strength & power
  – Alcohol ingestion during recovery
    • ↓ Strength recovery only when muscle damage is present
      - in men but not women

Summary: Alcohol & Exercise

Effects on physiological responses to exercise

– Acute use
  • ↓ Protein synthesis and signaling (no exercise)
  • ↓ mTOR pathway signaling (men but not women)
  • ↑ Total and free testosterone during recovery (men)
  • ↓ Cytokines (IL-6 & IL-8) (altered inflammatory capacity)
  • ↓ AR (men but not women)

– Chronic use
  • Type II fiber myophathy (no exercise)
  • ↓ Protein synthesis and signaling (no exercise, male only)
  • ↓ AR (fiber type dependent, male)