# Alcohol

Ethyl alcohol (ethanol) is the most commonly consumed drug globally, with an estimated 1.6 gallons (6.1 L) consumed by each person (over the age of 15) each year (World Health Organisation, 2014). In the United States, an estimated 2.35 gallons (8.9 L) of pure ethanol is consumed per capita. This places the United States as the 49th highest consumer of ethanol in the world (World Health Organization, 2014). While other alcohols, such as methyl and isopropyl alcohol are commonly used in medical and industrial settings, only ethanol is tolerated, in appropriate amounts, within the body. Even in low doses, other forms of alcohol are extremely toxic and can cause severe illness and death. Ethanol is often overlooked in sports nutrition, as it is not essential for health or performance; however, given its popularity and potential for altering physiological function, an understanding of ethanol and its effects is important.

## Alcohol structure and functions

Given ethanol is produced by the fermentation of glucose, it is not surprising that the two are structurally similar, with each composed of carbon, hydrogen, and oxygen. However, while glucose has six carbons and five hydroxyl (-OH) groups, ethanol is comprised of two carbons and a single hydroxyl group (Figure: Chemical Structure of Ethanol).

Unlike carbohydrates and fat, the metabolism of ethanol is not regulated by hormones and there is no storage depot or circulating pool of ethanol in the body. Ethanol is not essential for biological function and is, therefore, perceived as a homeostatic threat (a toxin of sorts). As such, in order to remove it and its metabolites from the body, the metabolism of ethanol takes priority, above the use of other energy providing macronutrients.

A diagram of a group of hydroxyl groups

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Critical!

Unlike the other macronutrients, ethanol is not required in the diet and, therefore, has no beneficial function.

Ethanol is often considered the fourth macronutrient because, when metabolised, 7.1 kcals per gram of ethanol are liberated as energy—more than carbohydrate and protein and only slightly less than fat. However, while ethanol does provide energy, it is perhaps better to think of it as a psychoactive drug, rather than a macronutrient (Lieber, 2000).

### Alcohol absorption

When an alcoholic beverage is ingested, a small amount of the ethanol in the beverage is immediately metabolised in the gastric mucosa (stomach lining) by alcohol dehydrogenase(ADH) in what is referred to as first-pass metabolism. The majority of ethanol, however, passes unaltered into the bloodstream through the stomach and small intestine by simple diffusion. Once in circulation, the water solubility of ethanol allows it to diffuse into the majority of tissues, particularly the liver, due to the flow of blood directly from the stomach. The rate of absorption and subsequent amount of alcohol circulating in the blood [i.e., blood alcohol content (BAC)] is dependent on a number of factors, including sex, body mass, the type of beverage consumed, whether the stomach is empty, and the speed at which the alcoholic beverage is consumed (Paton, 2005).

**Alcoholic beverages and food**

The adage of “never consuming alcohol on an empty stomach” has some merit, as the absence of food in the stomach is the primary determinant of how quickly ethanol will be absorbed into the bloodstream. The presence of food in the stomach, rather than the type of food, appears to be the most important factor, as no differences in absorption rates are evident between foods high in fat, protein, or carbohydrates (Ramchandani, Bosron, & Li, 2001).

While food slows the absorption of alcohol, it also increases the rate at which ethanol is metabolized, both by first-pass metabolism and metabolism in the liver, as a result of increased liver blood flow, activity of ADH, and rates of NADH, the reduced form of nicotinamide adenine dinucleotide (NAD+) re-oxidation (Ramchandani, Bosron, & Li, 2001). The coenzyme NAD+ and its reduced form, NADH, are essential in glycolysis, gluconeogenesis, fatty-acid oxidation, amino-acid oxidation and the Krebs cycle. Once formed, NADH provides the majority of electrons used for ATP production by oxidative phosphorylation within the mitochondria.

Concentrated alcoholic beverages, such as spirits, will generally produce a greater rise in BAC compared to a beverage with a lower percent of ethanol, as each drink contains more ethanol. However, this effect is influenced by the fed/fasted state. Ethanol from concentrated alcoholic beverages may be absorbed at a greater rate than dilute alcoholic beverages, such as beer, when the stomach is empty. Interestingly, the opposite is true.

Critical!

Food reduces the rate of alcohol absorption and increases the rate of metabolism, thus reducing the rate of rise in BAC. The type of beverage interacts with the fed state to alter ethanol absorption.

When food has been consumed prior to or during alcohol consumption, dilute alcoholic beverages are absorbed at a greater rate than concentrated alcoholic beverages (Roine, 2000; Roine et al., 1993). Additionally, consuming ethanol in carbonated beverages may result in a greater rate of absorption than when consuming alcohol in noncarbonated beverages (Roberts & Robinson, 2007).

**Sex and body composition**

While rates of ethanol absorption and metabolism by the liver are similar in females and males (Mumenthaler, Taylor, O'Hara, & Yesavage, 1999), a given amount of ethanol will typically result in a greater BAC in females due to several physiological differences. Firstly, since ethanol from the bloodstream diffuses down a concentration gradient into all water-containing tissues, BAC in individuals with more total body water, such as males, and those with greater amounts of lean muscle mass will be lower than those with less total body water (Figure: Male vs Female Body Water Content). When total body water is accounted for, no difference in BAC is evident between females and males (Goist & Sutker, 1985).

A silhouette of two people

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Secondly, due to differences in ADH activity in the stomach, first-pass metabolism is greater in males than females, which means less ethanol enters the bloodstream after a male consumes an alcoholic beverage (Baraona et al., 2001). Therefore, caution is needed when individuals of different body sizes, body composition, and sex are drinking together, because the rate of ethanol absorption and subsequent metabolism will not be the same for everyone.

Critical!

Differences in body size, body composition, and enzyme activity mean that females will respond very differently to males when consuming the same amount of alcohol. This needs to be considered when using standard blood alcohol content estimation tools that only compare number of drinks to bodyweight

A table with numbers and numbers

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### Metabolism of ethanol

Once in circulation, 90% of ethanol is metabolised in the liver by ADH at a rate of approximately 0.25 ounces (7 grams) per hour. The other 10% is excreted through breath, sweat, and urine. As the rate of metabolism by the liver is not upregulated in response to greater circulating levels of ethanol, absorption of ethanol at a rate greater than that of ethanol metabolism will see BAC rise accordingly and intoxication will begin. Metabolism of ethanol by ADH results in the formation of acetaldehyde and NADH (Figure: Metabolism of Ethanol). Acetaldehyde is toxic, and is therefore metabolised rapidly and preferentially above other macronutrients to acetate by the mitochondrial enzyme acetaldehyde dehydrogenase (ALDH2). The majority of the acetate, which is not toxic, is released into the bloodstream, taken up by skeletal and cardiac muscle and brain cells, and subsequently converted to the Krebs cycle substrate acetyl-CoA by the enzyme acetyl-CoA synthetase. As occurs in beta-oxidation of fat, acetyl-CoA is then used in the Krebs cycle where it is eventually broken down to carbon dioxide and water via the electron transport chain.

Coach's Corner

For individuals trying to lose body fat, frequent ethanol consumption is particularly counterproductive. The acetate from ethanol metabolism provides ample acetyl-CoA to the aerobic pathways, thus reducing the body's need to utilise its own fat stores. Furthermore, by meeting energy needs with acetate, carbohydrates and fats consumed along with the alcoholic beverage will be treated like any other excess calories and be stored for later, creating a two-fold roadblock to optimal body composition management.

A diagram of a chemical reaction

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An alternative, yet complementary pathway for the metabolism of ethanol is the microsomal ethanol-oxidising system (MEOS) occurring in microsomes of the liver. This pathway is used when the ADH pathway is saturated; for example, when large amounts of ethanol are consumed and it is up-regulated by repeated heavy consumption of alcohol. It is, therefore, more active in alcoholics than in the general population. The MEOS also results in the production of acetaldehyde, which, as described previously, is converted to acetate. However, unlike the ADH reaction, the MEOS oxidises its co-factor, the reduced form of nicotinamide adenine dinucleotide phosphate (NADPH), thus altering the energy coupling of ethanol oxidation and oxidative phosphorylation, resulting in the generation of heat (Foster & Marriott, 2006).

The enzymatic activity of catalase, an enzyme that is responsible for the breakdown of hydrogen peroxide, may also contribute to the metabolism of ethanol in a small and indirect manner. Depending on the pathway used to oxidise ethanol, a maximum of 13 or 8 ATP are produced per ethanol molecule by the ADH or MEOS pathways, respectively.

The metabolism of anything more than a few grams of ethanol can result in disruption in the ratio of NADH and NAD+ within the cytosol of hepatocytes. Under normal conditions, when ethanol is absent or present in very small amounts, NADH is re-oxidised in a timely manner through the shuttling of electrons into mitochondria via the malate-aspartate and glycerophospate shuttles to maintain a low NADH to NAD+ ratio. However, when moderate to large amounts of ethanol are present, the shuttling of electrons is unable to match the production of NADH.

Critical!

Even though there are three pathways, the majority of ethanol metabolism occurs in the liver through the alcohol dehydrogenase reaction.

As many of the reactions that occur within the cytosol are close to equilibrium, this increase in NADH directly impacts dehydrogenase reactions, in particular, the lactate dehydrogenase reaction, which usually metabolises circulating lactate to produce pyruvate. Alterations in this reaction may result in elevations in circulating levels of lactate and subsequent lactic acidosis. Additionally, the reduction in concentrations of pyruvate may impact hepatic gluconeogenesis, which, under conditions of low hepatic glycogen content, may lead to severe hypoglycaemia (Lieber, 2005).

The altered NADH to NAD+ ratio also impacts a number of other metabolic processes, including a shift toward lipogenesis and hepatic fatty-acid accumulation and a shift away from fatty-acid oxidation, which is usually the main source of energy in hepatocytes. This can result in fatty liver disease (Zakhari, 2006) and, if habitual ethanol consumption is not decreased, may result in liver disease, cirrhosis, and cancer (Baan et al., 2007).

Food for Thought

Some individuals, particularly those of Asian descent, may have a deficiency in the acetaldehyde dehydrogenase enzyme. This causes an accumulation of acetaldehyde and a number of associated side effects, including acute flushing (reddening) of the skin and nausea. It is also linked with an increased risk of oesophageal cancer (Brooks, Enoch, Goldman, & Yokoyama, 2009).

## The dietary impact of alcohol

Unlike the other macronutrients, specifically programming ethanol into the diet is not necessary. However, given the popularity of alcohol as a socially acceptable, recreational drug, it is unrealistic to expect complete abstinence in the majority of the population. It is, therefore, important to take alcohol consumption into consideration when planning a healthy diet.

### Alcohol intake guidelines

The *2015–2020 Dietary Guidelines for Americans* (U.S. Department of Agriculture, 2015) recommends that if alcohol is to be consumed, it should be done so in moderation. Moderate drinking is classified as up to one standard drink per day for females and up to two standard drinks per day for males. Alcohol consumption is considered high-risk drinking for females if four or more standard drinks are consumed per day, or if eight or more standard drinks are consumed per week. For males, five or more drinks per day or 15 or more drinks per week is considered high-risk alcohol consumption. At these levels, the risk of alcohol-related harm is greatly increased (U.S. Department of Agriculture, 2015).

Of additional concern, binge drinking is classified as a single episode of drinking where more than four or five standard drinks are consumed, by females and males respectively, over a short time period. Although individuals who regularly binge drink may not necessarily exceed weekly recommendations for ethanol intake, as all ethanol may be consumed on one occasion, this behavior is associated with considerable physical, mental, and societal harm (Figure: Short-Term Health Effects of Binge Drinking; Naimi et al., 2003).

Although ethanol may be well tolerated by most of the population, at least in small to moderate amounts, females who are or may be pregnant, those under the age of 21, and those who are driving or planning to drive a motor vehicle should not consume alcohol.

Critical!

Due to the differing ethanol content of alcoholic beverages and the range of volumes that alcohol is served in, anyone consuming alcohol must be aware of how much ethanol is in each drink to ensure alcohol consumption does not reach hazardous levels. Care is needed when consuming several drinks in a single session, or when a single beverage contains more than one standard drink, so that binging on alcohol does not occur. For example, someone drinking two Long Island Iced Teas over 2 hours will actually consume 7.5 standard drinks! This is more than three times the recommended daily alcohol consumption for males and seven times the recommended amount for females and is, therefore, classified as high-risk, binge drinking behaviour.

**Defining a drink**

The ethanol content of alcoholic beverages differs greatly, ranging from beer, which is typically 4 to 5% ethanol, to spirits, which may contain over 40% ethanol. In order to quantify the amount of alcohol in a beverage and provide a way of monitoring alcohol consumption, a unit, known as a standard drink, or drink equivalent, is used. In the United States, a standard drink is any alcoholic beverage containing 0.6 ounces (14 grams) of ethanol (Figure: Common Beverages with One Standard Drink). By comparison, throughout Europe and the United Kingdom, a standard drink ranges from 8 grams to 18 grams, with the majority of countries classifying a standard drink as containing 10 grams of ethanol. As the amount of ethanol and volume of an alcoholic beverage can differ greatly, simply counting the number of drinks consumed, rather than the amount of ethanol consumed, can be misleading and result in excessive drinking (Table: One Standard Drink Around the World).

A diagram of different types of alcohol

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One Standard Drink Around the World

| **Country** | **Grams of Ethanol in a Standard Drink** | **Recommended Daily Alcohol Consumption** |
| --- | --- | --- |
| Argentina | 14 | Up to 20 g for males and females |
| Australia | 10 | Up to 20 g for males and females |
| Canada | 13.5 | No more than three drinks for males and two drinks for females, up to 15 drinks per week for males and 10 drinks per week for females |
| Chile | 14 | Up to 14 g for males and females |
| China | Not Classified | Up to 25 g for males and 15 g for females |
| France | 10 | Up to 20 g for males and females and no more than 100 g per week |
| Germany | Not Classified | Up to 24 g for males and 12 g for females |
| India | 8 | Up to 16 g for males and 8 g for females |
| Italy | 12 | Up to 24 g for males and 12 g for females and males aged between 18 to 21 and above 65 years |
| Japan | 20 | Up to 40 g for males and 20 g for females |
| Mexico | 13 | 13 to 26 g for males and 13 g for females |
| South Africa | Not Classified | Up to two beers or glasses of wine for males and females |
| United Kingdom | 8 | Up to 112 g per week for males and females |
| United States | 14 | Up to 28 g for males and 14 g for females |
| Visit the International Alliance for Responsible Drinking (IARD) website at [http://www.iard.org](http://www.iard.org/) for a more detailed look at each country's alcohol intake reccomendations. | | |

**Accommodating alcohol into a healthy diet**

Although many alcoholic beverages may contain some macro- and micronutrients, such as beer, which contains carbohydrates and various vitamins and minerals, and wine, which contains polyphenols, antioxidants, and flavonoids, ethanol itself has no additional nutritive value and is, therefore, considered an empty source of energy. The actual energy from ethanol in an alcoholic beverage may be relatively small (about 99.4 kcal); however, many alcoholic beverages contain considerably more energy due to the carbohydrate content of the alcohol itself (Figure: ABV and Calories in Common Drinks) and sometimes more, if a mixer was used in the beverage. This energy must be accounted for in a healthy diet, particularly as alcoholic beverages tend to be consumed in addition to a normal diet, rather than replacing energy from other sources (Yeomans, Caton, & Hetherington, 2003).

Along with solid fat and added sugars, the energy from alcoholic beverages can be considered as discretionary energy; that is, energy from these sources can be used to make up daily energy requirements once nutrient requirements are met. Based on the 2000-kcal-per-day U.S.-style eating pattern (U.S. Department of Agriculture, 2015), 270 kcal per day (14% of total energy intake) may come from discretionary food sources. If alcohol is to be consumed, then the energy from all discretionary sources should not exceed calculated discretionary calories. As such, the amount of fat and added sugar must be reduced accordingly. However, minimising discretionary calories from fat and sugar alongside alcohol consumption is often easier said than done.

Critical!

Energy from alcohol should not displace energy from other food sources that also provide macro- and micronutrients. Energy from alcohol must be accounted for when calculating energy requirements.

A chart of different types of alcohol

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### Alcohol and body composition

According to the NCAA (2013), ethanol can influence body composition because it is stored as fat. But, is this true? The answer is not as straightforward as it seems. Like the way in which excess glucose alters whole-body fat oxidation, excess acetate, produced during the metabolism of ethanol, is transported and oxidised in peripheral tissue at the expense of normal fat oxidation. Unlike the distribution of glucose, this process does not rely on insulin. Oxidation in peripheral tissue is the fate of up to 80% of acetate, with only a small amount (<5%) being directly converted to fat (Siler, Neese, & Hellerstein, 1999).

Further compounding the issue, poor dietary choices are often made before, during, and after alcohol is consumed, leading to excess caloric intake, when both large and moderate amounts are consumed (Lloyd-Richardson, Lucero, DiBello, Jacobson, & Wing, 2008; Foster & Marriott, 2006). These factors, coupled with the fact that physical activity levels tend to decrease as habitual ethanol intake increases (Liangpunsakul, Crabb, & Qi, 2010), highlight the importance of monitoring and moderating ethanol consumption to ensure fat mass is not increased.

Interestingly, individuals who consume ethanol in moderate amounts have been shown to have less fat mass than both abstainers and heavy drinkers (Foster & Marriott, 2006). Females, in particular, appear to benefit from moderate alcohol consumption (Beardsley, 2014; Thomson et al., 2012), while waist to hip ratio, and therefore abdominal adiposity, is closely associated with ethanol consumption in males (Beardsley, 2014; Liangpunsakul et al., 2010).

When consumed regularly at high levels, ethanol may reduce lean muscle mass (alcohol myopathy) through dose-dependent reductions in testosterone (Gordon, Altman, Southren, Rubin, & Lieber, 1976), protein synthesis (Kimball & Lang, 2018), and the actions of reactive oxygen species created during MEOS (Jolley & Molina, 2017). Taken together, the metabolic disruptions and physiological alterations ethanol can cause have the potential to alter body composition; however, many of these effects are dose and sex-specific, with men who drink large amounts of ethanol likely to be affected the most.

### Monitoring alcohol use

When planning a diet, it is essential to understand the individual’s habitual dietary behaviour, including their alcohol consumption, so that all energy sources and factors that may affect overall health are considered. In order to identify an individual’s habitual alcohol consumption and risk of alcohol-related harm, the U.S Alcohol Use Disorders Identification Test (USAUDIT-C) is recommended as a first step (Higgins-Biddle & Babor, 2018). This abbreviated version of the full AUDIT (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001) has been adapted to take into consideration the higher amount of ethanol in a U.S. standard drink and the U.S. low-risk drinking guidelines, which differ slightly from other countries.

Comprised of three questions, the USAUDIT-C provides an indication of whether an individual is drinking alcohol at harmful levels—above recommended guidelines. A total score of seven or more for males and five or more for females is a positive score; however, due to losses in lean body mass during old age, men over the age of 65 use the same 5 or more criteria for a positive score similar to women. The number of drinks consumed weekly can be calculated by multiplying number of drinks (Q1) and frequency of drinking (Q2). The answer to Q3 provides an indication of the frequency of binge drinking. The higher the total score from the three questions, the greater the likelihood of alcohol-related harm. If an individual has a positive score, further questioning, using the remaining seven AUDIT questions (Babor et al., 2001) is recommended in order to understand alcohol dependence and harm. Depending on the results of the full AUDIT (USAUDIT-C + AUDIT), an individual may require alcohol education, counselling, or a brief or significant intervention in order to minimise the risk of alcohol-related harm in the future.

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## The physiological and health effects of alcohol

The recommendation to consume ethanol in moderate amounts stems from the detrimental acute and chronic physiological effects ethanol has on the body. As a water-soluble toxic substance, ethanol and its main metabolites have the ability to affect a number of tissues in the body. These effects are both the reason individuals drink alcohol and the reason moderation is recommended (Figure: Health Effects of Alcohol).

Regular consumption of moderate to harmful levels of ethanol has been linked to an increased risk of over 200 health conditions. These include, but are not limited to, a number of cancers (including the most common forms of cancer: breast, prostate, and colorectal cancer), cardiovascular disease, neuropsychiatric conditions, gastrointestinal diseases, and diabetes mellitus (WHO, 2014). Females are particularly susceptible to ethanol-related diseases and illness; of particular concern is the increased risk of breast cancer with even moderate amounts of ethanol (Scoccianti, Lauby-Secretan, Bello, Chajes, & Romieu, 2014). Ethanol consumption contributes to over 88,000 deaths annually in the United States and over 3.3 million deaths globally (USDA, 2015; WHO, 2014).

Critical!

Although ethanol may provide some protection against some diseases, in general, there are no health benefits from drinking alcohol. Furthermore, on the gradient of “How much does this help me?” there are many other factors that play a bigger role in offering health benefits than alcohol alone.

A diagram of a person's body

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### Effects on the central nervous system

The popularity of ethanol as a legal drug is due to its depressant effects on the central nervous system (CNS) (Table: Alcohol Effects on the Nervous System). Once absorbed, ethanol (but not acetaldehyde) readily crosses the blood-brain barrier, allowing it to act at a number of locations within the CNS in a dose-dependent manner; the greater the dose the more extreme the effect (Reilly, 2002). Acute, moderate ethanol consumption will significantly alter cortical excitability and the way signals are transmitted in the CNS; these changes are responsible for many of the cognitive impairments associated with intoxication (Kähkönen, 2005; Volkow et al., 2008). Additionally, increased activity in the limbic region, through the actions of dopamine and serotonin, reinforce the pleasure associated with ethanol consumption, making it a highly addictive drug (Volkow et al., 2008).

Over time, the consumption of ethanol at harmful levels can result in significant, permanent structural and functional damage to the brain. Such damage can cause memory loss, learning difficulties, psychosis, mental confusion, and, in extreme cases, paralysis (Thomsom, Heap, & Shaw, 1994). Abstinence from ethanol and dietary supplementation with thiamine may reverse some of the structural and functional deterioration; however, for some, the damage will be irreparable (Ridley, Draper, & Withall, 2013).

Alcohol Effects on the Nervous System

| **Blood Alcohol Level (mg/100ml blood)** | **Blood Alcohol Content (BAC %)** | **Effects** |
| --- | --- | --- |
| 30 | 0.03 | Enhanced sense of well-being, retarded simple reaction time, impaired hand-eye coordination, and increased risk of having an accident |
| 60 | 0.06 | Mild loss of social inhibition, impaired judgement, and increasing cheerfulness |
| 90 | 0.09 | Marked loss of social inhibition, coordination reduced, and noticeably under the influence |
| 120 | 0.12 | Apparent clumsiness, loss of physical control, tendency towards extreme responses, and definite drunkenness noted |
| 150 | 0.15 | Erratic behavior, slurred speech, staggering gait, quarrelsomeness, and exuberance |
| 180 | 0.18 | Loss of control of voluntary activity and impaired vision |
| 400 | 0.400 | Oblivion, sleepiness, and coma |
| 500 | 0.500 | Death possible |
| 600 | 0.600 | Certain death |

### Effects on the cardiovascular system

Drinking ethanol is likely to acutely increase heart rate and, to a lesser extent, blood pressure. The increase in heart rate compensates for the well-documented decrease in left ventricle contractility that occurs when ethanol is consumed (Horwitz & Atkins, 1974) No significant changes in cardiac output are observed with moderate to high levels of alcohol consumption (Kupari, 1983). Chronic, harmful ethanol consumption is linked to an increased risk of coronary heart disease and alcoholic cardiomyopathy (Guzzo-Merello, Cobo-Marcos, Gallego-Delgado, & Garcia-Pavia, 2014).

In hot environments, ethanol-related increases in peripheral vasodilation (increased blood flow to the skin), along with increased feelings of being hot, (T. Yoda et al., 2005) can be cause for concern. Caution should also be taken when consuming ethanol in cold environments, as perceptions of cold and thermal discomfort are reduced (Tamae Yoda et al., 2008), which may lead to a greater time exposed to the cold. Both scenarios put an individual at risk of developing hypothermia.

Coach's Corner

When consuming alcohol, drink with food or on a full stomach to slow the rate of intoxication. Avoid drinking large amounts of alcohol in hot or cold environments and keep track of the number of *standard drinks* you are consuming, not simply the number of drinks.

### Effects on immune and hormonal function

Chronic alcohol use has long been associated with altered immune function, as evident in chronic alcoholics who often exhibit increased susceptibility to a range of infectious diseases (Cook, 1998). However, acute alcohol consumption may also negatively impact immune function, thus making the drinker more susceptible to infection (Greiffenstein, Mathis, Stouwe, & Molina, 2007; Szabo, 1999) and impacting recovery after illness or trauma.

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Additionally, at certain doses, ethanol can alter normal hormone secretion with a reduction in testosterone in men and an increase in oestrogen in both sexes (Emanuele & Emanuele, 2001; Emanuele, Wezeman, & Emanuele, 2002). These changes may impact muscle mass, bone density, fertility, and sexual function (Emanuele & Emanuele, 2001; Van Thiel et al., 1980) and may contribute to the increased risk of breast cancer in females (Sarkola, Mäkisalo, Fukunaga, & Eriksson, 1999).

A poster of alcohol effects on performance

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### Alcohol myths and hot topics

As with the three macronutrients (carbs, protein, and fat), the "fourth macro", alcohol, is surrounded with misinformation that can bring considerable confusion to the discussion of how it fits within a generally healthy lifestyle. The following section will address and discuss some of the more prolific myths and hot topics regarding alcoholic beverages and how they impact overall health and wellness.

**Ethanol helps protect the cardiovascular system**

Light to moderate regular ethanol consumption has been suggested, by association, to reduce total mortality and protect against cardiovascular disease and stroke (Agarwal, 2002). High in antioxidant polyphenols, red wine, in particular, has consistently been shown to improve a variety of health outcomes, including reducing the risk of cardiovascular disease, hypertension, some cancers, and diabetes. As such, daily moderate consumption (one to two standard drinks) of red wine is recommended, as part of a healthy diet (Snopek et al., 2018).

Conversely, recent studies (Knott, Coombs, Stamatakis, & Biddulph, 2015; Stockwell et al., 2016) challenge the popular view that moderate ethanol consumption may provide benefits for health. To date, the strongest evidence against ethanol’s health enhancing/protective effects comes from a study based on data analysed from 1990–2016 across 195 countries (Adhikari, 2018). Although this study identified some protective effects of ethanol against heart disease and diabetes in females, these were offset by other negative health consequences. Overall, not only did this study fail to find any ethanol-related health benefits, the authors concluded that no level of ethanol consumption was safe. Irrespective of the amount consumed, ethanol consumption appears to negatively impact health and contribute to premature death, particularly in males. These recent findings have implications for alcohol regulators as current alcohol guidelines may, in fact, overestimate how much alcohol is safe.

**Drinking ensures a good night’s sleep**

On the face of it, drinking an alcoholic beverage before bed may seem like a great way to get to sleep. After all, ethanol’s depressant effects on the CNS lead to drowsiness and reduce the time it takes to fall asleep, irrespective of how much ethanol has been consumed. However, once asleep, ethanol can disrupt normal sleep patterns so that the quality of sleep, measured by the time spent in REM and non-REM sleep and total time asleep is reduced. Non-REM deep sleep is considered as regenerative, mainly due to the release of growth hormone, and, although this type of sleep is increased when ethanol is consumed, growth hormone secretion by the pituitary gland is decreased (Roehrs & Roth, 2001).

For the athlete, reduced sleep quality and quantity as well as the associated decrease in growth hormone may have a number of implications, including suppressing immune function, impairing next-day cognitive functioning, and reducing physical performance. Additionally, a reduction in growth hormone secretion may also have implications for tissue repair, protein synthesis, and subsequent growth (Fullagar et al., 2015). For athletes who may already suffer from poor sleep quality and quantity as a result of training, competition, travel, and social factors (Drew et al., 2017; Halson et al., 2017), the consumption of ethanol in the hours prior to sleep should ideally be avoided or minimised.

**Alcohol improves athletic performance**

The use of alcohol to improve athletic performance has it foundations in ancient Greece where, as part of his diet, the great Olympic champion Milo of Croton was said to have consumed 2.6 gallons of wine a day (Harris, 1966). While this is an unlikely tale, the popularity of consuming ethanol as an ergogenic aid before and during sport and exercise continued until the middle of the 20th century. Unbeknownst to these early athletes, ethanol consumed prior to or during exercise has no performance enhancing benefits and, in fact, is more likely to be ergolytic, particularly when consumed in higher amounts.

Short duration efforts, such as sprinting and one-off, simple-strength tasks do not appear to be affected even at high BACs. However, for longer duration, aerobic exercise performance is reduced with greater effects seen as the amount of ethanol consumed increases (Barnes, 2014). Importantly, the reductions in coordination, reaction time, and decision making at even moderate BACs may reduce the ability of an athlete to execute exercise technique or other training-related motor tasks efficiently and safely. Combined, these effects strongly suggest that there is no place for ethanol consumption prior to training or exercise.

Drinking ethanol before and during exercise is rare, although not unheard of; however, drinking after exercise is a more likely scenario, with athletes more likely to binge on alcohol at higher rates than non-athletes (Sønderlund et al., 2014; Tavolacci et al., 2016; Veliz, McCabe, & Boyd, 2016). Drinking alcohol in amounts similar to those reported by athletes may negatively impair recovery from exercise-induced muscle damage in males (Barnes, Mündel, & Stannard, 2010a & 2010b), but not females (Levitt et al., 2017; McLeay, Stannard, Mundel, Foskett, & Barnes, 2017).

However, even when very-high doses of alcohol are consumed, if muscle damage is not considerable or the type of exercise performed prior to drinking is not novel, then recovery may be minimally affected (Levitt et al., 2018; Murphy, Snape, Minett, Skein, & Duffield, 2013; Prentice, Stannard, & Barnes, 2014).

Large amounts of ethanol, consumed after resistance exercise, alter hormone secretion (Vingren & Kraemer, 2006) and reduce protein synthesis (Duplanty et al., 2017; Parr et al., 2014) and inflammation, (Levitt et al., 2016) suggesting that ethanol has the potential to impair adaptation to resistance exercise. Whether this is the case is currently unknown. As with recovery from damaging exercise, similar responses to ethanol as those seen in males are not necessarily evident in females (Budnar, 2015; Duplanty et al., 2017) possibly as a result of the female sex hormone oestrogen.

Food for Thought

As a population, college athletes tend to binge on alcohol and are more at risk of alcohol-related harm than other populations in the United States (Martens, Dams-O'Connor, & Beck, 2006) and other countries (O’Brien et al., 2012; Zhou & Heim, 2014). Although drinking behaviour may differ between intramural/club athletes who regularly consume alcohol at hazardous levels and intercollegiate athletes who drink less often but consume very-large quantities when they do drink, both groups of athletes are at an increased risk. The difference in drinking behaviour between the two groups may be due to the more structured nature of intercollegiate sport and the more time intramural athletes have for socialising (Barry, Howell, Riplinger, & Piazza-Gardner, 2015; Marzell, Morrison, Mair, Moynihan, & Gruenewald, 2015). Additionally, team sport players, who have a strong athlete identity often consume alcohol in very-large, harmful amounts. The opposite is true of athletes in individual sports; the stronger their athlete identity is, the less they are likely to drink (Zhou, Heim, & O'Brien, 2015). College athletes drink alcohol as a reward for the hard work they put in during training and competition, to celebrate success (Pitts, Chow, & Donohue, 2018), and as a way to deal with sport-related stress (Martens, Pedersen, Smith, Stewart, & O'Brien, 2011). Educating college athletes about the harm, both physical and social, that alcohol can do is important. The success of such education can be helped greatly if the coach takes an appropriate attitude toward harmful drinking by showing concern for the athlete’s alcohol use and by being less permissive of this type of behaviour (Mastroleo, Marzell, Turrisi, & Borsari, 2012; Pitts, Chow, & Yang, 2018).

If ethanol is to be consumed after exercise, then, in order to ensure the effects of ethanol on recovery and subsequent performance are minimised, normal post-exercise nutritional recommendations should be followed prior to consuming alcohol. Alcohol consumption should be delayed, until foods containing carbohydrates and protein are eaten. This will ensure substrates are available for glycogen resynthesis and protein synthesis and are not replaced by energy from ethanol. Remember from earlier in the chapter, ethanol is preferentially metabolised by the body, negatively impacting repair. Although ethanol will not worsen the level of post-exercise hypohydration (Hobson & Maughan, 2010), rehydration prior to consuming large volumes of alcohol is also recommended (Evans, James, Shirreffs, & Maughan, 2017).

The main form of alcohol contained in the recreational beverages we drink is ethanol. Because ethanol is metabolised in such a unique way, it is often referred to as the fourth macronutrient. But ethanol has no nutritive value and the acetate produced when metabolising it can get in the way of the body oxidising its own fat. When used in moderation, alcohol can, in fact, have some positive benefits for an individual's overall health and wellness; however, it can quickly transition to a harmful (or even deadly) substance when consumed in excess.

Alcohol is the most widely consumed drug on Earth, so it is important for Nutrition Coaches to understand the wide range of effects is has on the body. By understanding how alcohol is absorbed and metabolised (while considering the physiological differences between males and females) Nutrition Coaches can help their clients stay on track with their health-and-wellness goals while still having a little fun on the side!

In this chapter, you learned about:

* The makeup of common alcoholic drinks.
* The chemical structure of ethanol.
* How consumed ethanol is processed and eliminated from the body.
* Ethanol absorption and metabolic differences for men and women.
* The cognitive and health impact of consuming ethanol.
* How the body uses metabolised ethanol for energy.

Strategies for incorporating alcoholic drinks into a healthy diet.