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## Effect of alcohol on athletic performance and recovery

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### Abstract

Alcohol consumption within elite sport has been continually reported both anecdotally within the media and quantitatively in the literature. The detrimental effects of alcohol on human physiology have been well documented, adversely influencing neural function, metabolism, cardiovascular physiology, thermoregulation and skeletal muscle myopathy. Remarkably, the downstream effects of alcohol consumption on exercise performance and recovery, has received less attention and as such is not well understood. The focus of this review is to identify the acute effects of alcohol on exercise performance and give a brief insight into explanatory factors.

**Keywords:** Effect, Skeletal muscle, Glycogen, Protein synthesis.

### Introduction

Athletes, like the rest of the population, consume alcohol. Sporting clubs and associations are frequently reported in the media to place bans or restrictions on the availability and consumption of alcohol by contracted athletes. Yet the same media organizations also report on alcohol-fuelled violence or misdemeanors perpetrated by these same athletes, suggesting anecdotally that athletes consume alcohol, occasionally to excess. This is quantitatively supported by dietary surveys of athletic populations that demonstrate self-reported alcohol intake constitutes up to 5% of the total daily energy intake in elite athletes. However this is far from universal, as survey data reports either greater or reduced alcohol ingestion in athletic populations than the general community. This high variability in reported alcohol intake within athletic groups may in part be due to the characteristics of each sporting discipline. Alcohol intake appears to be positively associated with team sports where alcohol consumption is often encouraged as a component of team/group bonding and can be related to stress relief. The detrimental effects of alcohol on human physiology have been well documented with acute alcohol ingestion affecting many aspects of metabolism, neural function, cardiovascular physiology, thermoregulation and skeletal muscle myopathy. Yet the impact that alcohol ingestion has on exercise performance and more critically recovery has received less detailed scrutiny. This review aims to provide insights into the current knowledge around how alcohol acts to impair both exercise performance and the critical mechanisms by which alcohol acts at the cellular level to retard recovery following strenuous activity.

### Effect of alcohol on human physiology

Alcohol consumption has a deleterious effect on a multitude of systems within the body and an in-depth analysis of each is beyond the scope of this review. However a brief insight into common symptoms linked to acute alcohol misuse will guide the following discussion on how alcohol influences human performance and recovery.

### Skeletal muscle

Multiple detrimental actions of alcohol within skeletal muscle are likely. Firstly, alcohol inhibits  $Ca^{2+}$  transients into the myocyte by inhibiting sarcolemmal  $Ca^{2+}$  channel actions. This action is reported in isolated human myotubes and rodent muscle tubes *in-vitro*. Consequently this will impair excitation-contraction coupling, decreasing strength output. Yet human clinical data fails to support this *in-vitro* evidence. Secondly, alcohol consumption may compromise sarcolemmal integrity, with evidence of greater plasma rises

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in the intracellular enzyme creatine kinase (CK), following alcohol ingestion and exercise. Indeed, in rodents a supra-physiological dose of alcohol markedly increased plasma CK. Furthermore, in both electrically stimulated rodent muscles and in human subjected to eccentric loading this not evident. Thus clear mechanisms remain elusive, with a need for supporting clinical data. It is well understood that muscle cramps, pain and a loss of proprioception are common symptoms of alcohol misuse; however the underlying mechanisms remain speculative.

### Metabolism

In addition to being a readily accessible source of energy (29kJ per gram), alcohol has a number of effects that bear ramifications for human metabolism. Alcohol-induced hypoglycemia has been proposed as a possible cause of symptoms common to alcohol misuse. The intake of high alcohol doses has been demonstrated to impair hepatic gluconeogenesis and subsequent glucose output, decrease the uptake of gluconeogenic precursors lactate and glycerol, and reduce muscle glycogen uptake and storage. Alcohol has also been shown to induce a reactive hypoglycemia by exacerbating insulin secretion in the presence of a high carbohydrate meal. While the detrimental effect of alcohol on glucose metabolism is strongly documented, some authors maintain that this can be negated if glycogen stores are maintained at homeostatic levels. Specifically to exercise, acute alcohol intoxication inhibited the exercise induced rise in serum glucose concentration and caused a mild decrease in serum glucose during recovery from anaerobic exercise. Further acute alcohol intoxication has been implicated in attenuating post exercise increases in serum fatty acid concentration. These findings bear considerable ramifications for exercise performance and recovery. It is well documented in the literature that glucose availability plays a pivotal role in endurance performance and further readily available stores of energy are necessary to fuel protein synthesis during muscle recovery from exercise.

### Alcohol and athletic performance

Given the numerous and complex mechanisms by which ethanol impacts on physiological systems it can be strongly hypothesized that elevated blood alcohol concentrations at the time of exercise will impair performance. Remarkably there are relatively few clinical trials that address this question.

**Alcohol use cancels out gains from your workout consuming** alcohol after a workout, practice, or competition can cancel out any physiological gains you may have received from such activities. Not only does long-term alcohol use diminish protein synthesis resulting in a decrease in muscle build-up, but even short term alcohol use can impede muscle growth.

**Alcohol causes dehydration and slows down the body's ability to heal.** Speeding the recovery of sore muscles and injuries is integral to optimal performance. Alcohol is a toxin that travels through your bloodstream to every organ and tissue in your body, causing dehydration and slowing your body's ability to heal itself.

**Alcohol use prevents muscle recovery.** In order to build bigger and stronger muscles, your body needs sleep to repair

itself after a workout. Because of alcohol's effect on sleep, however, your body is robbed of a precious chemical called "human growth hormone" (HGH). HGH is part of the normal muscle-building and repair process and the body's way of telling itself your muscles need to grow bigger and stronger. Alcohol, however, can decrease the secretion of HGH by as much as 70 percent!

**Alcohol use depletes your source of energy.** Once alcohol is absorbed through your stomach and small intestines and finally into your cells, it can disrupt the water balance in muscle cells, thus altering their ability to produce adenosine triphosphate (ATP), which is your muscles' source of energy. ATP provides the fuel necessary for your muscles to contract. A loss of ATP results in a lack of energy and loss of endurance.

### How alcohol affects nutrition and recovery

- **Alcohol uses and constricts metabolism and endurance.** Being physically fit and well conditioned is the hallmark of a champion. However, no matter how many wind sprints you do, drinking alcohol constricts your aerobic metabolism and endurance.
- **Alcohol use requires increased conditioning to maintain weight.** Alcohol holds very little nutritional value to the athlete. The relatively high calories in alcohol are not available to your muscles. Alcohol calories are not converted to glycogen, a form of stored carbohydrates, and thus are not a good source of energy during exercise. Each drink contains approximately 100-150 empty calories. The body treats alcohol as fat, converting alcohol sugars into fatty acids.
- **Alcohol use inhibits absorption of nutrients.** Not only is alcohol devoid of proteins, minerals, and vitamins, it actually inhibits the absorption and usage of vital nutrients such as thiamin (vitamin B1), vitamin B12, folic acid, and zinc:
- **Thiamin** (vitamin B1) is involved in the metabolism of proteins and fat and the formation of hemoglobin. It is also essential to optimal performance for its role in metabolizing carbohydrates.
- **Vitamin B12** is essential to good health. It helps maintain healthy red blood and nerve cells.
- **Folic acid** is an integral part of a coenzyme involved in the formation of new cells; a lack of it can cause a blood disorder called "megaloblastic anemia," which causes a lowering of oxygen carrying capacity and thus negatively affects endurance activities.
- **Zinc** is also essential to your energy metabolic processes. Since alcohol depletes your zinc resources, the effect is an even greater reduction of your endurance.

### Aerobic performance

Earlier studies found no significant consequence of alcohol on a sub-maximal endurance performance and a 5-mile treadmill time trial respectively. Contrastingly and not surprisingly, there is also literature that demonstrates that alcohol is detrimental to endurance performance. What is

apparent is that a threshold exists at which point alcohol becomes detriment to aerobic performance. Cofan and colleagues describe an alcohol intoxication threshold of 20mmol/L of ethanol in both animal and human studies, beyond which did performance decrements become significant. Further research has elaborated that this cause-effect relationship may exist in a dose dependent manner.

### **Anaerobic performance**

Despite the long list of skeletal muscle and neurological symptomatology associated with alcohol consumption, the majority of literature has been unable to establish a significant cause-effect relationship between alcohol and anaerobic performance. To the reviewers knowledge McNaughton and Pierce have conducted the only research that has identified an effect of alcohol on sprint performance. This research examined five sprinters using sprint time as a measure of performance and established a detrimental, albeit inconsistent, association between alcohol dosage and sprint performance. Alcohol was ingested immediately prior to exercise testing so this data is limited to the acute effects of alcohol intoxication and does not apply to more chronic hangover symptoms. Recent research has been unable to validate these findings, and have consistently seen no change in strength or power characteristics following acute alcohol ingestion. Contrasting to McNaughton and Pierce, these studies have examined force output using an isokinetic dynamometer as their outcome measure of anaerobic performance. Comparatively time trial sprint performance incorporates a high degree of motor control and coordination and may provide insight as to why these findings cannot be replicated.

### **Effects of alcohol on sports performance**

Alcohol consumption is a major concern in the sports world. It remains one of the most abused drugs among athletes despite the well-known negative effects it can have on the mind and body. Drinking often begins among athletes during the high school years. If you play sports, it's essential that you understand how alcohol can damage -- even destroy -- your athletic ambitions.

### **Muscle development**

Strength training is an important part of getting your body fit for athletic activity, but drinking alcohol can negate the results of your workouts. Its toxic effects also impair your body's ability to produce ATP, which is the primary energy source for your muscles. Alcohol affects your ability to get adequate sleep, resulting in a lack the human growth hormone that helps build strong, larger muscles. It also causes the liver to release a chemical that impairs testosterone, which is a key hormone in muscle development.

### **Aerobic performance**

Aerobic activity involves the use of oxygen to energize the large muscle groups needed to physically perform. It increases blood circulation and your heart rate. Your body's ability to respond aerobically is vital to play many sports, but alcohol can interfere with these physical reactions. It slows respiratory function, affects body temperature regulation and increases your risk for dehydration -- all of which affect your aerobic performance. Dehydration is particularly dangerous, as it can lead to heatstroke, seizures and shock.

### **Cognitive & motor function**

Being able to learn strategies and respond quickly -- both physically and mentally -- are vital when you're playing sports. Alcohol can affect how your brain is able to form memories, resulting in your inability to learn and recall new information. Drinking five alcoholic beverages in one night can affect your cognitive function for up to three days. While low alcohol amounts can improve some motor skills, moderate amounts cause slow reaction time, decreased balance and poor hand-eye coordination.

### **Long-term Effects**

Many of alcohol's effects on sports performance occur quickly, but long-term use can lead to serious repercussions as well. It affects your cardiovascular function in response to physical activity in addition to causing muscle weakness. Chronic drinking also affects your body's ability to absorb essential nutrients including zinc, folic acid and vitamin B12. It can alter your hormonal balance as well as cause heart damage.

### **Effect of alcohol on endurance performance**

Obviously, a major hangover puts a damper on your motivation -- we've all been there. But even moderate alcohol intake can negatively impact your body on the trail. While there's no need for trail runners who are moderate drinkers to suddenly go on the wagon, keep several things in mind.

- Alcohol is a diuretic, and after drinking you may become dehydrated, says Stephen Rice, M.D., director of the Jersey Shore Sports Medicine Center. To stay hydrated, drink more water than you're used to, and bring some on your run, especially if it's over an hour long.
- Also because it's a diuretic, alcohol depletes your electrolytes (potassium and sodium). And despite what your frat bros may have told you, alcohol -- even beer -- is not nutritious. In fact, the American College of Sports Medicine (ACSM) states that orange juice has four times the potassium of beer. So eat bananas or drink OJ for potassium, and drink sodium-containing sports drinks such as Gatorade to replace both potassium and sodium.
- Alcohol left over in your system impairs your body's ability to regulate its temperature. In cold conditions, your body could lose heat more rapidly than normally, and in hot weather your body might not release enough heat. Dress in appropriate layers for the outside temperature. If it's cold, protect your extremities and keep exposed skin to a minimum. Be especially careful not to overheat if you're running in an unusually hot climate and, again, drink plenty of non-alcoholic fluids.
- Even social drinking can have a negative effect on balance and coordination the next day. If you notice that you're having trouble handling the trail's rough surface or negotiating obstacles, "Slow down your pace a bit," recommends Rice. "You'll be able to handle things much better at a slower speed."
- Be aware that even if you don't feel a hangover, the lingering effects of alcohol will impede training and conditioning progress and reduce total work output, according to the ACSM. If you're working up to a goal, a post-drinking run might not bring results.
- If you have a race coming up and need to be really on top of your game, the ACSM recommends skipping

anything beyond "low amount social drinking" for 48 hours prior to the event. It can take your body up to three days to purge itself of alcohol. One drink (sorry) over the course of an evening is your best bet.

### Alcohol and exercise recovery

Most of the studies examining alcohol and athlete recovery have focused predominately on functional measures of muscle performance and blood borne markers of cellular tissue damage. To date, these studies have produced inconclusive results that fail to demonstrate a dose-dependency or critical threshold above which muscular recovery is compromised. Creatine kinase (CK) is an intra-muscular enzyme which when present in the peripheral circulation is widely used as a measure of muscle damage. Despite the clinical association between chronic alcohol abuse and skeletal muscle myopathy, acute ingestion appears to have little impact on exercise-mediated muscular damage the lack of results may be attributable to the parameters measured within these above mentioned trials. CK is highly variable and may not provide the best measure of muscle damage more recently; circulating levels of pro-inflammatory cytokines, released from the musculature may provide alternative measures of muscular stress and damage. Inflammatory processes appear to be variably modulated by chronic and acute alcohol use. Prolonged alcoholism is associated with high circulating levels of pro-inflammatory mediators, whilst conversely acute consumption has been shown to decrease production of TNF- $\alpha$  and (IL-1) in rodent studies. It has yet to be established if cytokine concentrations are altered by acute alcohol ingestion during or immediately following intense exercise.

Similarly to the analysis of markers of muscle damage, the intra-muscular consequences of acute alcohol ingestion on aspects metabolic pathways of recovery are also ambiguous in humans. Alcohol ingestion immediately following prolonged cycling exercise has a modest impact to impair glycogen re-synthesis. This action is dependent in part on alcohol replacing carbohydrates in energy-matched meals. Although acute suppression of glycogen synthesis may have been evident, examination of glycogen repletion over 24 hours demonstrated no long term detrimental impact of alcohol ingestion on muscle glycogen stores.

Of particular relevance to the recovery of strength athletes is the enhanced protein synthesis that occurs post-exercise to facilitate repair and adaptive hypertrophy. Acute alcohol ingestion decreases muscle protein synthesis in a dose- and time-dependent manner, in the absence of an exercise stimulus. Alcohol facilitates this firstly by suppressing the phosphorylation and activation of the mTOR pathways, the critical kinase cascade regulating translation initiation. Complementing the decreased activation of the protein synthetic pathway, alcohol increases the expression of muscle specific E3 ligases; atrogin-1 and Muscle-specific RING finger 1 (MuRF1). These proteins are up regulated by conditions that promote skeletal muscle atrophy. Interestingly this was not associated with increased proteolysis, suggesting alcohol primarily impairs protein synthesis. It remains to be confirmed in rodents subjected either to muscle loading or resistance exercise that alcohol impairs protein synthesis. Subsequent clinical data is also lacking and this remains a critical absence in the scientific literature.

Functionally, the consumption of moderate amounts of

alcohol augments the loss of force associated strenuous eccentric exercise. To the researchers knowledge Barnes, Mündel and Stannard have produced the only research that has used functional measures of muscle performance to identify an interaction between post-exercise muscle damage and alcohol. This research established a significant decrease in average peak isometric, concentric and eccentric torques at 36 hours post-exercise. This decrement appeared to be exacerbated across all three variables in the group that consumed 1g per kg of body weight immediately post-exercise. Whilst this research provides new insights into the effect of alcohol consumption on post-exercise muscle recovery, further research is required to ascertain how this relationship exists and establish the physiological mechanisms governing this response.

### Conclusion

Both the affects of alcohol on human physiology and the parameters that determine athletic performance are multi-factorial and extremely complicated. A significant body of literature has established an array of adverse symptoms caused by acute alcohol ingestion. However the notion that alcohol consumption effects performance has not received enough consistent validation to advance beyond being anecdotal. Nevertheless, just because alcohol is not yet comprehensively shown to have a negative influence on performance, does not imply this review advocates its use prior to, or following competition. Indeed, the data demonstrates a severe lack of analysis on the possible detrimental action of alcohol in the recovering athlete. However, based on the available experimental evidence in cellular and rodent-models, athletes should remain wary of ingesting alcohol following intense exercise, focusing instead on effective dietary strategies proven to enhance recovery.

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