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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
## Alcohol Use & Physical Activity

> Frequency and amount of use w. ↑ frequency of exercise

### Male and female college students

<table>
<thead>
<tr>
<th>Measures</th>
<th>Infrequent (0-2 d/wk)</th>
<th>Regular (3-4 d/wk)</th>
<th>Frequent (5-7 d/wk)</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

Moore and Werch, 2008
## Alcohol Use & Physical Activity (BRFSS)

<table>
<thead>
<tr>
<th></th>
<th>Alcohol use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abstaining</td>
</tr>
<tr>
<td><strong>Women (n=140,925)</strong></td>
<td></td>
</tr>
<tr>
<td>Weekly min of total PA**</td>
<td>70</td>
</tr>
<tr>
<td>Weekly min of vigorous PA**</td>
<td>22</td>
</tr>
<tr>
<td>Any vigorous PA (%)**</td>
<td>34</td>
</tr>
<tr>
<td><strong>Men (n=109,931)</strong></td>
<td></td>
</tr>
<tr>
<td>Weekly min of total PA**</td>
<td>96</td>
</tr>
<tr>
<td>Weekly min of vigorous PA**</td>
<td>38</td>
</tr>
<tr>
<td>Any vigorous PA (%)**</td>
<td>52</td>
</tr>
</tbody>
</table>

**P<0.01 across alcohol use categories**

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 450 Revolutions (9,860 mkg).

<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></td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>5.05 min</td>
</tr>
<tr>
<td>E</td>
<td>4.85</td>
</tr>
<tr>
<td>H</td>
<td>4.78</td>
</tr>
<tr>
<td>L</td>
<td>4.84</td>
</tr>
<tr>
<td>mean</td>
<td>4.89</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subject</th>
<th>Caffeine</th>
<th>Cocaine</th>
<th>Strychnine</th>
<th>Nitroglycerin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>30 cg</td>
<td>0</td>
<td>12 cg</td>
</tr>
<tr>
<td>K</td>
<td>5.25 min</td>
<td>5.09 min</td>
<td>5.25 min</td>
<td>5.31 min</td>
</tr>
<tr>
<td>L</td>
<td>5.16 —</td>
<td>5.05 —</td>
<td>5.16 —</td>
<td>4.99 —</td>
</tr>
<tr>
<td>S</td>
<td>5.07 —</td>
<td>5.04 —</td>
<td>5.07 —</td>
<td>5.10 —</td>
</tr>
<tr>
<td>mean</td>
<td>5.16 —</td>
<td>5.06 —</td>
<td>5.16 —</td>
<td>5.13 —</td>
</tr>
</tbody>
</table>

Asmussen and Bøje, 1947
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

Lecoultre & Schutz, 2009
Strength: During “Intoxication”

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

Blood alcohol concentration (BAC)
Peak: 0.14 g·dl⁻¹

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
  - ⅓ 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

**Strength**

- Hand Grip
- Back/leg Pull

**Power**

- Vertical Jump

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

Haugvd et al, 2014
Power: Alcohol During Recovery

- 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

No effect of alcohol

<table>
<thead>
<tr>
<th></th>
<th>PRE-ALC</th>
<th>PRE-PLA</th>
<th>AM-ALC</th>
<th>AM-PLA</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pull Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vert Jump Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Leg Soreness (Right) | 0.5 ± 0.8 | 0.4 ± 0.5 |
| Leg AM Soreness (Right) | 2.3 ± 1.5 | 2.6 ± 1.3 |
Alcohol “intoxication” after exercise (during recovery)

- Summary on effect of alcohol:
  - ↓ Strength only when muscle damage is present in men
  - ↔ Strength and power with 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?
Acute effect of alcohol (no exercise)

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

- Alcohol likely affects signals for protein synthesis and NOT degradation

Vary et al., 2008
Myofibrillar fractional synthetic rate (Endurance + resistance exercise)

Men

- Leg extensions (5x8)
- Cycling:
  - 30 min @ 63% VO\textsubscript{2max}
  - 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
Signaling for Protein Synthesis

Spiering et al., 2009
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

Translation initiation, peptide elongation, Protein synthesis
What are the combined effects? (Alcohol + RE)

Signals for Protein Synthesis

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

Duplanty & Vingren, in Press
Acute Effects of Alcohol: mTOR signaling

Men
- Leg extension (5x8)
- Cycling:
  - 30 min @ 63% VO$_{2\text{max}}$
  - 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
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
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)

Levitt & Vingren, 2016

IL-6 (pro-inflammatory)

(con x time) $\eta_p^2 = 0.295$

IL-8 (chemokine)

(con x time) $\eta_p^2 = 0.164$
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
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

Vingren et al., 2005

Androgen Receptor (arbitrary units)

Vingren et al., 2005

Soleus Rectus EDL

Ex-Al
Sed-Al Ex-Nml Sed-Nml Baseline

*: Significant difference compared to baseline
#: Significant difference compared to Sed-Nml
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

Take Home (Performance):

1. ↓ Endurance type exercise
2. ↔ Strength w/o muscle damage
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)

Take Home (Physiology):
3. Protein synthesis “disruption”
4. Endocrine “disruption”
Alcohol & Exercise: A popular cocktail, but do they mix? Well, it depends on the circumstances.

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Collaborators on Alcohol Research

• Faculty
  – David Hill, PhD
  – Brian McFarlin, PhD
  – Lymperis Koziris, PhD
  – William Kraemer, PhD

• Current and former students
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  – Anthony Duplanty, PhD
  – Hui-Ying Luk, MS
  – Ronald Budnar, MS
  – Danielle Levitt, MS
  – Alex Fernandez, MS
  – Nosa Idemudia, MS

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