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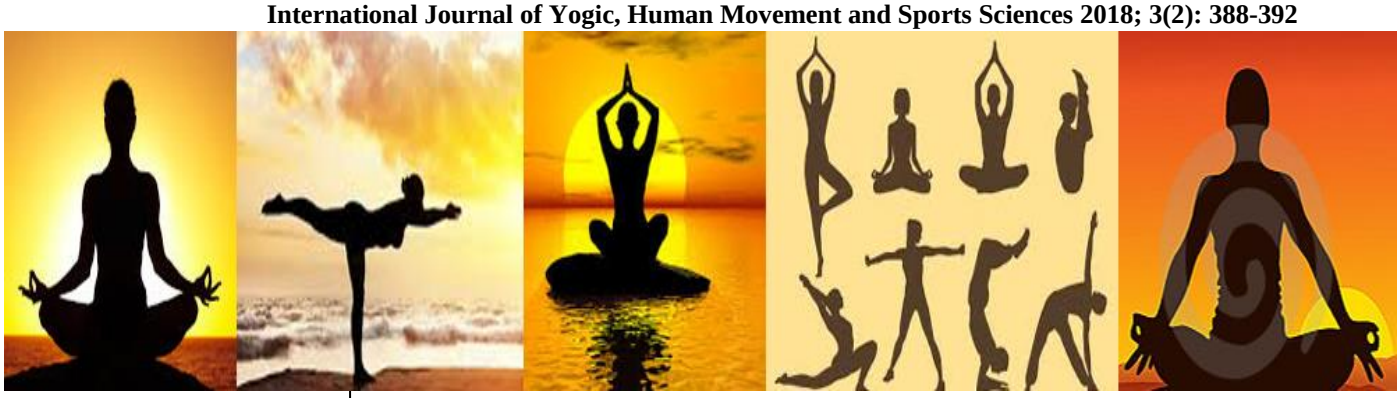

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Use of milk for sports performance

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Abstract
The composition of milk is influenced by various factors: the genetic and nutritional status of the animal, environmental conditions, stage of lactation… On average, milk is composed of 87% water, 4 to 5% lactose, 3% proteins, 3 to 4% lipids, 0.8% minerals and 0.1% vitamins.
Milk is the first food for humans, and it is seen as the only richest natural food in terms of the nutritional elements the body needs. Similarly, it provides many of the nutritional elements necessary for the growth and maintenance of the human body, in adequate amounts. The human body is in need of milk and its properties throughout their life as it is useful for all ages and groups. Milk represents a more nutrient dense beverage choice for individuals who partake in strength and endurance activities, compared to traditional sports drinks. Bovine low-fat fluid milk is a safe and effective post exercise beverage for most individuals, except for those who are lactose intolerant.
Athletes have good reason to focus on nutrition: replacing fluid and nutrients after an intense work out helps repair and replenish muscles and maintain strong bones. If nutrients are not replaced during and after exercise, athletes experience fatigue and may not be able to keep up the intensity of their workouts.
One beverage that is often overlooked as a recovery drink is milk. Milk's nutrients-protein, carbohydrates, vitamins, minerals and water-are rapidly absorbed and metabolized by the body to produce energy during and replenish nutrient stores after activity. New research shows that milk consumed as a post-exercise recovery and rehydration beverage is just as effective, if not more so, than commercially-available sports drinks, and can increase muscle growth.
One of the key nutrients in milk is protein. The recommended dietary allowance (RDA) for protein for healthy adults is 0.4 grams per pound of body weight, however for athletes it may be higher.

Keywords: Milk, nutritional, RDA, various factors

Introduction
Athletes have good reason to focus on nutrition: replacing fluid and nutrients after an intense work out helps repair and replenish muscles and maintain strong bones. If nutrients are not replaced during and after exercise, athletes experience fatigue and may not be able to keep up the intensity of their workouts.
One beverage that is often overlooked as a recovery drink is milk. Milk's nutrients—protein, carbohydrates, vitamins, minerals and water—are rapidly absorbed and metabolized by the body to produce energy during and replenish nutrient stores after activity. New research shows that milk consumed as a post-exercise recovery and rehydration beverage is just as effective, if not more so, than commercially-available sports drinks, and can increase muscle growth. One of the key nutrients in milk is protein. The recommended dietary allowance (RDA) for protein for healthy adults is 0.4 grams per pound of body weight, however for athletes it may be higher. So, a growing teenage athlete who weighs 160 pounds needs 144 - 160 grams of protein per day and a 120 pound woman who exercises recreationally needs 60 - 90 grams.
One cup of low-fat dairy foods in California contains 10 grams of protein per cup (milk produced in other states contains 8 grams). Whey protein in milk may confer additional benefits to physical performance. Whey protein contains an ideal balance of essential amino acids that cannot be produced by the body, and branched-chain amino acids which ensure proper muscle tissue growth.
Athletes requiring extra protein can easily reach their recommendation by enjoying one or two more servings of high-protein foods such as milk, cheese, eggs, nuts or lean meat. There is no need for protein or amino acid supplements, however--it is best to get protein from food

sources throughout the day for the right combination of readily-digestible amino acids.

Milk is also a good source of carbohydrates. Carbohydrates consumed within thirty minutes after exercising will be transported to muscles for immediate use or stored as glycogen for the next activity. Failing to consume adequate carbohydrates after exercising can lead to fatigue and muscle soreness.

The vitamins and minerals in milk are important for maintaining good health and optimizing athletic performance. Most dairy foods contain vitamins A and D. Vitamin A maintains healthy tissue growth while vitamin D helps the body utilize minerals such as calcium and phosphorus. The minerals found in milk-calcium, potassium and magnesium 5-help maintain strong bones, proper muscle functioning and fluid balance.

Nutritional components in milk

This page describes the function of nutritional components in milk: Energy, Water, Carbohydrate, Fat, Protein, Vitamins, M inerals, and Minor Biological Proteins & Enzymes. Links are provided to move the reader to pages that present the content of specific nutrients in milk, important background information on the chemistry of milk carbohydrate (lactose), fat, protein, and enzymes.

Energy

The energy in milk comes from its protein, carbohydrate and fat content, with the exception of skim milk that has virtually no fat. Food provides energy to the body in the form of calories (kcal). There are many components in food that provide nutritional benefits, but only the macronutrients protein, carbohydrate and fat provide energy. The energy value of a food is calculated based on the calories provided by the amount of protein (4 kcal/gram), carbohydrate (4 kcal/gram), and fat (9 kcal/gram) that is present.

Water

Milk is approximately 87% water, so it is a good source of water in the diet. Water does not provide a nutritional benefit in the same manner as proteins or vitamins, for example. However, water is extremely important in human metabolism. Water is a major component in the body. Water maintains blood volume, transports nutrients like glucose and oxygen to the tissues and organs, and transports waste products away from tissues and organs for elimination by the body. Water helps to lubricate joints and cushions organs during movement. Water maintains body temperature regulation through sweating. Lack of water (dehydration) results in fatigue, mental impairment, cramping, and decreased athletic performance. Severe dehydration can be life-threatening.

Carbohydrate

Milk is approximately 4.9% carbohydrate in the form of lactose. Carbohydrates are the primary source of energy for activity. Glucose is the only form of energy that can be used by the brain. Excess glucose is stored in the form of glycogen in the muscles and liver for later use. Carbohydrates are important in hormonal regulation in the body. Lack of adequate levels of glucose in the blood and carbohydrate stores leads to muscle fatigue and lack of concentration. Lactose is a disaccharide made up of glucose and galactose bonded together. Before it can be used by the body, the bond must be broken by the enzyme lactase in the small intestine. People that have decreased activity of lactase in the small intestine may have problems digesting lactose and this is referred to as lactose intolerance or malabsorption.

Fat

Milk is approximately 3.4% fat. Fats are a structural component of cell membranes and hormones. Fats are a concentrated energy source and are the main energy source used by the body during low intensity activities and prolonged exercise over 90 minutes. Fat is the main storage form of excess energy in the body. Fats cushion organs during movement.

There are 2 fatty acids that are considered "essential" that cannot be made by the body and must come from the diet, and these are linoleic (18:2) and linolenic (18:3) acids. These fatty acids are used to synthesize the longer chain fatty acids arachidonic acid (AA, 20:4o-6), docopentaenoic acid (DPA, 22:4o-6), eicosapentaenoic acid (EPA, 20:5o-3) and docohexaenoic acid (DHA, 22:6o-3). These fatty acids are essential for the synthesis of hormones such as prostaglandins, thromboxanes, and leukotrienes that are involved in muscle contraction, blood clotting, and immune response.

Protein

Milk is approximately 3.3% protein and contains all of the essential amino acids. Proteins are the fundamental building blocks of muscles, skin, hair, and cellular components. Proteins are needed to help muscles contract and relax, and help repair damaged tissues. They play a critical role in many body functions as enzymes, hormones, and antibodies. Proteins may also be used as an energy source by the body.

Nine amino acids must be obtained from the diet and are referred to as the "essential" amino acids: leucine, isoleucine, Valine, phenylalanine, tryptophan, histidine, threonine, methionine, and lysine. Proteins that contain all 9 essential amino acids are often called "complete" proteins. Proteins of animal origin and soy are complete proteins, whereas proteins from grains and legumes are missing 1 or more of the essential amino acids, which means that consumers must eat complementary foods in order to get all of the essential amino acids.

Milk protein consists of approximately 82% casein and 18% whey (serum) proteins. Both casein and whey proteins are present in milk, yogurt, and ice cream. In most cheeses the casein is coagulated to form the curd, and the whey is drained leaving only a small amount of whey proteins in the cheese. During cheese making, the 6-casein is cleaved between specific amino acids and results in a unique protein fragment that is drained with the whey. This fragment, called milk glycomacropeptide, does not have any phenylalanine and can be used as a source of protein for people with phenylketonuria, the inability to digest proteins that contain phenylalanine. Whey proteins have become popular ingredients in foods as an additional source of protein or for functional benefits. Whey proteins are used as a protein source in high protein beverages and energy bars targeted to athletes. Some examples include the use of whey proteins to bind water in meat and sausage products, provide a brown crust in bakery products, and provide whipping properties that replace a portion of egg whites.

Whey proteins contain immunoglobulins which are important in the immune responses of the body. Whey proteins contain branched chain amino acids (leucine, isoleucine, and valine) and have been proposed to have some benefits to athletes for muscle recovery and for preventing mental fatigue.

Vitamins

Vitamins have many roles in the body including metabolism co-factors, oxygen transport and antioxidants. They help the body use carbohydrates, protein, and fat. The functions of vitamins are described below in alphabetical order.

Vitamin A is a fat soluble vitamin involved in vision, gene expression, reproduction, and immune response. The compounds with vitamin A activity are called retinoids and are found in foods in different forms – typically animal foods provide retinol and retinyl esters, and plant foods provide ß-carotene, a starting molecule (precursor) for vitamin A synthesis. Milk contains retinol, retinyl esters, and ß-carotene. Dairy products are a good source of vitamin A, although the vitamin A

The content of thiamin (vitamin B1) in milk. Thiamin is a water soluble vitamin that is an enzyme cofactor involved in the metabolism of carbohydrates and branched chain amino acids.

The content of riboflavin (vitamin B2) in milk. Riboflavin is a water soluble vitamin that is an enzyme cofactor involved in electron transport reactions. Milk is a recommended source of riboflavin.

The content of niacin (vitamin B3) in milk. Niacin is a water soluble vitamin that is an enzyme cofactor involved in electron transport reactions required for energy metabolism.

The content of pantothenic acid (vitamin B5) in milk. Pantothenic acid is a water soluble vitamin that is an enzyme cofactor in fatty acid metabolism. Milk is a good source of pantothenic acid.

The content of vitamin B6 (pyridoxine) in milk. Vitamin B6 is a water soluble vitamin involved in the metabolism of proteins and glycogen (energy stored in the liver and muscles), and in the metabolism of sphingolipids in the nervous system. An 8 oz serving of 2% milk contains approximately 7% of the DRI for vitamin B6.

The content of vitamin B12 (cobalamin) in milk. Vitamin B12 is a water soluble vitamin involved in protein metabolism and blood functions. Milk is a recommended source of vitamin B12. An 8 oz serving of 2% milk contains approximately 47% of the DRI for vitamin B12.

The content of vitamin C in milk. Vitamin C is a water soluble vitamin that is an important antioxidant. It has a role in collagen formation in connective tissue and helps in iron absorption and healing of wounds and injuries. There is a negligible amount of vitamin C in milk, and a serving of milk contains less than 1% of the DRI for Vitamin C.

The content of vitamin D in milk. Vitamin D is a fat soluble vitamin that is important in maintaining blood calcium and phosphorus balance and assists calcium metabolism. Milk is typically fortified with vitamin D. Fortified milk is a good source of vitamin D, and an 8 oz serving of 2% milk contains over 50% of the DRI for vitamin D.

The content of vitamin E in milk. Vitamin E is a fat soluble vitamin that has antioxidant activity. The compounds with vitamin E activity are the tocopherols and tocotrienols. Milk contains a small amount of vitamin E, which increases with increasing fat content of dairy products. An 8 oz serving of whole milk contains 1% vitamin E, and an 8 oz serving of 2% milk contains only 0.5% of the DRI for vitamin E.

The content of folate in milk. Folate is one of the water soluble B vitamins. Folate is an enzyme cofactor important in the metabolism of proteins and nucleic acids and blood functions. There is a small amount of folate in milk. An 8 oz serving of 2% milk contains 3% of the DRI for folate.

The content of vitamin K in milk. Vitamin K is a fat soluble vitamin involved in blood clotting, bone metabolism, and protein synthesis. Milk contains a small amount of vitamin K, which increases with the fat content in dairy products. An 8 oz serving of milk contains less than 1% of the DRI for vitamin K.

Minerals

Minerals have many roles in the body including enzyme functions, bone formation, water balance maintenance, and oxygen transport. They help the body use carbohydrates, protein, and fat. The functions of minerals are described below in alphabetical order.

The content of calcium in milk is shown in the Nutrient Content Tables. Calcium plays an essential role in bone formation and metabolism, muscle contraction, nerve transmission and blood clotting. Dairy products are a significant source of calcium in the diet. Milk is a recommended source of calcium, and an 8 oz serving contains almost 30% of the DRI for calcium.

The content of copper in milk is shown in the Nutrient Content Tables. Copper is a component of enzymes used in iron metabolism. Milk contains a small amount of copper. An 8 oz serving of 2% milk contains approximately 3% of the DRI for copper.

The content of iron in milk is shown in the Nutrient Content Tables. Iron is a component of blood and many enzymes. It is involved in blood metabolism and oxygen transport. Milk contains a small amount of iron, and an 8 oz serving of milk contains less than 1% of the DRI for iron.

The content of magnesium in milk is shown in the Nutrient Content Tables. Magnesium is an enzyme cofactor and is important in bone metabolism. Milk is a recommended source of magnesium, and an 8 oz serving of 2% milk contains approximately 7% of the DRI for magnesium.

The content of manganese in milk is shown in the Nutrient Content Tables. Manganese is involved in bone formation, and in enzymes involved in amino acid, cholesterol, and carbohydrate metabolism. There is a small amount of manganese in milk. An 8 oz serving contains less than 1% of the DRI.

The content of phosphorus in milk is shown in the Nutrient Content Tables. Phosphorus is involved in maintaining body pH, in storage and transfer of energy, and in nucleotide synthesis. Milk is a recommended source of phosphorus, and an 8 oz serving of milk contains over 30% of the DRI for phosphorus.

The content of potassium in milk is shown in the Nutrient Content Tables. Potassium is an electrolyte that is important in the maintenance of water balance, blood volume and blood pressure. Dairy products are a recommended source of potassium, and an 8 oz serving of milk contains approximately 8% of the DRI for potassium.

The content of selenium in milk is shown in the Nutrient Content Tables. Selenium is important in oxidative stress response, electron transport, and regulation of thyroid hormone. Milk is a good source of selenium, and an 8 oz serving of 2% milk contains approximately 11% of the DRI for selenium.

The content of sodium in milk is shown in the Nutrient Content Tables. Sodium is an electrolyte that is important in the maintenance of water balance and blood volume. An 8 oz serving of milk contains approximately 7% of the DRI for sodium.

The content of zinc in milk is shown in the Nutrient Content Tables. Zinc is a component of many enzymes and proteins,

and is involved in gene regulation. Milk is a good source of zinc, and an 8 oz serving contains approximately 10% of the DRI for zinc.

Minor biological proteins & enzymes

Other minor proteins and enzymes in milk that are of nutritional interest include lactoferrin and lacto peroxidase. There are many other enzymes in milk but these do not have a role in human nutrition.

Lactoferrin is an iron binding protein that plays a role in iron absorption and immune response. Many other functions of lactoferrin have been proposed, but their confirmation is still under study, including protection against bacterial and viral infections, and it's role in inflammatory response and enzyme activity. The use of lactoferrin as an antimicrobial agent is discussed in the section on Antibacterial Properties of Milk in this website.

Lacto peroxidase is an enzyme that, in the presence of hydrogen peroxide and thiocyanate, has antibacterial properties. The use of lacto peroxidase as an antimicrobial agent is discussed in the section on Antibacterial Properties of Milkin this website. Lacto peroxidase does not provide antimicrobial protection to fresh milk because hydrogen peroxide is not normally present in milk – it must be added to activate this system.

Lipases, a group of enzymes that break down fats, are present in milk but are inactivated by pasteurization, which increases the shelf life of milk. A popular belief among raw milk consumers is that the native lipase in milk plays an important role in the digestion of fat. Fat digestion begins in the stomach with gastric lipase, and the majority of fat digestion occurs in the small intestine, using enzymes secreted by the pancreas. The relative importance of the native milk lipase in digestion compared to the pancreatic lipases is not clear.

Lactase (ß-galactosidase) is the enzyme responsible for the breakdown of lactose into glucose and galactose for digestion. There is no lactase present in fresh milk. Any lactase present in milk products comes from lactic acid bacteria that are either added to milk on purpose, as in the case of yogurt and cheese, or that enter milk from airborne or other contamination. A popular belief is that people with lactose intolerance are able to drink raw milk but not pasteurized milk because the lactase present in raw milk is inactivated during pasteurization. Because there is no lactase present in fresh milk, this concept is a myth. People with lactose intolerance have, themselves, lower levels of lactase which creates problems when it comes to digesting large amounts of lactose in a timely manner. Naturally occurring lactase used to digest milk is normally secreted by the small intestine. Lactase found in any lactic acid bacteria present will minimally help to digest lactose when it is released as the milk is digested in the small intestine.

Milk health benefits

- Building and Maintaining bone and teeth.
- Preventing cardiac diseases
- Keeping the blood pressure at a normal rate.
- Protecting against some types of cancer such as colon cancer.
- Diminishing the likelihood of developing the diabetes.
- Keeping and improving the performance of the nerve system.
- Helping in growth
- Improving the digestion process.
- Boosting the immunity.
- Protecting the eyesight.
- Maintaining the skin, hair, and delicate membranes.
- Treating the dehydration.
- Providing the body with energy.

Milk's Makeup

According to the National Dairy Council, milk is filled with nine essential nutrients that benefit our health:

- **Calcium:** Builds healthy bones and teeth; maintains bone mass
- **Protein:** Serves as a source of energy; builds/repairs muscle tissue
- **Potassium:** Helps maintain a healthy blood pressure
- **Phosphorus:** Helps strengthen bones and generate energy
- **Vitamin D:** Helps maintain bones
- **Vitamin B12:** Maintains healthy red blood cells and nerve tissue
- **Vitamin A:** Maintains the immune system; helps maintain normal vision and skin
- **Riboflavin (B2):** Converts food into energy
- **Niacin:** Metabolizes sugars and fatty acids

Summary

In other words, milk packs quite a punch when it comes to nutrition-and you don't have to drink a gallon to reap the benefits, the National Dairy Council says. In fact, the council says that just one 8-ounce glass of milk provides the same amount of vitamin D you'd get from 3.5 ounces of cooked salmon, as much calcium as 2 1/4 cups of broccoli, as much potassium as a small banana, as much vitamin A as two baby carrots and as much phosphorus as a cup of kidney beans!

Table 1: Breaking down the nutritional elements in a cup of milk

Nutrients	Low-Fat Milk	Fat-Free Milk	Full-Fat Milk
Calories	102	86	146
Fats	2mg	0mg	8 mg
Cholesterol	12mg	5mg	24mg
Sodium	107mg	128mg	98mg
Carbohydrates	13mg	12mg	13mg
Sugar	13mg	12mg	13mg
Proteins	8mg	8mg	8mg

One beverage that is often overlooked as a recovery drink is milk. Milk's nutrients-protein, carbohydrates, vitamins, minerals and water-are rapidly absorbed and metabolized by the body to produce energy during and replenish nutrient stores after activity. New research shows that milk consumed as a post-exercise recovery and rehydration. Athletes requiring extra protein can easily reach their recommendation by enjoying one or two more servings of high-protein foods such as milk, cheese, eggs, nuts or lean meat. The vitamins and minerals in milk are important for maintaining good health and optimizing athletic performance.

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