

WATER & HEALTH

How water protects and improves health overall

HYDROLIFE

Definition of a global framework
for Hydration



FEMTEC

WORLD FEDERATION OF HYDROTHERAPY AND CLIMATOTHERAPY
NGO IN OFFICIAL RELATION WITH WHO (WORLD HEALTH ORGANIZATION)

Water is Life, Wellness and Health *Manifesto*

Water is essential for our body to function. *It helps digestion, absorption of nutrients and elimination of indigestible metabolic wastes, and also facilitates blood circulation. Water carries nutrients and all other substances across our body and regulates body temperature. Water is essential for human life as physically and biochemically all biological processes need water to occur.*

As part of a healthy diet, *water ensures proper hydration at any age. Drinking the right amount of quality water is vital considering how important hydration is for people's health and wellness, cognitive abilities, physical performance and regulation of body temperature.*

By removing toxins, *water detoxifies our body and makes it stronger, reinforcing its self-healing ability and enhancing health. As a detoxifying agent, water is crucial to prevention and cure.*

The World Health Organization (WHO) sees water as a resource *that is key to promote health and wellness of individuals and communities around the world. In 1994, the European Commission's Scientific Committee on Food (Italy's Daily Reference Intakes -LARN- 1996) stated that a healthy diet is to include not only vitamins but also minerals and water in the respective recommended daily intake amounts, to maintain fluid and electrolytes balance. That was the first time dietary reference intakes included water, recognizing its key role in human diet and body functions.*

Water is the best fluid *for hydrating the human body. This is to be made clear, especially in Western countries where obesity is on the rise and has been associated with high-calorie drinks that often replace water as a source of fluids.*

We need to drink often, *throughout the day, before we feel thirsty. Thirst is a signal that our body is already low on fluids and on the way to dehydration (i.e. that we don't have replenished enough fluids).*

Even a modest drop in our body's water supply affects *not only our physical condition but also our mental abilities as it can lead to problems such as impaired short-term memory and reduced attention span, difficulties with math, fatigue, reduced psychomotor speed and perceptual decision-making speed. Lack of water in the human body can worsen digestion, increase the likelihood of infections and allergic reactions, cause musculoskeletal pain (trunk pain), headache and generalized joint pain.*

Proper hydration is beneficial for ...

Kidney function. *Drinking enough water is important to prevent a number of diseases, ailments and disorders, such as kidney stones, urinary tract infections and constipation.*

Helping to manage non-communicable disease. *It is well-established that regular over consumption of sugar-sweetened beverages is linked to increased energy intake, weight gain and obesity in children and adults, as well as an increased risk of developing type 2 diabetes, cardiovascular disease, and gout. Adopting healthy drinking behaviours by switching from sugary-sweetened beverages to healthier beverages such as water, would help to manage non-communicable disease.*

Brain function. *Dehydration impairs brain efficiency and cognitive process. A drop in water supply by one liter leads to dehydration of brain tissues impacting brain function with effects that are similar to those seen after two and a half months with Alzheimer's disease.*

Immune system function. *Regular intake of water increases glucocorticoid and catecholamine levels. It therefore facilitates adaptation to stress and determines modifications in lymphocyte subpopulations, in particular T-suppressor cells, through induced changes in cytokine messages.*

Intake of calcium, *which is an essential nutrient especially for strong bones. Calcium-rich water is a source of bio-available calcium similar to dairy products.*

In the light of the foregoing evidence we call upon all Countries to include adequate hydration as part of a healthy diet among the key priorities for health protection.
And to make this an ongoing and long-lasting commitment we invite the leading international organizations, the United Nations and the World Health Organization, to soon adopt a World Hydration Day, to raise awareness of the importance for all people to take and keep the habit of drinking water which is key to ensure the health of future generations.

This Manifesto was prepared on the basis of the Consensus Document "Water & Health. How water protects and improves health overall" (A FEMTEC initiative with the technical support of the WHO) and the speeches at the conference "Hydration and Health, the hidden link", Milan EXPO 2015, June 11, 2015.

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World Hydration INITIATIVE

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Water & Health

How waters protects and improve health overall

**HYDROLIFE Definition of a global
framework for Hydration**

**A FEMTEC initiative
with the technical support of the
World Health Organization (WHO)**

Preamble

Water is the most valuable resource for life. Water makes up 70% of the human body, it is the 'cradle of life' and is essential for our development since conception. Water is key to preserve and promote human health and wellbeing in all their varied aspects and across all life stages.

Water is also closely connected with civilization, as evidenced and celebrated in literature, architecture and art.

Water's physical and chemical properties, different uses and healing power were already well-known to the Romans from whom our 'water culture' originates. To them we owe medicinal bathing, the precursor of today's thermal medicine which is grounded in the great progress made by modern medical science and technology.

Today we are all familiar with most of the roles water plays in our body and aware of the importance that drinking the right amount of quality water has for appropriate hydration.

Water is crucial for our survival because biochemical reactions and all the physiological processes that keep us in good health and ensure our wellbeing throughout our life need water to take place.

In fact, there is not a single body function – from cell nutrition to matrix purification, from breathing to joint lubrication - that can do without water. Lastly, it should be noted that water plays a role in preserving our physical and mental capabilities.

Average daily water intake, including with food, should be approximately 2.5 litres. Poor fluid intake may result into a range of disorders, from minor to severe ones, according to the extent of the deficit.

Appropriate hydration is therefore a key pillar of modern healthy lifestyles. Environmental conditions, climate, and lifestyle affect the body's homeostasis, which can only be restored by the intake of water that is rich in mineral salts and properties.

In his book *Water, a comprehensive treatise* (Plenum Press, N.Y. 1973), Berlin scientist Felix Franks wrote: "Of all the known fluids, water is probably the most thoroughly researched, yet the least understood."

Being conscious of the importance of providing correct information to both specialists and consumers, FEMTEC is releasing this "initiative document" to present reliable scientific data based on specific methodological criteria, on the importance of hydration for human health and wellbeing and as a crucial component for the global promotion and advancement of health and wellbeing.

Founded in 1937, FEMTEC (the World Federation of Hydrotherapy and Climatotherapy, (www.femteconline.org) is one of the most representative associations of Thermal

Medicine and Hydrotherapy and coordinates the activity of the sector's national institutions in over 30 countries. FEMTEC entertains official relations with the World Health Organization (WHO), with which it cooperates to develop and implement programmes for the scientific use of Complementary Medicine.

The Federation closely cooperates with the ISMH (International Society of Medical Hydrology), as well as with Universities and Ministries of Health in several Member States.

Before concluding, we wish to express our appreciation to those who participated in the drafting of this document. In addition to the Members of the Steering Committee, we particularly acknowledge our colleagues Cristiano Crotti and Emilio Minelli for their dedication and competence.

Prof. Umberto Solimene, President of FEMTEC

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BRIEF DESCRIPTION OF THE PROJECT

HYDRATION AND TRADITIONAL MEDICINE (T&CM), WHO

For many years and in many papers, adequate hydration has been indicated as one of the ways to promote wellbeing and protect health.

In particular, the use of water falls within the broader realm of traditional medicine in relation to:

- detoxification techniques;
- hydrotherapy;
- medicinal use of water combined with phytotherapy.

Since 2007 hydrotherapy as a whole has been taken as a reference by the TRM/CM Team at the WHO Headquarters in Geneva, and the different uses of mineral water have been included in the WHO 2014-2023 Strategies for Traditional Medicine (www.who.int).

THE SCIENTIFIC AND MODERN USE OF HYDRATION

8 What people in traditional cultures knew from experience and knowledge passed on from generation to generation is now grounded in modern science with evidence supporting the benefits of adequate hydration and the specific action of various types of water on the different organs and systems of the human body.

Knowing this information can lead to safer, more effective, and appropriate use of mineral water both by consumers and practitioners.

METHODOLOGY

For a thorough analysis of the complex role of hydration in the preservation of human health and well-being we chose a multi-dimensional approach (anthropological, ethnobiological, medical-scientific, biochemical, pharmacological, biological) focusing, in particular, on the systematic review of scientific literature in relation to clinical efficacy and safety.

The review of literature was aimed at gathering information on water properties, uses – both traditional and modern – and specific actions on the different organs and systems, as well as applications at specific stages and ages in human life. Whenever possible, in addition to clinical trials we also included select mechanistic studies carried out on animal models.

PURPOSE OF THE PROJECT

Applying the method above, the ultimate purposes of this project are:

- providing a univocal definition of hydration;
- highlighting the importance of water and hydration for the different components and functions of the human body;
- collecting and presenting scientific data on efficacy, safety, and right approach to hydration;
- providing objective information and guidance to professional practitioners and consumers.

01

Introduction

People's approach to water has traditionally been characterized by mixed feelings. As told in many stories and myths, throughout history and in different regions of the world, people have been threatened by severe floods, which they miraculously survived. And yet as theories about the origin of the world explain, water is what makes life possible, and the fact that 70% of the human body is made of water reminds us of our primeval origin.

Death by water and yet life by water and rebirth by water. People across the centuries have often associated water with both physical and spiritual purification and return to life. Not surprisingly, then, water played and still plays a crucial role in the pursuit of wellbeing, and has been used to achieve good health. Often people have sought and found in sacred and miraculous water springs effective resources for disease prevention and healing.

Traditional therapies – including phytotherapy – are also based on water, used as an ingredient in century-old and yet new medicinal preparations, such as tisanes or herbal teas. So, it does not come as a surprise that today, in the biomedical age, people tap the wealth of past experience with water uses, while trying to get scientific information about the indications for, and limits of water drinking for health and wellbeing and, particularly, about the basic mechanisms that relate hydration with the resulting sensation of global energy, which makes water a simple, effective, safe, holistic, low-cost solution to be in good health.

Getting a comprehensive view of the use and action mechanisms of both old and modern hydrotherapy requires a thorough review of human history from the very first experiences human beings had of the use of water for wellbeing and health purposes, through Greek and Roman bath and spring water culture to modern scientific studies on the benefits of hydration in terms of reduced morbidity and mortality, as well as improved quality of life.

02

**Water and
Traditional &
Complementary
Medicine (T&CM)**

2.1 T&CM and wellbeing

Traditional and Complementary Medicine (T&CM) has a long history.

It is the sum total of the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, used in the maintenance of health, as well as in the prevention, diagnosis, improvement or treatment of physical and mental illnesses.¹

The terms complementary/alternative/non-conventional medicine are used interchangeably with traditional medicine in some countries.²

Ever since its foundation and then the drafting of the *Millennium goal 2000 Health for all*³, the World Health Organization (WHO) has acknowledged the strategic role of traditional medicine in contributing to human health and wellbeing and has issued a series of guidelines to ensure safety, efficacy, and quality of traditional medicine, help building the evidence base starting from its traditional use and promote its recognition. In its latest strategy document *Traditional Medicine Strategy: 2014-2023*⁴, the WHO reiterated the need to build the knowledge base, develop national policies, and promote the safe use of T&CM through research and integration.

2.2 Traditional medicine and hydrotherapy

According to the WHO definition⁵, Traditional Medicine (TM) includes:

«a set of health practices, approaches, notions, and beliefs that involves the use of medications based on plants, animals, and/or minerals, spiritual therapies, manual techniques, and activities, used individually or in combination to preserve wellbeing, treat, diagnose, or prevent illnesses.»

Most of traditional medicine disciplines are very old and their epistemological background can be defined as proto-scientific rather than anti-scientific, as they formed at a time when the scientific method at the basis of modern medicine did not exist.

But traditional medicine is built on a valuable wealth of knowledge developed by different communities over the centuries, on an inexhaustible source of theoretic and

1 WHO (2000). *General guidelines for methodologies on research and evaluation of traditional medicine*. Geneva, <http://apps.who.int/medicinedocs/pdf/whozip42e/whozip42e.pdf>.

In its latest strategy document *Traditional Medicine Strategy: 2014-2023* the WHO reiterated the need to build the knowledge base, develop national policies, and promote the safe use of T&CM through research and integration. http://apps.who.int/iris/bitstream/10665/92455/1/9789241506090_eng.pdf

2 In many countries, the terms “complementary medicine” and “alternative medicine” refer to a broad set of health care practices that are not part of the country’s own tradition and are not integrated into the dominant health care system.

3 The Alma Ata Declaration on primary health care was adopted during the International Conference on Primary Health Care held on September 6-12, 1978 in Alma Ata, Kazakhstan. Its final slogan was «Health for All by the year 2000». http://www.euro.who.int/_data/assets/pdf_file/0009/113877/E93944.pdf

4 WHO (2013). *Traditional Medicine Strategy: 2014-2023*. Geneva, http://apps.who.int/iris/bitstream/10665/92455/1/9789241506090_eng.pdf

5 WHO (2000). *General guidelines for methodologies on research and evaluation of traditional medicine*. Geneva, <http://apps.who.int/medicinedocs/pdf/whozip42e/whozip42e.pdf>

practical experiences, and has proven to valuably contribute to the promotion and protection of human health in a much more cost-effective way than conventional Western biomedicine.

Being based on beliefs and experiences, traditional medicine is more readily accepted by most traditional communities, that are, instead, wary of Western conventional medical practices.

And over the past two decades, traditional medicine has significantly expanded and gained popularity in the West as well, for a number of reasons, including its:

- low or no toxicity;
- efficacy;
- holistic approach to the patient;
- enhancement of each patient's self-healing potential;
- prevention approach to health;
- lower costs.

Hydrotherapy is one of the oldest traditional medicine disciplines. Its roots run deep, reaching back to ancient Greek and Roman medicine, widely used in all the areas ruled or under the influence of the Roman empire, and enriched through the contributions of the various cultures encompassed within that empire, including those of Northern and Eastern Europe, as well as the Middle East and North Africa.

2.3 Primary health care

T&CM and hydrotherapy share some key principles:

- health is not just the absence of illness or disease, but a state of complete physical, mental, and social wellbeing; it is a human right; and the achievement of the highest possible degree of health is one of the world's main social goals, whose attainment involves other social and economic domains. Pursuing this goal requires combining the effort of health-care systems and of broader socioeconomic groups of the population;
- primary health care is to reflect the social, cultural, and political framework as well as the economic conditions of a country and its communities, and its development is to build on all this. Primary health care is to include education on major health issues and methods for disease prevention and control; promotion of appropriate food supply and nutrition, appropriate supply of drinking water and basic sanitation; mother and child care, including family planning; immunization against major infectious diseases; prevention and control of local endemic diseases; appropriate treatment of common diseases and disorders, and availability of basic medications.

Within this framework, for its nutritional and purifying properties and also as a true form

of therapy, including its use as a solvent or diluter for the extraction and administration of the active ingredients of medicinal plants, water is a component of T&CM.

And being used to extract active ingredients by cold maceration, soaking in it plants and herbs, or to obtain infusions or herbal teas by infusion or decoction, combining phytotherapy and water treatments, water has always effectively promoted people's health.

Phytotherapy is one of the oldest, most geographically widespread and most popular forms of traditional medicine.

The idea that the human body is largely made of water as well as the practice of drinking water including as a way to wash away toxins from our body and to regenerate ourselves, date back to the dawn of time.

2.4 Meanings and symbols of water in traditional cultures

Water in traditional cultures is often connected with purification and renewal practices. Exploring the signs and symbols to which water is related can improve understanding of their origin, in that these represent the cultural traces of the vision of self in anthropological terms.

A vision which projects onto the world thus making up the scenarios that are at the origin of the myths, and at the same time, onto the individual, where it combines with a set of layered empirical wisdoms and determines the development of practices and methods on which traditional medicine is built.⁶

In ancient traditional cultures water is often connected with rituals of renewal, regeneration, purification.

This is reflected in New Year rituals that, according to traditions, can regenerate time and, therefore, life.^{7,8}

Ancient Egyptian creation myths held that water was the first thing to exist - even before God's ordaining word - and that the earth, the sun and everything else first originated by emerging from the Primeval Ocean (Nun). The same idea is also found in the Holy Bible, e.g. in the following lines of the Book of Genesis:

«Now the earth was formless and empty. Darkness was on the surface of the deep. God's Spirit was hovering over the waters», and «God said: let the water under the sky be gathered to one place, and let dry ground appear.»

6 Eliade M. *Immagini e simboli: saggi sul simbolismo magico-religioso*. Jaca Book, Milan 1981

7 Eliade M. *Le Mythe de l'Eternel Retour*. Gallimard, Paris 1949 (It. transl.: Il mito dell'eterno ritorno, Rusconi, Milan 1975)

8 Eliade M. *Storia delle credenze e delle idee religiose*. BUR Biblioteca Univ. Rizzoli, Milan 2006

Not surprisingly, then, in most traditional cultures water is not only consumed for nutritional purposes, but is also associated with purification and renovation rituals and methods.

One of the most popular uses of water for the promotion of health and wellbeing, now organized into a form of therapy, is thermal hydrotherapy.

2.5 Water for people's wellbeing and health

Water, and drinking water in particular, is now so broadly available that we tend to take it for granted. Indeed, human beings have always adopted all kinds of strategies to search for water and to make it available and drinkable.

These efforts started even before the discovery of fire ignition by rubbing two sticks together. Methods to improve the taste and smell of drinking water were documented as early as in 4000 B.C. Whilst historical data often contains mentions of the appearance of water (unpleasant look, unpleasant smell or taste), it took thousands of years for people to acknowledge that their senses were not accurate enough to judge the quality of water for drinking.

Today, we know that water quality is key for human health and wellbeing and, as noted earlier, is part of primary care strategies to protect people's health, whatever their social status or region of residence.

In this respect, several international programmes stress the importance of water for development and human health, because:

- the lack of access to drinking water is the primary cause of hunger, illness, and poverty in the developing world;
- without water, crops fail and cattle die, people starve and lose strength. Weakness allows illness to take its toll and lastly, the *silent killer* – hunger – prevails. On the other hand, when a community can rely on fresh, clean water, a new life starts – released from the threat of famines and the whole host of health issues associated with hunger;
- the lack of drinking water is the main cause of illness – about 80% of illnesses – around the world today. Tens of thousands of people die every day from causes related to water contamination;
- at times of drought, water resources decrease destroying agriculture in the region and forcing the rural population to leave and travel hundreds of miles;
- water is the lifeblood of a community. When water is unsafe, the whole community suffers. Children lack energy to go to school and learn, youths do not have the strength to work hard – and poverty spreads.

The solution to change the desperate conditions that affect many regions around the world is not just providing food supplies to starving people when there is a humanitarian

crisis, usually caused by a drought, but find adequate water resources.

The lack of clean water severely impacts entire populations, but it is well known and proven that poor water intake affects individuals as well, by reducing concentration⁹, arithmetic efficiency¹⁰, short-term memory^{11,12}, reaction time¹³, and impacting other indirect indicators of wellbeing.

9 Hypertext110. Gopinathan PM, Pichan G, Sharma VM (1988). *Role of dehydration in heat stress-induced variations in mental performance*. Arch. Environ. Health 43, 15–17. <http://www.ncbi.nlm.nih.gov/pubmed/3355239>

10 *Ibidem*

11 Hypertext111. Wilson M, Morley E, *Impaired cognitive function and mental performance in mild dehydration*. European Journal of Clinical Nutrition (2003) 57, Suppl 2, S24–S29. doi:10.1038/sj.ejcn.1601898. <http://www.nature.com/ejcn/journal/v57/n2s/full/1601898a.html>

12 Hypertext112. Cian C, Barraud PA, Melin B, Raphel C. *Effects of fluid ingestion on cognitive function after heat stress or exercise-induced dehydration*. Int J Psychophysiol. 2001 Nov;42(3):243-51. <http://www.ncbi.nlm.nih.gov/pubmed/11812391>

13 Hypertext113. Grandjean A, Grandjean N. *Dehydration and Cognitive Performance*. *Journal of the American College of Nutrition*, Volume 26, Supplement 5, 2007. <http://www.ncbi.nlm.nih.gov/pubmed/17921464>

03

Water and detoxification

3.1 What is detoxification?

Detoxification is a therapeutic action based on the calibrated activation of organs or intermediate structures of the body's excretory systems, through a combination of varied body treatments, natural remedies and diet, to remove toxic substances from the body. It involves six areas of the human body: the liver, the lungs, the skin, the kidneys, the intestines, and the extracellular matrix.

3.1.1 The origin of detoxification

Detoxification's roots run deep into the history of medicine.

The earliest references to it, in fact, are found in the works of Hippocrates (Kos, approx. 460 B.C. – Larissa approx. 377 A.D.), one of the greatest physicians of ancient times. Hippocrates claimed that:

«Waste fluids need to be specifically directed through the most convenient ways towards the place they tend to move to.»

Hippocrates saw detoxification as a physiological process, whose effective implementation required the identification of the natural excretory tendencies of each individual and each disease. Thus, for example, if a disorder is caused by an accumulation of bile, the liver needs to be drained through the gallbladder and intestines, whereas if fluid retention occurs, excretion needs to be promoted through the urinary tract.

The lesson of Hippocrates was clearly understood by Paracelsus, a great innovator of medical science in the Renaissance (Einsiedeln, Zürich, 1493 – Salzburg, 1541). Commenting on Hippocrates, he said:

«Hippocrates provides useful instructions for the removal from the body of substances that are harmful to health. Some physicians pursue healing with laxatives, others with emetics, others yet with diuretics or even perspiration. However, no general rule exists: physicians need to acknowledge the direction in which nature tends to lead the drainage of substances that are harmful to health. Nature is the best healer, man comes next.» «When nature starts seeking a way of disposal, physicians need to help it use the selected way: because nature is the best healer, it knows which way is best for disposal.» «If nature gives a sign, you need to understand what it refers to and, without any other references, you need to help it express itself. If you feel pain in a given point, you know that nature wants an excretory action at that point. If there is no natural excretory way, create one, because nature wants to have it.»

In 1806, Samuel Hahnemann (1755-1843), a German physician, published *The Medicine of Experience*, a work that contains the fundamental ideas of homeopathy (from the

Greek ομείος ‘similar’ and πάθος ‘illness’). According to Hahnemann, every organism has a weak part that is more prone to attacks and the origin of illness is a change inside the body. Therefore medications should be selected according to the patient’s symptoms, rather than to the disease that is thought to have caused them. Based on the Hippocratic *principle of similars* (*similia similibus curantur which means ‘like cures like’*), medications should be selected on the ground of the similarity observed between the effects they cause and the patient-reported symptoms, and should be administered in small doses:

«To treat a disease, sufferers should be administered a remedy that would cause the same disease if they were healthy.»

Detoxification acquires significance within the framework of the homeopathic theory and practice. Preparing the body for the reaction that the remedy, appropriately selected, will trigger within the body is essentially the role that homeopathy attributes to detoxification: the reaction in question, in fact, often occurs in the form of expulsion. The preparation of excretory organs to ensure that expulsion occurs in a fit body and as physiologically as possible is therefore an integral part of treatment.

The use of natural water with specific mineral characteristics or as a solvent or diluter of phytotherapeutic substances has undoubtedly a long history as one of the most popular and most geographically spread methods for detoxification.

20

The idea that the human body is a body of water and the practice of regenerating ourselves with the intake of ‘new’ water that washes away toxins and other waste with ‘old’ water, in fact, date back to the dawn of time.

3.1.2 The dual target of detoxification

Toxins are generally the main target of detoxification, whose function is essentially expelling intoxicating substances from the body. Toxins have a dual origin and nature and are divided in two classes: endogenous toxins that are intrinsically *produced* inside the body; and exogenous toxins that are introduced from the surrounding environment.¹⁴ Endogenous toxins are the waste produced by our body in its metabolic functioning, e.g. bacteria, dead cells, ingested and degraded food residues. If not appropriately expelled, these toxins cause the obstruction and subsequent intoxication of cells. Endogenous toxins include harmful compounds produced by intermediary metabolism. However unbelievable, the energy production processes supporting our life often generate substances that are extremely harmful to our health.

¹⁴ Luster MI, Rosenthal GJ. *The immunosuppressive influence of industrial and environmental xenobiotic*. TIPS; 1986: 408-412

This is the case with, for example, free radicals.

Formed in preceding energy production processes at mitochondrial level, they are necessary for our survival, because they help our body to fight and kill viruses, as well as to dispose of the cancer cells that at times our body produces.

However, if generated in excess, free radicals can attack enzymes, cell membranes (both from the inside and from the outside of their coat), and DNA itself, causing cell degeneration or necrosis.

Similar, albeit not identical, intoxication processes can be triggered, for example, as a consequence of acid development following muscular effort. Endogenous toxins can be countered, for some time and in limited amounts, by the body's own homeostatic protection systems. However, in case of overproliferation and accumulation in the body, they can cause severe illnesses.

In addition to endogenous toxins, there are, as mentioned earlier, exogenous intoxicating factors. As described below, exogenous intoxicating factors are produced by common environmental pollution, and include the toxic substances and the true poisons contaminating the water and food we consume, the ground we walk on, and the air we breathe. Exogenous toxins are mainly conveyed or produced by material flows, where heavy metals (nickel, cadmium, aluminium, lead, mercury) add to artificial compounds (such as solvents, alcohol, formaldehyde, food additives, or dyes).

Exogenous toxins are also disseminated by mediating agents (i.e. through long-range diffusion, transport and chemical/biological reaction processes, for example passing through the food chain), and include chemical substances such as pesticides, herbicides, or simply nitrogen and phosphorus-based fertilizers (whose intensive use causes widespread soil and underground water contamination in densely inhabited areas, such as the Po valley).¹⁵

The primary and secondary material and energy flows that as a result of human activities are incessantly released into the environment, form, as a whole, complex and multi-faceted toxic agents that are almost impossible to avoid.¹⁶

3.1.3 Water - the foundation of life

Life first developed in the sea: saltwater is a natural saline solution and contains the necessary energy to generate life. All forms of life on Earth, in fact, originated from the sea. Today we can see how life developed by looking at the development of a human embryo. The embryo goes through all stages of evolution: 250 million years of biological

¹⁵ Solimene U, Brugnoli A, Minelli E. *Meteoropatie*. Edizioni red!, Novara 2002

¹⁶ Rousseau D. *Your home, your health, your well-being*. Hartley and Marks, 1998

evolution are condensed in nine months of pregnancy, from the single-cell organism to the conscious living being. The amniotic fluid in which the embryo grows is a saline solution – water and 1% salt, at a temperature of 37°C. The human body as a whole has everything it needs to survive and generate new life. Each individual, in fact, has self-healing abilities and self-regulatory mechanisms that preserve and, if necessary, restore the natural balance in physiological functions – the so-called homeostasis, first explained by W.B. Cannon¹⁷:

«The health of our body, starting from the cells, depends on the self-regulatory ability of every living being to maintain a stable internal balance despite changes in the external environment.»

Intoxication and the resulting toxins first generate one or more changes in the *homeostatic systems* and their components. Following an intoxication, the affected homeostatic system can no longer make up for the imbalance and gradually develops pathological conditions, first with disrupted functioning followed by organic damage. If purification or detoxification does not promptly occur, body conditions deteriorate into more and more severe pathological conditions.

3.1.4 A unique example of homeostasis: the matrix

22

Water accounts for 70% of the human body, and covers 70% of the Earth's surface. Water permeates every cell of our body in the form of bodily fluids, such as blood, lymph, and intra-and intercellular fluids; allows communication among different cell tissues; conveys substances; carries nutrients; removes metabolic waste, controls cell osmotic pressure and body temperature. Additionally, it is involved in digestive, metabolic, and cardiocirculatory functions and in the removal of toxins from the body through the kidneys, blood, skin, and lungs.

The reason for the high amount of water in our body is easy to understand: body fluids surrounding cell tissues, are for cells, the vehicle to attracts nutrients and remove waste, while providing a means to support cross-cell communication and allowing all the cells, including fixed parenchymal cells, to interact through the secretion and reuptake of messenger molecules into the flow.

Today, great importance is attached to the fluid in the mesenchymal intracellular space – called extracellular matrix¹⁸ – for its role in sustaining and detoxifying the parenchyma.

17 US physiologist Walter Bradford Cannon (1871-1945) is acknowledged for introducing the term *homeostasis* and for articulating the *cortico-diencephalic theory* or *theory of emotions*, by which the origin of emotions is located in the hypothalamus..

18 Albergati F, Bacci PA, Mancini S, *La matrice extracellulare. Struttura, ruolo e funzioni nella clinica*, Minelli Editore 2004

The extracellular matrix, in fact, works as a filter for incoming and outgoing micronutrients and toxins through the parenchymas.

Given that the fluids that pervade the body make up the environment for the development of human cells, clearly, any change in this environment can significantly affect the overall health or pathological conditions of the body.

The cells that make up the different types of connective tissues are coated inside, and joined together outside, by a single substance, the matrix, an organic *medium* made up of a fibrous portion enclosed in a gel solution, which can be found either in the liquid and soluble state, known as sol, or as a gel.

The entire cell metabolism, in both its components of nutrition and detoxification (that imply, respectively, the supply of nutrients and oxygen through the arteries and the expulsion of carbon dioxide and catabolites through the veins), is founded in the relations between the cells and the matrix and is closely connected with the sol or gel state of the matrix itself. Nutrition and removal of waste from the body, in fact, depend on the status of the mesenchyme that, in the sol state, i.e. when more fluid, allows better waste removal, whereas in the gel state, i.e. when thicker, is more susceptible to intoxications and accumulations that over time can damage various cell and body functions.

The matrix is a true structure, not just a tissue supporting cells. It is the true *basic regulation system* of the body and, through it, any change in our body's internal or external environment affects cell functioning. This fundamental substance is at the core of the efficiency of our body's defence system: communication between cells and the outer environment occurs through the huge amount of information that the matrix can store and convey to the cells as instructions for their physiological functioning.

The matrix is the *superorgan* of the human biosystem. This is where autonomic nerve fibres terminate and where psycho-neuro-endocrine-immune (PNEI) information travels through neuroendocrine substances (such as neurotransmitters, neuropeptides, hormones) or cytokines. The matrix is also where immune cells reside and inflammatory processes develop.

Cell functioning physiology therefore depends on the anatomical and functional integrity of the matrix and is a final consequence of its cleanness, pureness, and detoxification.¹⁹

3.1.5 From matrix intoxication to body intoxication

The causes of toxification of the liquid environment surrounding the cells are multiple, and most were discussed above, but we can generally say that any surplus of harmful

¹⁹ Murray TM, Pizzorno JE jr. *Trattato di medicina naturale*. red edizioni 2001, pp. 475-489

substances, such as toxins or microbes, can result into matrix gelification and intoxication.

Similarly, a deficit or lack of fundamental trophic substances (including vitamins, macro and trace elements, or nutrients) or a significant or excessive amount of substances that are usually found in the body (including cholesterol, uric acid, or urea) can delay, interrupt, or anyway disrupt the overall chemical processes of cells, with subsequent generation of toxins that are discharged into the matrix, causing its malfunction and the production of cascade effects on other body organs and systems.

The toxin overload, in fact, affects the cells and tissues directly. Matrix thickening delays or stops the circulation of all fluids at micro and macro level. The subsequent slowdown of cell perfusion hampers, or even prevents exchanges between the cell and the matrix, and interrupts the flow of outgoing toxins and incoming oxygen-bearing nutrients.

Alterations of matrix composition parameters and constants interfere with cell metabolism and may cause a number of related disorders that mostly depend on which cell compartments are specifically affected.

Consequently, a number of diseases can only be healed by purifying the matrix. Detoxification is a fundamental step in the therapeutic action aimed at treating any illness to allow the body to benefit from all the healing opportunities offered by the therapist. In fact, cell, tissue, and organ revitalization is often achieved through deep purification allowing the cell mesh to recover its lost vitality.

24

The detoxification theory is therefore closely connected with the need to expel from the body the toxins generally produced by functional cell metabolism alterations. Toxins, in fact, act on the amount and quality of the enzymes involved in metabolic reactions and can negatively affect the overall appropriate functioning of the body starting at sub-cell level. As a consequence of the onset of illness, some tissue parameters are also altered, such as pH or salt, vitamin, nutrient, and catabolyte concentrations.

Toxin accumulation in the body can ultimately interfere with electric charge flows and, particularly, hamper the functioning of the enzyme/coenzyme system, with subsequent alterations of related biochemical reactions.

3.2 Steps and guidelines for a detoxification strategy

Whatever the selected therapy, a prerequisite for any detoxification action and the foundation for its success is that the excretory element triggered by the therapy (whether an entire system, an intermediate structure, or a single organ) be completely available for the removal of toxins from the body. A high volume of toxins, as a consequence of an underlying intoxication or following the unusually strong action of an adopted

remedy, can, in fact, be very dangerous.²⁰

As already mentioned, the excretory organs used by the body to eliminate waste include the liver, lungs, skin, kidneys, intestines, and extracellular matrix. Due to the physiology of the excretory activity, the kidneys and liver are subject to the greatest stress.

The *Liver*, in particular, suffers the consequences of an unhealthy diet, that puts it under strain as a result of which the entire metabolic activity of the body is slowed down. When there is a surplus of toxins to be metabolized, the liver's purifying capacity gets saturated and, as the liver can no longer eliminate them, toxins remain in the bloodstream. To cleanse the liver, smoking, alcohol, and coffee should be avoided, and it is recommended to eat food such as pineapple, red beet, chard, and peas, and use herbs with a choleric cholagogic, liver-protecting, and anti-inflammatory action, such as milk thistle, curcuma (turmeric, which also used as a spice), and dandelion. Saline (sodium chloride) and sulphurous waters can also be extremely beneficial.

In order for the *Lungs* to remain healthy, the immune system should be supported and the airways should be kept free. For lung depuration, it is recommended to eat broccoli, Savoy cabbage, hot pepper, pistachio, and leek, due their spicy taste that stimulates elimination of phlegm, and use herbs with an expectorant action, such as eucalyptus, lavender, mint, and thyme. Arsenical-ferruginous waters can provide additional benefits.

The *Skin* performs important draining functions that should be taken in due account in any detoxification therapy. Severely intoxicated patients, in fact, can report skin reactions, such as erythema or rash, or abundant and foul-smelling night perspiration. For more advanced skin detoxification and drainage, specific medications can be prescribed. The skin can be purified with masks prepared with tomatoes, extra-virgin olive oil, and yoghurt, or by taking vitamins with a strong antioxidant action, such as vitamin A, C, and E, and herbs such as burdock and pansy, always in the appropriate mode. Sulphurous waters can be beneficial.

The *Kidneys* are in charge of the elimination of metabolic waste and their specific activity needs to be supported. Kidney detoxification requires increased fluid intake and is supported by the consumption of such foodstuffs as azuki beans, fennel, barley, corn, and radicchio, as well as of herbs such as beech, horsetail, poison ivy, and goldenrod.

20 Crinnion WJ. *Results of a decade of naturopathic treatment for environmental illness*. J Nat Med, 1997; (7)2: 21-28

Oligomineral waters can be beneficial.

Intestines: this is where the catabolytes of nutrition pass. When you take something that disagrees with your body, diarrhoea is a frequent occurrence, as a way for your body to reject what you have ingested. However, diarrhoea should not be stopped, because this would hamper the physiological self-detoxification of the body. On the other hand, the intestines should be supported with the intake of specific probiotics. The diet should be free of pesticides and dyes, low in gluten and lactose, and rich in fibres and appropriate probiotics. To help intestine cleansing, people should consume food such as lemon, almonds, apples, and honey, and use herbs such as aloe, bitter orange peel, and dandelion. Magnesium-bicarbonate waters can be beneficial.

The *Extra-cellular Matrix* is the tissue that contains, nourishes, and supports the cells of the entire body. Its conditions can be evaluated by measuring the urinary pH. Special care should be given to the dietary intake of alkalizing salts to adjust the pH of the body tissues. The matrix can be purified by consuming foodstuffs such as pineapple, berries (strawberries, raspberries, blackberries, and red or black currant), and wheat sprouts, and using herbs such as centella, horse chestnut, and ginkgo. Bicarbonate waters can be beneficial.²¹

04

The scientific
and modern
use of water for
wellbeing

4.1 Body water requirements

The growing interest of these past years in health intended as wellbeing, and encompassing such features as nutrition and appropriate body hydration, has prompted the issue of guidelines to provide guidance to the population at large and practitioners on appropriate hydration, based both on traditional wisdom and on modern scientific knowledge.

According to the 1994 *European Commission's Scientific Committee on Food (Italy's Daily Reference Intakes -LARN 1996)*, well-balanced nutrition should include vitamins, mineral salts and water in the recommended amounts to preserve the water and salt balance. For the first time, then, water was included among nutritional recommendations for the population, thus acknowledging its role in human nutrition and physiology.

Whilst water is the ultimate beverage and the ideal fluid for body hydration, it should be noted that other fluids are available on the market to make up for the daily losses of this valuable nutrient. These fluids (milk, fruit juices, tea, soft drinks, specific mineral supplements, soups, as well as beer or wine) have a variety of flavours, offer higher nutritional properties, or are just more palatable. The market offers a host of beverages with a broad variety of properties. These include all kinds of infusions (sedative, stimulating, tonic, etc.), soft drinks, and aromatic waters. The current supply is so wide that specific rules and recommendations are required for each beverage based on its hydrating capability, calories, or other nutrients, as well as its potential effects on the human body.²²

In this respect, drinking water remains the primary vehicle for human body hydration considering, in particular, the issue of obesity, a widespread disorder in Western countries and also the result of the consumption of caloric beverages to replace water as a hydration source.

Scientific literature shows that calorie intake through beverages stimulates appetite regulation to a limited extent, unlike energy intake from solid food. This may result into a significant increase in calorie intake through sugar-sweetened beverages that do not satiate, but rather generate an increased risk of obesity.^{23,24,25,26}

22 Hypertext1. Popkin B, Armstrong L, Bray G, Caballero B, Frei B, Willen C. *A new proposed guidance system for beverage consumption in the United States*. Am J Clin Nutr 2006; 83: 529-42.

23 Hypertext2. Raben A, Tagliabue A, Christensen NJ, Madsen J, Holst JJ, Astrup A. *Resistant starch: the effect on postprandial glycemia, hormonal response, and satiety*. Am J Clin Nutr 1994; 60: 544-51.

24 Hypertext3. Mattes RD. *Dietary compensation by humans for supplemental energy provided as ethanol or carbohydrate in fluids*. Physiol Behav 1996; 59: 179-87.

25 Hypertext4. Di Meglio DP, Mattes RD. *Liquid versus solid carbohydrate: effects on food intake and body weight*. Int J Obes Relat Metab Disord 2000; 24: 794-800.

26 Hypertext5. Brownell KD, Farley T, Willett WC, Popkin BM, Chaloupka FJ, Thompson JW, et al. *The Public Health and Economic Benefits of Taxing Sugar-Sweetened Beverages*. N Engl J Med 2009; 361: 1599-1605.

Multiple epidemiological studies, in fact, associated the overconsumption of refined carbohydrates and sugar-sweetened beverages with weight gains, diabetes, and cardiovascular events.^{27,28,29,30}

Water is the main component of the human body: it accounts for 75% of the human body at birth and for almost 70% in adults. About 60% of the water content is found inside the cells (intracellular fluid), while the rest (extracellular fluid) circulates through the blood and keeps tissues moist. Water is crucial for physiological digestive processes, for nutrient absorption, and for the elimination of non-digestible metabolic waste, and participates to the appropriate functioning of the circulation system. It ensures the conveyance of nutrients, as well as of all the other substances within the body, and helps control body temperature. Studies show that an adult male who exercise moderately, lives at an ambient temperature of about 20°C, and follows an appropriate diet loses 2200 to 2300 ml of water every day.³¹

Water, combined with appropriate nutrition, can ensure good hydration at all ages.³² It is therefore very important to ensure its intake in the right amount and quality, knowing to what extent hydration can influence the health conditions and wellbeing of people at cognitive level, as well as in terms of physical performance and thermoregulation efficiency.³³

4.2 Water balance adjustment

Our body's water content needs to remain at a constant level (water balance) and for our body's water balance to be maintained water loss (through urine, faeces, the skin, and breathing) must be compensated for by water intake (from drinking water, liquid

27 Hypertext6. Hu FB, Malik VS. *Sugar-sweetened beverages and risk of obesity and type 2 diabetes: epidemiologic evidence*. *Physiol Behav* 2010; 100: 47-54. [Epub 2010 Feb 6].

28 Hypertext7. Duffey KJ, Gordon-Larsen P, Steffen LM, Jacobs DR, Jr, Popkin BM. *Drinking caloric beverages increases the risk of adverse cardiometabolic outcomes in the Coronary Artery Risk Development in Young Adults (CARDIA)*. Study. *Am J Clin Nutr*. 2010.

29 Hypertext8. Johnson RK, Appel LJ, Brands M, Howard BV, Lefevre M, Lustig RH, et al. *Dietary sugars intake and cardiovascular health. A scientific statement from the American Heart Association*. *Circulation* 2009; 120: 1011-1020.

30 Hypertext9. Muckelbauer R, Libuda L, Clausen K, Toschke AM, Reinehr T, Kersting M. *Promotion and provision of drinking water in schools for overweight prevention: randomized, controlled cluster trial*. *Pediatrics* 2009; 123: e661-7.

31 Hypertext1. Popkin B, Armstrong L, Bray G, Caballero B, Frei B, Willen C. *A new proposed guidance system for beverage consumption in the United States*. *Am J Clin Nutr* 2006; 83: 529-42.

32 Hypertext10. Fernández-Martín JL, Benito Cannata-Andía J. *Agua de bebida como elemento de la nutrición*. *Barcelona Med Clin* 2008; 131:656-7

(http://apps.elsevier.es/watermark/ctl_servlet?_f=10&pident_articulo=13128725&pident_usuario=0&pcontactid=&pident_revista=2&ty=29&accion=L&origen=zonadelectura&web=www.elsevier.es&lan=es&fichero=2v131n17a13128725pdf001.pdf)

33 Hypertext11. Jéquier E, Constant F. *Water as an essential nutrient: the physiological basis of hydration*. *Eur J Clin Nutr*. [Online] September 2, 2009. Disponible en: <http://www.nature.com/ejcn/journal/vaop/ncurrent/pdf/ejcn2009111a.pdf>. doi:10.1038/ejcn.2009.111

component of food). The human body relies on a number of mechanisms that allow it to maintain the water balance, while controlling losses. Any failure of these mechanisms, and the subsequent water balance disruptions, can result into severe, sometimes life-threatening conditions.³⁴

Water balance adjustment occurs in different ways.

The body loses water:

- by evaporation through the skin and lungs, for an amount of 800-1250 ml per day;
- in faeces, for an amount of 100-150 ml per day;
- in urine, for an amount of 800-1500 ml per day.

For our body to expel urea, toxic metabolites and other waste, it takes at least 1700 ml of water every day.

4.2.1 Water requirement and water balance

Since the human body cannot store water, the water lost daily needs to be replaced to ensure appropriate body functioning.

The body's water supply is mainly replenished through the water we drink, the water we eat, and the water we produce:

- the water we drink includes water-based beverages and other fluids with a high water content (85-90%);
- the water we eat comes from a variety of food with a high water content (40-48%);
- the water we produce is the result of the oxidation of macronutrients (endogenous or metabolic water).

30

Generally 20-30% of the daily water intake comes from food and 70-80% from beverages. This is not a fixed ratio and depends on the foods and beverages that are chosen. (EFSA, 2008).³⁵

The average daily water intake of an individual, at rest and living in a temperate climate, should be at least 1.5 l of water per day. This amount obviously varies depending on age, gender, climate, and physical activity. The water content of food, too, can vary broadly and, therefore, the amount of water provided by food can range from 500 ml to 1 l per day. Additionally, sedentary individuals produce approximately 250-350ml of endogenous or metabolic water per day but, since the daily water loss amounts to 2 l – also considering changes attributable to such factors as ambient temperature, physical

34 Institute of Medicine (U.S.). *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate*. The National Academy Press; 2005. http://www.nap.edu/openbook.php?record_id=10925&page=73

35 Hypertext12. EFSA (2008). *Draft dietary reference values for water. Scientific Opinion of the Panel on Dietetic Products, Nutrition and Allergies*, (agreed on 11 April 2008 for release for public consultation). (<http://www.efsa.europa.eu/it/scdocs/doc/1459.pdf>)

activity, etc. – appropriate water intake should amount to approximately 2 or 3 l/day (for women and men respectively) (EFSA, 2008).

As noted earlier, water intake is needed to make up for water loss and maintain our body's water balance.

Our body regulates the water balance through the hypothalamic thirst centre and the antidiuretic hormone (ADH), which can increase water re-absorption by the kidneys. Water consumption for metabolic activities requires a water turnover of about 3-4 l per day and about 5-10% of the body water is replaced every day. These values can obviously vary according to physical activity and to environmental conditions. An individual at rest normally loses 60% of body water per day through urine, while physical activity, physical conditions (hyperpyrexia), and ambient temperature can cause increased sweating and insensible perspiration. Water losses are physiologically maintained at around 2% of body weight and the body can regulate the urine elimination volume by secreting the antidiuretic hormone (ADH). This, in fact, promotes water re-absorption by the kidneys, while reducing the amount of urine output.

Our body loses water also through the skin, the respiratory tract and, partly, the gastrointestinal tract.

Water is lost by evaporation through the skin. This phenomenon is also known as insensible perspiration, because it occurs invisibly and, in temperate climates, it entails a daily loss of approximately 450 ml of water.

Water is also lost by evaporation through the respiratory tract (250-350 ml per day).

Lastly, a sedentary adult loses about 200 ml of water per day through faeces.

Therefore, a sedentary adult loses 2-3 l of water per day on average. Water losses through the skin and lungs depend on environmental conditions, temperature, and relative humidity. When the internal body temperature increases, the only mechanism to enhance heat loss is the activation of the sweat glands. Water evaporation by skin perspiration is a very effective way to reduce the body temperature.

When physical activity is performed in a warm environment, perspiration can cause a loss of up to 1-2 l of water per hour³⁶, which may result into dehydration and hyperosmolarity of the extracellular fluid (ECF).

It should be noted that sweat is always hypotonic relative to plasma or the extracellular fluid. Whilst sweat contains 20-50mmol/l of Na⁺, the extracellular Na⁺ concentration is 150mmol/l. Heavy perspiration therefore causes greater fluid and electrolyte losses. The consequence is an increased extracellular osmolarity, which can cause water migration

36 Hypertext13. Sawka MN, Cheuvront SN, Carter III R (2005). *Human water needs*. Nutr Rev 63, S30-S39. (<http://www.ncbi.nlm.nih.gov/pubmed/16028570>)

from the cells to the extracellular fluid. This is why, as it is known, hypotonic beverages should be consumed during physical activity. Dehydration and a hyperosmolar extracellular fluid can also affect consciousness and are involved in the onset of the so-called heatstroke, a condition in which the internal body temperature exceeds the critical threshold, as is the case when exercising in warm and humid environments.

Water intake is partly a result of *thirst*. The activation of hypothalamic osmoceptors causes the release of the antidiuretic hormone (ADH) by the posterior pituitary gland. The thirst sensation is therefore aroused both by the increase of extracellular fluids and by osmotic pressure and the ADH. The thirst-arousing receptors have a higher osmotic threshold compared to the osmoceptors involved in the release of the ADH.³⁷

The ADH can act on the kidneys to enhance water re-absorption, thus triggering thirst. As it will be further detailed herein, the thirst sensation is often reduced in elderly people, whose water intake tends to be too low in conditions of high ambient temperature and humidity.³⁸

The *kidneys* are in charge of regulating water losses. Their unique property is the ability to broadly modify urine osmotic pressure in response to minimal changes in the osmotic pressure of plasma.

Two closely interconnected conditions bring about an increase in urine production and, therefore, greater water losses: A) water intake in excess of demand; B) a subsequent minor decrease in plasma osmolarity with suppression of ADH secretion, which causes the production of hypotonic urine.

To sum up, both hydration deficits and surpluses are compensated by subtle hormone changes (ADH, aldosterone, atrial natriuretic peptide), which help mitigate the negative impact of these abnormal conditions.

In short, final and accurate regulation of the water balance depends on the thirst sensation and on ADH release, with its predominant role in water re-absorption by the kidneys. Therefore, drinking water is a good way to preserve the water balance of the body. As a consequence, consuming drinking water before the onset of thirst is a good habit to ensure appropriate hydration and keep the body in good health.

Also of great practical importance is being able to evaluate the hydration degree of individuals who are subject to potentially dehydrating environmental conditions.³⁹

37 Ganong WF (2005). *Review of Medical Physiology*, 23rd edn, LANGE Science: New York. <https://emergencypedia.files.wordpress.com/2013/04/ganong-pdf.pdf>

38 Hypertext15. Phillips PA, Rolls BJ, Ledingham JG, Forsling ML, Morton JJ MJ et al. (1984). *Reduced thirst after water deprivation in healthy elderly men*. N Engl J Med 311, 753–759. (<http://www.nejm.org/doi/full/10.1056/NEJM198409203111202>)

39 Armstrong L, Casa D, Millard-Stafford M, American College of Sports Medicine position stand, et al. *Exertional heat illness during competition*. Med Sci Sports Exerc. 2007;39:556–72 http://www.medscape.com/viewarticle/769626_5

Elderly people, in particular, are susceptible to hydration deficits during the summer, as they do not feel thirst as readily as younger people do and their urinary system is less efficient. A 1-2% reduction in the body's water content can affect cognitive functions, alertness, and the ability to carry out daily tasks. Young *children* are also susceptible to dehydration, being unable to express their thirst sensation. Whilst healthy people feel thirst and can appropriately quench it, children, as well as *athletes*, and most elderly or sick people do not feel it as readily. These groups of people should drink water even without feeling thirsty, because they are more susceptible to water imbalances, which can have significant impacts on their health, physical and mental performance.

As noted earlier, fluid intake (from water and other beverages), usually amounts to 2.2 to 3 l per day. In specific conditions and for a limited time, our body can survive with a more limited water supply thanks to water distribution in the different organs and to its adjustment mechanisms, which allow to save some of it. It is anyway important to note that people engaged in moderate physical activity, sick people, or individuals exposed to warm and humid ambient conditions require a higher water intake.

Healthy individuals have effective mechanisms to dispose of surplus water and preserve the water balance of the body. However, when water is consumed too quickly (0.7-1 l per hour), *intoxication* may occur, because the amount introduced exceeds the kidney elimination rate.

4.2.2 The stimulus to thirst

As mentioned, the stimulus to thirst is regulated by receptors that are activated when water losses exceed 0.5% of body weight.

Two mechanisms can generate a thirst sensation:

- hypovolemic thirst when volaemia is reduced following a loss of water and solutes in both the extracellular and the intracellular space;
- osmotic thirst, when the increased osmotic pressure of the extracellular fluid, following a sudden increase in the concentration of solutes in the extracellular fluid (an abundant and salty meal), causes a transfer of water from the intracellular fluid to the extracellular fluid, which is thus diluted and less hypertonic, at constant water volume.

Constant water consumption throughout the day obviously inhibits thirst and is a much desired condition for individuals, including elderly people and children, whose stimulus to thirst and water balance restoration mechanisms are impaired.

Dehydration occurs when the water balance is disrupted.

Main causes include:

- climatic factors (dry and windy climate, cold temperatures that increase water loss through urine);
- physical factors (higher vapour tension in exhaled air than in ambient air, as in case of increases in the respiratory rate, following increased ventilation due to endogenous stimuli, including fever, or exogenous stimuli, including high ambient temperatures);
- clinical factors (vomiting, diarrhoea, bleeding, burns);
- behavioural factors (intense physical activity, inappropriate fluid intake).

The consequences of dehydration include:

- a thirst sensation, when water loss is 0.5% of body weight;
- altered thermoregulation and plasma volume when water loss is 2% of body weight, with more viscous blood and limits to the individual's activities and physical capabilities;
- muscular cramps, when water loss is 5% of body weight;
- hallucinations and loss of consciousness, when water loss is 7% of body weight;
- death water loss is 20% of body weight.

4.3 The role of water in the human body

Water is the main constituent of the human body.⁴⁰ The human body cannot produce enough water through metabolism or obtain enough water from food intake to satisfy its requirements. Therefore, in order to prevent any negative impacts on health, we need to be careful about what and how much we drink to satisfy daily water requirements. Water is found in all the cells of the human body, as well as in the different tissues and compartments, and is the main constituent of life.

As mentioned earlier, most of the water in the human body has an exogenous origin, i.e. is introduced with beverages and food. In a 70 kg 'standard' male the water content is approximately 70% of body weight, or approximately 40 kg. Women have a lower water content than men, about 50% of body weight. They have, in fact, greater fatty tissue reserves that, unlike muscular tissue (more abundant in men), contain less water (about 10%). People who are obese and elderly individuals, also have a lower water content as a percentage of their body weight, as they have reduced lean body mass, due to sarcopenia, and more fat. In infants, water content is 75% of body weight.

A major division of bodily fluids containing water is into two major compartments: intracellular fluids (ICF) accounting for 2/3 or 67% of total volume, and extracellular fluids (ECF) which is divided into smaller compartments that include plasma, lymph, the

40 Hypertext18. Jéquier E, Constant F, *Water as an essential nutrient: the physiological basis of hydration* European Journal of Clinical Nutrition (2010) 64, 115–123; doi:10.1038/ejcn.2009.111; published online 2 September 2009 (<http://www.nature.com/ejcn/journal/v64/n2/full/ejcn2009111a.html#bib4>)

interstitial fluid, and the cerebrospinal fluid. Extracellular fluids account for 33% of total volume. The division into fluid compartments is based on which side of semi-permeable membranes the fluid lies. Plasma, for example, is separated from the interstitial fluid by the walls of blood vessels, while cell membranes separate the interstitial fluid from the intracellular fluid, thus avoiding that they may come into direct contact.

It is, in fact, crucial that the volume of fluid in each compartment remains constant (homeostasis).

Water in the body is mainly found in lean tissue and accounts for about 72% of lean body mass.

In physiological conditions the intracellular fluid is an indicator of the body cell mass. The ratio of extracellular fluid to intracellular fluid tends to decline with ageing, with subsequent increased water requirements.

In the first year of life, the percentage of total body water declines because the body cell mass, which is made up of 20% solid materials and 80% intracellular fluid, grows quickly, whereas the extracellular fluid, which contains lower amounts of solid materials, grows more slowly. This results into gradual reduction of the percentage of the extracellular fluid relative to the intracellular fluid. (Table 4-1)

Total body water as a % of weight			
	Children	Men	Women
Slim	80	65	55
Normal weight	70	60	50
Overweight	65	55	45

table 4-1

Whilst total body water is lower in elderly people, it is not clear how such loss is distributed, it is not clear whether such loss is in the intracellular or the extracellular fluid, or both, and at what rates.

Both intracellular and extracellular fluids contain *minerals*.

Whilst potassium, magnesium, and phosphorus ions prevail in the intracellular fluid, sodium, chloride, and bicarbonate ions prevail in plasma and the interstitial fluid.

Sodium, potassium, calcium, magnesium, and phosphate ions play a role in metabolic processes, in cellular balance, in muscle contraction, and in nervous system conductivity.

The volume of the intracellular fluid depends on the concentration of solutes in the interstitial compartment. Under normal conditions, the interstitial fluid and the

intracellular fluid are isotonic, i.e. have the same osmolarity. If solute concentrations were higher in the intracellular fluid, cells would inflate by osmosis; and if they were lower, cells would shrink. Both conditions would be highly detrimental to cell structures.

Plasma volume (volaemia) is to remain constant to ensure, among other things, good heart functioning. In fact, if plasma volume increases, blood pressure increases too (hypertension), while if plasma volume decreases (hypovolaemia), blood pressure decreases and blood viscosity increases, putting the heart under strain.

Total body water needs to remain constant for homeostasis of intracellular and intravascular fluid volumes. For this to occur water intake must match water output to ensure water balance in the body.⁴¹

4.3.1 Biochemical and physical properties of living system

If living beings are observed from a biochemical and physical viewpoint, one of their main features is that all biological processes depend on water. The main functions of water can be summarized as follows:

- transportation of nutrients;
- energy balance regulation;
- detoxifying capacity;
- body temperature regulation;
- water balance regulation;
- mineral salt replenishment;
- promotion of digestive processes;
- dilution of substances following oral intake.

As it is known, water is formed by two different elements – hydrogen and oxygen. No living being can live an active life with less than 60% water in the cytoplasm, and only few species can survive on lower levels, provided they are in a state of dormancy.

Most of the peculiarities of water derive from the asymmetrical structure of its molecules, whose positive and negative charges are quite distant from one another. Therefore, the molecules act as dipoles, and each dipole tends to bind with the others via hydrogen bridges, forming short chains or polyhedral structures.

At normal temperatures, these bonds are not very stable, but stable enough to keep the molecules together in the liquid state. Compounds with a high affinity for water, but with no or less evident polar properties (H_2S , NH_3 , HF), for example, come in a gaseous

state at temperatures at which water is liquid or even solid instead.

Water is the best solvent, as it can dissolve almost all known substances, even if some only to a very limited extent. This is due to the polar structure of water molecules, that is also what makes these molecules interact closely with each other and tend to exclude any non-polar molecules. Any substances made up of non-polar molecules, e.g. hydrocarbons, fats, and others, which as such do not mix with water, are defined as hydrophobic.

Adding one or more solutes to water brings about significant changes in its physical and chemical properties. Adding solutes raises the boiling point, lowers the freezing point as well as the vapour tension, and also change osmotic pressure.

Chemically, adding a solute can change the hydrogen ions concentration and, thus, affect the basicity or acidity of water. Solutes can also affect the sensory properties of water.

Moreover, water is an excellent dielectric vector. Due to this property, the electrovalent bonds of the substances dissolved in water are mitigated until they melt, with subsequent formation of ions with an opposite charge: NaCl is dissociated into Na⁺ and Cl⁻, H₂CO₃ is dissociated into H⁺ and HCO⁻, and so forth, and the H₂O molecules are also dissociated into H⁺ and OH⁻. Ions appear and behave differently from non-dissociated molecules, and generally tend to have sharp reactions.

Water has a high thermal vaporization power, which allows heat dispersion from the body even when the ambient temperature is higher than body temperature.⁴² When perspiration is stimulated, water evaporation from the skin surface is a very effective way to ensure heat dispersion.

Water is crucial for cell homeostasis because it carries nutritional substances to the cells and removes waste from them.⁴³

Water is the vehicle for fluid exchange at cellular, capillary, and interstitial level.⁴⁴

Water controls the vascular volume and allows blood circulation, which is essential for the survival of all the organs and tissues of our body.⁴⁵ Therefore, the cardiovascular and respiratory system, the gastrointestinal tract, the reproductive system, the kidneys, the liver, the brain, and the peripheral nervous system all depend on appropriate hydration

42 Hypertext19. Montain SJ: *Fluid and electrolyte supplementation for exercise heat stress*. Am J Clin Nutr 2000;72(suppl):564S-72S (<http://ajcn.nutrition.org/content/72/2/564s.full.pdf>)

43 Hypertext20. Häussinger D (1996). *The role of cellular hydration in the regulation of cell function*. Biochem J 313, 697–710. v <http://www.biochemj.org/bj/313/bj3130697.htm>

44 Grandjean AC, Campbell SM (2004). *Hydration: Fluids for Life*. A monograph by the North American Branch of the International Life. Science Institute. ILSI North America: Washington DC

45 Hypertext22. Ritz P, Berrut G (2005) *The importance of good hydration for day-today health*. Nutr Rev 63, S6-S13 (<http://www.ncbi.nlm.nih.gov/pubmed/16028567>)

for proper functioning.⁴⁶ Severe dehydration affects the functionality of most systems and is thus a life-threatening condition.⁴⁷

In combination with a variety of other molecules, water contributes to the formation of:

- joint-lubricating fluids;
- saliva;
- gastrointestinal secretions;
- mucus in the gastrointestinal tract;
- mucus in the airways and respiratory tract;
- mucus in the genitourinary tract.

In the cellular form, water also acts as a shock-absorber when walking or running. This function is important for the brain and spinal cord, and particularly for the foetus that is protected by a water buffer.

Additionally, thanks to its detoxifying power water eliminates wastes and inorganic minerals through urine, faeces, perspiration, and breathing.

The most significant feature of the detoxifying function of water is the disposal of urea, which is the final product of protein catabolism for the purpose of energy production. About 15 cc of water are required to dispose of 1 g of urea.

Body temperature regulation occurs:

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- at low temperature by heat dispersion through a number of mechanisms:
 - convection (heat transfer from the skin to the molecules in the air that surrounds the skin that move faster, and gain more kinetic energy);
 - conduction (direct heat transfer from a warm body to a colder body);
 - irradiation (heat transfer by emission of electromagnetic radiations).
- at 30°C a neutral thermal state occurs, where an undressed individual at rest does not develop and does not disperse heat;
- above 30°C, once the compensation capacities of the above-described mechanisms are exhausted, the evaporation mechanism kicks in through increased perspiration and sweat evaporation subtracting energy at a rate of 0.56 calories per gram of evaporated sweat.

The evaporation mechanism is obviously less efficient in conditions of poor ventilation and high humidity, where perspiration is more intense and involves an over dispersion of water and salts.

46 Hypertext20. Häussinger D (1996). *The role of cellular hydration in the regulation of cell function*. Biochem J 313, 697–710. v <http://www.biochemj.org/bj/313/bj3130697.htm>

47 Hypertext23. Szinnai G, Schachinger H, Arnaud MJ, Linder L, Keller U (2005). *Effect of water deprivation on cognitive-motor performance in healthy men and women*. Am J Physiol Regul Integr Comp Physiol 289, R275–R280. (<http://www.ncbi.nlm.nih.gov/pubmed/15845879>)

Constant temperature is ensured by another physiological compensation mechanism, peripheral vasodilation, i.e. the dilation of blood vessels in the skin, leading to increased blood flow, a broader caloric energy dispersion surface, and increased evaporation.

4.4 Dehydration

A water deficit of 1% of body weight is associated with increased body temperature during physical activity.⁴⁸ Body temperature is estimated to increase by 0.1°C–0.23°C following a 1% loss of body weight.⁴⁹ Dehydration increases body temperature while reducing some of the thermal benefits associated with aerobic exercise, and brings about heat addiction. Thus, localized perspiration as well as blood flow at skin level decrease in dehydrated individuals. As a consequence, dehydration reduces the normal body temperature toleration threshold.

As described above, the stimulus to thirst appears upon losses of a mere 2% of body weight. Dehydration associated with a 2% loss of body weight arouses a thirst sensation and reduces physical, as well as intellectual performance (short-term memory, alertness, resistance to fatigue, arithmetic skills, psychomotor speed, perceptive decision-making speed, etc.). Water deficits can also hamper gastrointestinal processes; increase the incidence of infections and allergic reactions; cause musculoskeletal pain at trunk level; cause headache and widespread joint pain. A dehydrated body should gradually recover with repeated ingestions of small amounts of food with high water contents. Rehydrating solutions can also be used.

As dehydration increases, symptoms get worse, and may include collapse and death. Dehydration increases the cardiovascular strain. The human body can lose up to 10% of its weight in the form of water, with potential increases in mortality, particularly if dehydration is combined with other sources of organic stress. Dehydration with a 10% loss of body weight calls for medical support for correction. Dehydration is a life-threatening condition in case of heatstroke. It should be noted that a strict diet combined with intense physical activity at warm temperatures can result into death due to the impairment of the cardiorespiratory system.⁵⁰

We have mentioned the importance of ensuring appropriate hydration in healthy individuals. However, there are conditions in life in which these recommendations are insufficient. Daily water intake by children is obviously much more limited, even

48 Hypertext24. Manz F. *Hydration and Disease*. J Am Coll Nutr 2007; 26 (5): 535S–41S. (<http://www.ncbi.nlm.nih.gov/pubmed/14681708>)

49 Heird, WC. *Nutritional Requirements*. Klieg-man RM, Jenson Behrman RE. Nelson Textbook of Pediatrics. Philadelphia: Saunders; 2004.

50 Hypertext24. Manz F. *Hydration and Disease*. J Am Coll Nutr 2007; 26 (5): 535S–41S.

if the amount of water per kg of body weight is substantially higher than for adults. In pregnant and breastfeeding women, elderly people, athletes, and in case of illness, recommendations for daily water intake are significantly different from those aimed at healthy individuals.

05

Water, wellbeing, and health

While bottled mineral waters do not display therapeutic properties in a strict sense, their specific sensory and sanitary peculiarities make them suited to carry out health-promoting actions.

5.1 Effects of hydration on the body

The *beneficial* properties of natural mineral water are the result, on one hand, of the amount and ratio of the salts it contains and, on the other, of the absence of polluting or undesired substances.

Water (and mineral water in particular) helps ensure appropriate hydration, promotes health and prevents illnesses, and also supports drug treatment.

Drinking does not only quench thirst, but also ensures the intake of important elements (trace elements such as calcium, sodium, iron, magnesium, sulphur, bicarbonate, fluorine) which, depending on their type and concentration, satisfy a variety of psychophysical requirements.

As a general principle, appropriate hydration can be deemed crucial for the natural course of the biochemical reactions and physiological processes that are necessary for life.

Drinking appropriately is thus a useful strategy to prevent a variety of illnesses and disorders. There is no single function in our body that can do without water.

Most people, however, do not drink enough water, because they are not aware of its importance and unique effect on their wellbeing.

Human health, skin ageing, and wellbeing are closely connected with water. Without water, the human body loses vitality, dries up, and suffers early ageing. Water is a source of beauty and makes up 80% of human skin.

Dehydration is one of the main causes for skin sensitivity. Any failure to reintegrate water losses is the first step towards the loss of skin suppleness. This, in fact, leads to thinning of the hydrolipidic film and lowered defences, leaving the skin exposed to environmental aggression.

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5.2 Water for good hydration

The public opinion is not aware of the effects of dehydration on the body, nor of the importance of water turnover in the body as a prerequisite for metabolism. The main properties of drinking water are also largely unknown. These include first and foremost high quality, hygienic safety, and satisfactory sensory parameters.

Natural water is not found in pure state (i.e. only made up of two atoms of hydrogen and one atom of oxygen, as represented by its chemical formula, H_2O), because as

it runs over the surface or through the ground, it comes into contact with rocks and dissolves minerals that provide useful substances for nutrition. In its *journey* through the environment, however, it can also take up contaminants, such as chemical substances or microbes. The properties of water as a dietary component are defined by the law, which recognizes three types of water:

- **water intended for human consumption:** this is water for drinking, for preparation of food or beverages, or for household use. It can have a superficial origin (such as river, lake, or sea water) or an underground origin (filtered through the soil), in which case it is generally safer. When it runs through the water mains this water is more exposed to microbial contamination, and is to be treated before it can be used for human consumption;
- **spring water:** water in its natural state, bottled at the source, originating from an aquifer or an underground deposit. Spring water - like mineral water - is not subject to treatments or addition of antibacterial or bacteriostatic substances, as it happens with water that runs through the water mains;
- **mineral water:** microbiologically pure water at the origin, with specific properties due to its constituents and beneficial for health. Mineral water is not subject to treatments (such as filtration, chlorination, and/or ozonation) and/or addition of antibacterial or bacteriostatic substances. This water is bottled as it emerges from the spring and can only be sold in sealed bottles with a maximum 2-l capacity.

To be suited for human consumption, water needs to satisfy certain requirements:

- **water with very low concentrations of dissolved salts, or even distilled water or, as is recently the case, water treated by reverse osmosis, is not suited for human consumption;**
- **it needs to contain a certain amount of dissolved mineral salts;**
- **it should not contain any toxic substances;**
- **it should not contain any pathogenic microorganisms.**

According to Council Directive 80/777/EEC, the term *natural mineral water* indicates a microbiologically wholesome water originating in an underground table or deposit and emerging from a spring tapped at one or more natural or bore exits.

Whilst the Italian law had already provided an early definition of mineral waters in 1916, focusing on their therapeutic properties, today mineral waters are rather classified according to their original pureness and, secondarily, by their beneficial properties.

This does not mean they cannot be used for healing purposes. They can, indeed, but today the properties they need to maintain unaltered in the long term in order to provide beneficial effects to human health are more clearly specified.

5.2.1 The origin of mineral waters

Mineral waters can have a meteoric, juvenile, fossil, or mixed origin.

Meteoric waters penetrate into permeable soil and take up minerals as they come into contact with rocks, at different depths.

Rocks are classified as:

- impermeable rocks, such as clay and whole granite: when voids (pores and fissures) in the rocks are smaller than one hundredth of a millimetre in diameter;
- permeable porous rocks: when voids (pores and fissures) in the rocks for water passage are larger than one hundredth of a millimetre in diameter;
- permeable fissured rocks, when compact rocks are crossed by fissures and cracks;
- permeable karst, when the rocks are fissured and soluble (dolomite rock and chalk).

Juvenile waters can have a magmatic or volcanic origin. Magmatic waters originate from condensation of the water vapour released during the magma crystallization process.

These waters have constant high temperature because they are heated by magma and, as they surface quickly, they do not have time to cool. These waters have constant salt concentration, too, as they come from deep layers where magma crystallizes, and taking up CO₂ as they rise quickly to the surface their contact with the rocks is limited.

Volcanic waters originate from condensation of the volcanic water vapour generated by the lava crystallization process.

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Fossil waters are waters that accumulated in underground reservoirs following changes in the surrounding geology.

Mixed waters – which are the majority – derive from a mix of waters of all origins, enriched with CO₂ of magmatic or volcanic origin.

Geochemistry of mineral waters

The geochemistry of mineral waters is the result of their circulation through the ground, that produces two actions:

- a mechanical action, characterized by erosion and sedimentation;
- a geochemical action, characterized by the formation of solutions where solutes may include acids, bases, or salts.

Based on the foregoing, water can be classified into:

- meteoric water, highly diluted, with solute concentrations up to 25-30 mg per litre at 120°C and with prevalent Na and K cations (positively charged ions);
- freshwater with concentrations up to 350-400 mg per litre and richer in ions (HCO₃, CO₃ bound with Cl, SO₄, Na);
- open-sea water with salt concentrations of 34-38 g per litre including about 80-90%

chlorides;

- closed-sea water with variable salt concentrations (from 8 to as much as over 39 g per litre).⁵¹

Origin of natural solutes

Solutes can have an exogenous or an endogenous origin.

Exogenous solutes include:

- chlorides derived from NaCl and KCl;
- carbonates and bicarbonates derived from karst rocks;
- sulphur compounds (sulphates, sulphides, hydrogen sulphide, and sulphur, originating from chalk with subsequent dissolution of metal sulphurs and pyrites);
- iodine and bromine, originating from fossil waters in sedimentary areas;
- lithium originating from silicate rocks; iron from pyrites and bicarbonates; arsenic from arsenic salts; ammonium from organic matter and nitrate breakdown.

Endogenous solutes include:

- fluorine derived solely from juvenile waters;
- chlorides, bromine, iodine, sulphur-based compounds, which are both endogenous and exogenous.

Main gases include CO₂ and N₂, as well as the noble gases argon and helium. CO₂ originates from juvenile, mostly volcanic waters, but can also have an exogenous origin.

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5.2.2 The temperature of mineral waters

The temperature of mineral waters defines their physical and chemical properties. Salt concentrations are, in fact, directly proportional to temperature increases and any fluctuations in this parameter affect the type and concentration of salts.

Water temperature depends on the geothermal gradient, on volcanism, on magma temperature, and on physical and chemical reactions.

Hot water springs

Water from hot springs is naturally heated in two ways.

In non-volcanic regions, water is naturally heated by heat from the Earth's crust and its contact with hot rocks as it emerges. The deeper you go into the earth, the higher the temperature is. The rise in temperature with depth is called the geothermal gradient and generally is 1°C every 30-35 metres. Depending on the type of rocks and soils, the 1°C rise in temperature can occur at lower depth, as is the case with volcanic areas but not

⁵¹ Gualtierotti R; *Elementi di Idrologia Medica*; Libreria dello Studente 1974

with granite rocks.

In volcanic regions, water is naturally heated by magma, up to the boiling point.

Volcanoes increase water temperature alongside the geothermal gradient and through water vapour condensation. This, combined with magma emission, brings about increased salt concentrations and the generation of thermal waters.

The presence of permeable layers, cracks and faults allows water to rise to the surface, enriched with CO₂.

The pressure water has, as it surfaces, is a function of the geothermal gradient and the temperature difference between external and internal temperature.

If the water becomes so hot that it builds steam pressure and erupts in a jet above the surface of the Earth, it is called a geyser. If the water only reaches the surface in the form of steam, it is called a fumarole. If the water is mixed with mud and clay, it is called a mud pot.

Hot waters are sometimes the result of very hot and colder waters surfacing in non-volcanic regions.

Cold water springs

Cold water springs are places where water emerges from an underground aquifer.⁵²

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The spring can be part of a karst system: water flows through pores and fissures, across rocks of different grain sizes or caves, then resurfaces.

The forcing of the water to the surface can be the result of a confined aquifer in which the recharge area is at a higher elevation than that of the outlet, as it happens with artesian wells.

Or the spring may flow from a higher to a lower elevation.

Springs can be a product of volcanism, and in this case water surfaces at high pressure.

Spring flow depends on multiple factors, including rainfalls, catchment and exit size.

Water can also emerge from permeable soils or underground streams.

Cold spring waters tend to have a constant average temperature with some seasonal fluctuations, but do not freeze in the winter.

5.3 The role of water in disease prevention

Water drinking is most often used to treat gastrointestinal, liver, biliary, and urinary

⁵² Crudeli Aurelio; *Il settore termale nella riorganizzazione dell'assistenza primaria a 10 anni dalla legge 323; La salute come bene comune nel Welfare delle opportunità* by Gianfranca Ranisio Valentina Mazzacane with an introductory essay by Crescenzo Simone. Records of the 5th national congress on general medicine cooperation, Fuggi 2010; October 2010 published by Stampa Editoriale s.r.l.; 136-138 (<http://www.aicanet.it/aica/ecdl-health/2b0%20VOLUME%20ANCoM.pdf>)

disorders.

Water is usually consumed in the morning on an empty stomach, as required according to the illness, and should be well tolerated by the patient, which means that it should not produce any side effects.

Water drinking therapies, including water drinking therapy at a spa, can last a few days or longer.

Minimum treatment is two weeks, and in some cases it can continue for one month or longer.

These treatments can take place at any time of the year.

There are treatments that use water that has been sterilized or heated before intake.

In fact, sometimes it is useful to change the temperature: water tolerability and taste can be improved by double-boiler heating or through heat exchange up to 25-30°C.⁵³

Heating reduces gastric irritation symptoms, such as nausea, heartburn, or vomiting, improves and enhances the purging action of some waters by stimulating neurovegetative reflexes and improving the laxative effect.

Highly concentrated arsenical-ferruginous waters should be abundantly diluted before use. In these therapies water is consumed on an empty stomach, in the morning or between meals when digestion is completed, to enhance the biological actions and therapeutic effects of the mineral waters used (e.g. intestinal peristaltic action of hypertonic waters, quick absorption of oligomineral ones, buffer effect of bi-carbonated ones, etc.).

The diuretic action, combined with prescription for consumption on an empty stomach, can be promoted via the intake of thermal water in the evening in order to slowdown the increase of the urinary concentration of lithogenic agents during the night (e.g. uric acid, microorganisms, calcium salts, etc.).

Most importantly, whilst the intake amount per session is not mandatory for certain waters, for others noncompliance with the physician's prescription may result into severe side effects, as is the case, for example, of the use of arsenical waters in children. Water drinking therapies can be followed at home, particularly in case of recurring or chronic diseases.

However, the therapeutic efficacy of drinking at the source is greater for a number of reasons:

- water has preserved all its important mineral constituents;
- thermal stations benefit from a favourable climate and also offer some entertainment;

53 Hypertext33. Van Tubergen A., Van der Linden S.; *A brief history of spa therapy*; Ann Rheum Dis 2002; 61:273-275 (<http://ard.bmj.com/content/61/3/273.full>)

- a spa or other on-site centre has competent medical staff that can help with advice, dietary and nutritional programmes, and offers also other thermal treatments.

Water can be used for disease prevention and the beneficial action of mineral water on health depends on the amount and ratio of dissolved salts, as well as on the absence of polluting or undesired substances.

Appropriate water intake ensures hydration and the intake of important elements (calcium, magnesium, sodium, bicarbonate, etc.). The type and concentration of these salts determine the denomination of the mineral water, and play a specific role in disease prevention, while ensuring that any drug treatments are performed smoothly. Important studies were carried out to evaluate the impact of mineral waters on certain body functions.

5.3.1 Hydration and the urinary tract

The *urinary tract* benefits from the use of oligomineral or low-mineral waters.

Oligomineral waters enhance diuresis, help eliminate waste, prevent stone formation, and perform an anti-inflammatory and anti-infective action. These last two actions are promoted by oligomineral waters rich of calcium that, according to recent studies, also prevent the formation of urinary tract stones.⁵⁴

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Oligomineral waters are used for urinary tract stone prevention and therapy. Water drinking therapies with pharmacologically active oligomineral waters increase the number and strength of peristaltic waves, as well as dilation of excretion pathways, thus creating optimal conditions for the elimination of stones from the body.⁵⁵ Oligomineral waters contain very low concentrations of solutes, in addition to trace elements and stone-prevention components.⁵⁶

On the other hand, bi-carbonated mineral waters are used for prevention of uric-acid stone formation. Oligomineral bicarbonated waters, in fact, have shown a diuretic action that can be partly attributed to hypotonia (a non-specific *mechanical action*) and partly to the contents of mineralizing agents. In particular, the specific diuretic action can be attributed to the presence of earthy-alkaline metals, which act both on the kidney parenchyma, enhancing its function, and on excretion pathways. In this respect, non-

54 Karagülle O, Smorag U, Candir F, Gundermann G, Jonas U, Becker AJ, Gehrke A, Gutenbrunner C. *Clinical study on the effect of mineral waters containing bicarbonate on the risk of urinary stone formation in patients with multiple episodes of CaOx-urolithiasis*. World J Urol. 2007 Jun;25(3):315-23.

55 Hypertext115. Coen G, Sardella D, Barbera G, Ferrannini M, Comegna C, Ferazzoli F, Dinnella A, D'Anello E, Simeoni P. *Urinary composition and lithogenic risk in normal subjects following oligomineral versus bicarbonate-alkaline high calcium mineral water intake*. Urol Int. 2001;67(1):49-53. (<http://www.ncbi.nlm.nih.gov/pubmed/11464116>)

56 Petracchia L., Mennuni G., Fontana Mr., Fraioli A., Cheltenham Waters, *Inauguration of the Central Spa Clin Ter.*, 2005 Sep-Oct; 156 (5): 231-3) <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2382110/>

oligomineral bi-carbonated waters are also active on diuresis, and have a protective action against electrolyte losses, as it can sometimes occur with minimally mineralized waters. Lastly, an action of bi-carbonated waters on hyperuricemia was reported.⁵⁷

A study published in 2001 within the framework of the Naiade project was carried out on a cohort of 1,102 patients with recurrent urinary tract stones. The patients received water drinking therapy with oligomineral waters for 2 years. Results indicated an improvement of clinical and socioeconomic indicators, with documented efficacy of treatment and cost savings resulting from the reduction of other therapeutic and social-security interventions.⁵⁸

Another study carried out by Bertaccini A. *et al*⁵⁹ showed that a medium-mineral water (119.7 mg/ml of calcium) with a high bicarbonate content (412 mg/l) produced specific changes in urine composition that help prevent stone formation. The bicarbonate charge makes urine alkaline and increases the urinary pH, while enhancing the excretion of urinary citrate. The increased urinary pH (with enhanced solubility of uric acid) prevents uric acid lithiasis, and the increase of urinary citrate (with the inhibition of calcium crystal formation and aggregation) prevents calcium lithiasis. Thus, administering a medium-mineral water with a high bicarbonate content increases the urinary excretion of uric acid, with no risk of stone formation, due to the increase of urine volume, urinary pH, and citrate excretion.

Some studies focused on the effect of the increased urine volume.

In particular, Di Paolo *et al*⁶⁰ showed the detoxifying action on the kidneys of high doses of mineral water in a study that compared outcomes, in two tests on the same patients who had additional 25 ml/kg of mineral water, first over 24 hours and then in 30 minutes. The individuals that consumed the water supplement in 30 minutes reported enhanced diuresis, greater creatinine and urea clearance at 24 hours, and higher serum levels of magnesium and folic acid, as well as a more abundant daily urinary excretion of endogenous metabolites.

Diuresis can also be enhanced by carbonated waters. While this action is stronger with oligomineral or minimally mineralized waters, CO₂ itself may significantly affect

57 Hypertext116. Wu CL, Doong ML, Wang PS. *Involvement of cholecystokinin receptor in the inhibition of gastrointestinal motility by oxytocin in ovariectomized rats*. Eur J Pharmacol. 2008 Feb 12;580(3):407-15. Epub 2007 Nov 23. (<http://www.ncbi.nlm.nih.gov/pubmed/18078924>)

58 De Luca S, Nappi G, Merconi Orsini A. *Progetto Naiade*; Med. Clin. Term. 47:197-206,2001 (http://www.worksafebc.com/health_care_providers/Assets/PDF/hydrotherapy_application_physiotherapy.pdf)

59 Hypertext36. Bertaccini A., Borghesi M., *Indications for a medium mineral high bicarbonate water (Cerelia) in urology*. Arch Ital Urol Androl. 2009 Sep; 81 (3): 192-4 (<http://www.ncbi.nlm.nih.gov/pubmed/19911684>)

60 Hypertext37. Di Paolo N, Nicolai GA, Lombardi M, Maccari F, Garosi G., *High doses of water increase the purifying capacity of the kidneys*. Int J Artif Organs. 2007 Dec;30(12):1109-15 (<http://www.ncbi.nlm.nih.gov/pubmed/18203073>)

diuresis by inducing vasodilation in gastric mucosal tissues, with subsequent quick absorption.⁶¹

5.3.2 Hydration and the cardiovascular system

The cardiovascular system, too, benefits from proper hydration. Proper hydration reduces blood viscosity and the risk of thrombosis, as magnesium promotes the relaxation of heart muscle cells, while calcium stimulates heart contraction and participates in blood coagulation. So, waters with a higher degree of *hardness* tend to enhance blood fluidity and thus reduce the risk of infarction.

A further benefit for the cardiovascular system comes from saline (sodium chloride), sulphated-saline (containing sulphur as well), calcic-bi-carbonated (with bicarbonate and calcium) waters, as all of them reduce blood fat levels and therefore the risk of arteriosclerosis.

Zubkova SM. *et al*⁶², demonstrated in a study that some trace elements found in mineral waters prevent atherosclerosis and protect against the risk of developing it.

Low-sodium oligomineral waters help in keeping blood pressure under control, as they enhance diuresis and support sodium reduction.

Other studies analyzed blood pressure values in individuals who consumed waters rich in magnesium. These studies found increased magnesium serum concentrations in all patients, observing different urinary excretion patterns as in some of these individuals a percentage of this cation deposited in the tissues, enhancing elimination of Na, thus reducing blood pressure and protecting the heart.⁶³ Additional study findings show that the induced excretion of sodium seems to be enhanced by medium-mineralized bi-carbonated (low-sodium) waters. Sodium levels had no significant variations: no major changes were observed on kaliuria and kalemia. Changes in natremia, albeit not significant, do not exclude that low-sodium bicarbonate waters may support a hypotensive therapy. A protective role of calcium on hypertension has also been reported.⁶⁴

61 Hypertext117. Siener R, Jahnen A, Hesse A. *Influence of a mineral water rich in calcium, magnesium and bicarbonate on urine composition and the risk of calcium oxalate crystallization*. Eur J Clin Nutr. 2004 Feb;58(2):270-6. (<http://www.ncbi.nlm.nih.gov/pubmed/14749747>)

62 Hypertext38. Zubkova SM, Varakina NI, Mikhaïlik LV, Bobkova AS, Chabanenko SS; *Experimental study of the role of essential trace elements of mineral waters in prevention of atherosclerosis risk factors*, Vopr Kurortol Fizioter Lech Fiz Kult. 2001 Mar-Apr;(2):8-11

63 Hypertext39. Rylander R, Arnaud MJ., *Mineral water intake reduces blood pressure among subjects with low urinary magnesium and calcium levels*. BMC Public Health. 2004 Nov 30;4:56 (<http://www.ncbi.nlm.nih.gov/pubmed/15571635>)

64 Hypertext118. Santos A , Martins MJ, Guimarães JT, Severo M, Azevedo I. *Sodium-rich carbonated natural mineral water ingestion and blood pressure*. Rev Port Cardiol. 2010 Feb;29(2):159-72. (<http://www.ncbi.nlm.nih.gov/pubmed/20545244>)

5.3.3 Hydration and the gastrointestinal tract

There are benefits also for the *gastrointestinal tract*.

The mechanisms through which saline and other similar waters carry out their therapeutic action at gastrointestinal level are quite complex and are still being studied. These waters basically stimulate chlorohydropeptic secretions and peristaltic waves in the gastrointestinal tract. Either action can prevail over the other according to salt concentration. In short:

- iso and hypotonic waters: significant stimulation of secretion, poor or no peristaltic stimulation;
- hypertonic waters: strong peristaltic stimulation, reduced stimulation of gastric secretions.

Quick intake (drinking in few minutes) promotes a laxative action. For the above reasons, iso and hypotonic waters are particularly recommended in case of non-specific gastrointestinal tract disorders, characterized by low gastric secretion and motility. The stimulation of digestive processes occurs at various levels in the stomach and duodenum, and includes: increased gastric emptying speed, stimulation of gastric, biliary, and pancreatic secretions with combined activation of some digestive enzymes; gastric and duodenal pH changes. The peristaltic action of hypertonic waters is beneficial in case of simple chronic constipation and in some intestinal atony conditions (functional intestinal disorders or irritable bowel syndrome). Intestinal transit speed is significantly increased and the laxative and purgative effect of highly saline waters usually appears within one hour after intake.

Earthy-alkaline, sulphated saline mineral waters promote intestinal motility and act on the dietary fibres, thus increasing transit speed.

The action of some mineral waters, including sulphated ones, on large intestine muscles was documented in individuals suffering from constipation, either chronic or due to colonic spasms, with abnormal haustra (pouches) and mass movements, whose spasm and atony returned essentially to normal as shown by x-ray findings. Pro-peristaltic hormonal stimulations (CCK, etc.), muscle relaxing, biliary function stimulation, and the osmotic actions of magnesium sulphate certainly contribute to laxative effects. Magnesium may be poorly absorbed in the intestine (about one-third of its content in food) and absorption speed be reduced by the presence of sulphates, but it is proven that part of these effects are independent of the action of sulphated waters on the duodenum, liver, and pancreas.⁶⁵

65 Hypertext119. Melgar S, Engström K, Jägervall A, Martinez V. *Psychological stress reactivates dextran sulfate sodium-induced chronic colitis in mice*. Stress. 2008 Sep;11(5):348-62. (<http://www.ncbi.nlm.nih.gov/>)

Guliaeva SF. *et al*⁶⁶ found that calcic-sulphated mineral water improves stomach and gallbladder motility and evacuation efficiency.

The action of bi-carbonated waters can hardly be summarized, in that it is significantly affected by the presence of other mineralizing agents. Similarities exist with the action mechanisms of sulphated waters.⁶⁷ The buffer effect was carefully studied. At gastric and duodenal level, these waters act on secretion and motility. Drinking bi-carbonated waters on an empty stomach raises the gastric pH and inhibits secretion following a stimulation reflex originating from the duodenum. Several studies confirm a reduced secretory activity and lesser mucosal damage due to acid secretions. If consumed with meals, these waters enhance secretions. This secretion-enhancing action and the increased acidity should be attributed to the presence of calcium ions deriving from the release of gastrin and other enteral hormones. The stimulating action of bi-carbonated waters on peristalsis and gastric emptying was observed both *in vivo* and *in vitro*. In clinical practice, this translates into confirmed efficacy of bi-carbonated waters in reducing hyperchlorhydria and gastric irritation, with subsequent beneficial effects on dyspeptic disorders of various origins.⁶⁸

Moreover, the study of the absorption of glycosides, lipids, and proteins indicates a clear effect of treatments with bi-carbonated and sulphated-bi-carbonated waters in terms of increased absorption in individuals with liver and pancreatic failure. The action on secretion, gastric and duodenal contraction, and mucosal trophism also contributes to improve digestion and, therefore, assimilation.⁶⁹

Alkaline-bi-carbonated waters (sodium, potassium bicarbonate) are beneficial in case of vomiting, diarrhoea, and irritable bowel syndrome, in that they reduce motility and make up for fluid and electrolyte losses.

Mineral waters have a variety of beneficial effects on *gastro-secretory functions*.

Bertoni M. *et al*⁷⁰ demonstrated in a study that an alkaline-bi-carbonated mineral water

pubmed/18666024)

66 Hypertext40. Guliaeva SF, Pomaskina TV, Guliaev PV, Martusevich AK, Aistov VI.; [Efficacy of sulfate calcium mineral water in disorders of motor evacuatory function of the stomach and gallbladder]. *Vopr Kurortol Fizioter Lech Fiz Kult*. 2004 Nov-Dec;(6):20-2 (<http://www.ncbi.nlm.nih.gov/pubmed/15717533>)

67 Hypertext120. Fornai M, Colucci R, Antoniolli L, Ghisu N, Tuccori M, Gori G, Blandizzi C, Del Tacca M. *Effects of a bicarbonate-alkaline mineral water on digestive motility in experimental models of functional and inflammatory gastrointestinal disorders. Methods Find Exp Clin Pharmacol*. 2008 May;30(4):261-9. doi: 10.1358/mf.2008.30.4.1159650 (<http://www.ncbi.nlm.nih.gov/pubmed/18773120>)

68 Li L, Somerset S2. *Digestive system dysfunction in cystic fibrosis: challenges for nutrition therapy*. *Dig Liver Dis*. 2014 Oct;46(10):865-74. (<http://www.ncbi.nlm.nih.gov/pubmed/25053610>)

69 Hypertext121. Beglinger C. *Effect of cholecystokinin on gastric motility in humans*. *Ann N Y Acad Sci*. 1994 Mar 23;713:219-25. (<http://www.ncbi.nlm.nih.gov/pubmed/8185162>)

70 Hypertext41. Bertoni M1, Olivieri F, Manghetti M, Boccolini E, Bellomini MG, Blandizzi C, Bonino F, Del Tacca M. *Effects of a bicarbonate-alkaline mineral water on gastric functions and functional dyspepsia: a preclinical and*

improved gastrointestinal functioning and functional dyspepsia by improving stomach motility, gastric emptying, and secretory functions, and stimulating gastrin/CCK-2 receptors.

Other studies have focused on the protective action of mineral waters on gastric walls attacked by various aggressors. Konturek SJ. *et al*⁷¹ analyzed the different gastric mucosa aggressors, such as pepsin and gastric acid in normal conditions; *Helicobacter pylori* and NSAIDs in case of illness, and other factors, such as stress, cytokines, as well as oxygen and nitrogen free radicals. The integrity of the gastric mucosa is preserved through an action that balances aggressors and protectors in which mineral waters, too, can participate with beneficial effects on health.

The same action performed on the autonomic nervous system and, particularly, on its parasympathetic component, is also responsible for the increase of chlorohydropeptic secretions (particularly of chloride) and motility brought about by carbonated waters.^{72,73} Some studies evaluated the improvement of *intestinal absorption* in individuals consuming mineral waters of different compositions.

Kastrikina TF. and Vavilova GL.⁷⁴ demonstrated that the solution used to wash the duodenum is responsible for regulating the secretion of inhibiting factors that control the activity of the Na-K ATPase pump of the enterocytes.

Waters also affect *intestinal motility*.

Fornai M. *et al*⁷⁵ carried out a study to evaluate the action of an alkaline-bi-carbonated water on gastrointestinal motility in experimental models of functional and inflammatory gastrointestinal disorders. In one experimental model, diarrhoea was produced with prostaglandins, and constipation with loperamide. Colitis was induced by dinitrobenzenesulphonic acid (DNBS) or acetic acid. The study found that alkaline-bi-

clinical study. Pharmacol Res. 2002 Dec;46(6):525-31. <http://www.ncbi.nlm.nih.gov/pubmed/12457626>

71 42. Konturek SJ., Brzozowski T., Konturek PC., Schubert ML., Pawlik WW., Padol S., Bayner J., *Control of Gastric Secretion** J Physiol Pharmacol 2008 Aug; 59 Suppl 2: 7-31 (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2092355/>)

72 Hypertext122. Newton CR, Gonvers JJ, McIntyre PB, Preston DM, Lennard-Jones JE. *Effect of different drinks on fluid and electrolyte losses from a jejunostomy*. J R Soc Med. 1985 Jan;78(1):27-34. (<http://www.ncbi.nlm.nih.gov/pubmed/3968667>)

73 Hypertext123. Flemström G, Mäkelä K, Purhonen AK, Sjöblom M, Jedstedt G, Walkowiak J, Herzig KH. *Apelin stimulation of duodenal bicarbonate secretion: feeding-dependent and mediated via apelin-induced release of enteric cholecystokinin*. Acta Physiol (Oxf). 2011 Jan;201(1):141-50. (<http://www.ncbi.nlm.nih.gov/pubmed/20726845>)

74 Hypertext43. Kastrikina TF, Vavilova GL: [*Endocrine intestinal low molecular weight factor inhibits Na⁺,K⁺-ATPase activity of enterocytes*]. Ukr Biokhim Zh; 1989 Sep-Oct;61(5):96-8 (<http://www.ncbi.nlm.nih.gov/pubmed/2555953>)

75 Hypertext45. Fornai M., Colucci R., Antonioli L., Ghisu M., Tuccori M., Gori G., Blandizzi C., Del Tacca M.; *Effects of a bicarbonate-alkaline mineral water on digestive motility in experimental models of functional and inflammatory gastrointestinal disorders*. Methods Find Exp Clin Pharmacol. 2008 May; 30 (4): 261-9 (<http://www.ncbi.nlm.nih.gov/pubmed/18773120>)

carbonated water enhanced gastric emptying through gastrin-mediated mechanisms, whereas activation of serotonergic pathways was important to regulate colonic functions.

Some studies focused on *gallbladder and biliary tract motility*.

Sulphurous waters contain sulphur compounds that are metabolized and used in the liver. These waters have demonstrated to protect liver cells from lipid degeneration induced by carbon tetrachloride (CCl₄), arsenic, phosphorus, and phenol-induced necrosis.⁷⁶

Alkaline-bi-carbonated waters alkalinize the bile and reduce its viscosity; earthy-alkaline-bi-carbonated waters relax the sphincter of Oddi; saline, sulphated-saline, and bi-carbonated-sulphated waters perform a choleric and cholagogic action, and all these waters are effectively used for prevention of biliary disorders and gallstones. Sodium-chloride waters are also used in chronic biliary inflammatory diseases, dyskinesias, postcholecystectomy syndrome, and some types of gallstones.

Gutenbrunner C. *et al*⁷⁷ reported circadian changes in the gallbladder related to the intake of sulphated water, probably induced by the release of cholecystokinin. Following the intake of this water, the mean size of the gallbladder decreased, and then increased after one hour (P < 0.001). The contraction was highest in the early morning and lowest at noon after lunch; maximum relaxation was achieved around 6.00 p.m. with a variation range of about 29% of the daily average in the morning and 38.5% during the night, demonstrating that the circadian rhythm of gallbladder contraction is related to water intake.

Tierney S., Gorbunov IuV *et al*⁷⁸ analyzed gallbladder motility, which is controlled by a set of hormonal and neural factors. Studies demonstrate that motility disorders precede the formation of gallstones⁷⁹ and that the efficacy of water is measured by the ability of the gallbladder to concentrate and expel the bile.

Sulphated-bi-carbonated waters are useful for digestion because they promote liver and pancreatic secretion and enhance the action of digestive enzymes, while reducing

76 Hypertext124. Toussaint C, Peuchant E, Nguyen BC, Jensen R, Canellas J. *[Influence of calcic and magnesic sulphurous thermal water on the metabolism of lipoproteins in the rat]*. Arch Int Physiol Biochim. 1986 Jun;94(2):65-76. (<http://www.ncbi.nlm.nih.gov/pubmed/?term=water+sulphurous+hepatic>)

77 Hypertext47. Gutenbrunner C, El-Cherid A, Gehrke A, Fink M. *Circadian variations in the responsiveness of human gallbladder to sulfated mineral water*. Chronobiol Int. 2001 Nov;18(6):1029-39 (http://www.pneumonet.it/scientifico/medline/ricerca.html?list_uids=11777077)

78 Hypertext49. Gorbunov IuV, Korepanov AM.; *[The treatment of patients with chronic cholecystitis and hypomotor biliary dyskinesia at a sanatorium]*. Vopr Kurortol Fizioter Lech Fiz Kult. 1997 Sep-Oct;(5):32-4 (<http://www.ncbi.nlm.nih.gov/pubmed/9446306>)

79 Hypertext48. Tierney S., Pitt HA., Lillemo KD., *Physiology and pathophysiology of gallbladder motility*. Surg Clin North Am. 1993 Dec;73(6):1267-90. (<http://www.ncbi.nlm.nih.gov/pubmed/8248838>)

heartburn and expanding the alkaline environment of duodenal digestion.

5.3.4 Hydration and metabolism

Water is also fundamental for the appropriate functioning of the *brain* and of *high-metabolism tissues*.

Moderate dehydration (2%) at high ambient temperatures produces headache, exhaustion, and reduced mental performance in terms of concentration, alertness, and ability to execute simple tasks.

Dehydration above 2.5% at high temperatures and under intense physical activity influences intellectual performance.

Thus dehydration reduces brain efficiency and hampers cognitive processes. A loss of one litre of water, in fact, dehydrates the brain tissue and produces effects on its functioning similar to those observed after 14-month ageing or two and a half months with Alzheimer's disease.

Sulphurous waters also stimulate the parasympathetic nervous system with subsequent significant capillary vasodilation and increased vessel permeability (observed, in particular, at lung level), as well as reduced systemic arterial pressure, bradypnea, and bradycardia.⁸⁰

The parasympathetic stimulation effect of sulphurous waters can also improve intestinal motility, gastric secretions, choleresis, and biliary tract motility.⁸¹

Some studies evaluated the positive effects of water intake (thanks to its minerals) in terms of *metabolism protection*.

One study showed that magnesian-calcic-bi-carbonated waters and arsenical-boric-iodic-bromic bicarbonate –saline-bi-carbonated waters can prevent the complex metabolic disorders typical of obesity by acting on lipid and carbohydrate metabolism.⁸²

Calcic mineral water helps bone metabolism, particularly in the groups of the population that are at higher risk of calcium deficits, such as children, pregnant or menopausal women, elderly people, and athletes. It ensures the appropriate daily intake of calcium, which is bioavailable, i.e. absorbed by the organism, more effectively than from dairy

80 Hypertext129. Erceg-Rukavina T, Stefanovski M. *Balneotherapy in treatment of spastic upper limb after stroke*. Med Arch. 2015 Feb;69(1):31-3. doi: 10.5455/medarch.2015.69.31-33. Epub 2015 Feb 21. (<http://www.ncbi.nlm.nih.gov/pubmed/25870474>)

81 Hypertext130. Soria M, González-Haro C, Esteva S, Escanero JF, Pina JR. *Effect of sulphurous mineral water in haematological and biochemical markers of muscle damage after an endurance exercise in well-trained athletes*. J Sports Sci. 2014;32(10):954-62. doi: 10.1080/02640414.2013.868921. Epub 2014 Feb 6. (<http://www.ncbi.nlm.nih.gov/pubmed/24499262>)

82 Hypertext51. Antoniuk MV, Ivanova IL, Khasina EI.; *[The effect of the internal intake of carbonate mineral waters on lipid and carbohydrate metabolism in the development of experimental obesity]*. Vopr Kurortol Fizioter Lech Fiz Kult. 1996 Jan-Feb;(1):23-5 (<http://www.ncbi.nlm.nih.gov/pubmed/8686219>)

products and avoids surplus calorie intake, as is the case with a diet rich in dairy products. Studies were carried out and others are under way to understand the potential dietary and therapeutic role of mineral waters. For bi-carbonated and, particularly, calcic- and earthy-alkaline bi-carbonated waters, opportunities have been identified for infant and child nutrition, athlete nutrition, hypertension and, more recently, osteoporosis.⁸³ Lastly, an anti-toxic action was observed on the metabolism of several organic substances and metals, including lead, bismuth, phosphorus, and botulin and diphtheria toxins.⁸⁴

Some studies focused on the *metabolic and immune-modulating function of mineral waters*.

Toussaint C. *et al*⁸⁵ observed that magnesian calcic sulphurous waters act on lipoprotein metabolism in case of hypercholesterolemia by involving cholesterol catabolism, increasing HDL cholesterol levels by 52%, stabilizing LDL levels, and promoting the transformation of cholesterol into biliary acids, as well as their secretion. Thermal waters are likely to increase the liver receptors identifying apolipoproteins B (LDL) and E (HDL) in rats administered a hypercholesterolemic diet, as well as to enhance the synthesis of antiatherogenic HDL apolipoproteins.

56

Thanks to its minerals, water also influences the *immune system* by increasing the levels of glucocorticoids and catecholamines. A regular intake of water promotes adjustment to stress and brings about changes in lymphocyte populations, particularly in T-suppressor cells, through changes in the cytokine message.⁸⁶

Some studies focused on the *contents of mineral waters*.

Garzon P. *et al*⁸⁷ examined the varying contents of bottled mineral waters. The level of major cations in mineral waters varies considerably. For example, the level of

83 Hypertext125. Adeva-Andany MM, Carneiro-Freire N¹, Donapetry-García C¹, Rañal-Muñio E¹, López-Pereiro Y¹. *The importance of the ionic product for water to understand the physiology of the acid-base balance in humans*. Biomed Res Int. 2014;2014:695281. (<http://www.ncbi.nlm.nih.gov/pubmed/24877130>)

84 Hypertext126. Prandelli C, Parola C, Buizza L, Delbarba A, Marziano M, Salvi V, Zacchi V, Memo M, Sozzani S, Calza S, Uberti D, Bosio D. *Sulphurous thermal water increases the release of the anti-inflammatory cytokine IL-10 and modulates antioxidant enzyme activity*. Int J Immunopathol Pharmacol. 2013 Jul-Sep;26(3):633-46. (<http://www.ncbi.nlm.nih.gov/pubmed/24067460>)

85 Hypertext63. Toussaint C, Peuchant E, Nguyen BC, Jensen R, Canellas J.; *[Influence of calcic and magnesian sulphurous thermal water on the metabolism of lipoproteins in the rat]*. Arch Int Physiol Biochim. 1986 Jun;94(2):65-76 (<http://www.ncbi.nlm.nih.gov/pubmed/2430538>) Arch Int Physiol Biochim. 1986 Jun;94(2):65-76.

86 Hypertext64. Kolesnikov O.L., Selianina G.A., Dolgushin I.I., Kolesnikova A.A., *[The question of mechanisms of the immunotropic effect of mineral drinking waters]*. Vopr Kurortol Fizioter Lech Fiz Kult. 2002 May-Jun; (3): 15-7 (<http://www.ncbi.nlm.nih.gov/pubmed/12221837>)

87 Hypertext59. Garzon P, Eisenberg MJ., *Variation in the mineral content of commercially available bottled waters: implications for health and disease*. Am J Med. 1998 Aug; 105 (2): 125-30 (<http://www.ncbi.nlm.nih.gov/pubmed/9727819>)

magnesium ranges from 0 to 126 mg per litre, and the level of calcium from 0 to 546 mg per litre. Mg reduces the frequency of sudden deaths, sodium increases pressure levels, and calcium can help prevent osteoporosis. Therefore, the recommended water should contain low concentrations of Na.

Markt W.⁸⁸ analyzed the effects of mineral waters on health, also with reference to the above-mentioned study. Calcium and magnesium cations are the most important, while iodine, fluorine, and lithium are the main trace elements. Mineral bioavailability in mineral waters is high and comparable to the values of milk. The effect of Na as a cause of hypertension is questionable, because Na is mostly found in mineral waters as sodium bicarbonate, which is not responsible for vascular hypertension.

One major benefit deriving from the intake of mineral water is that it supplies mineral elements and trace elements without any calorie intake.

Other studies focused on magnesium *absorption patterns*.

Sabatier *et al*⁸⁹ evaluated the consequences of the consumption of Mg from mineral waters rich in magnesium on this element's bioavailability, in that its absorption has an inverse correlation with the ingested dose. In fact, enhanced absorption (50.7% vs. 32.4% $p = 0.0007$) and increased retention (47.5% vs. 29% $p = 0,0008$) of magnesium were observed in the study when magnesium was introduced with mineral water in seven small portions (7 x 212 ml) vs. two larger portions (2 x 750 ml). Regular and ongoing consumption of magnesium water increases the cation's bioavailability.

Other studies focused on the potential *functions of calcium and bicarbonate*.

A study by Heaney *et al*⁹⁰ demonstrated that all mineral waters rich in calcium produce calcium absorption equal to calcium contained in milk, or slightly improved, and biodynamic responses that point out to good calcium absorption, namely: increased urinary calcium, reduced PTH, reduced bone re-absorption biomarkers, and bone mass protection.

Wynn E. *et al*⁹¹ demonstrated that, upon a normal intake of Ca, a Ca-rich acid water

88 Markt W., Wien Klin Wochenschr. 2009; 121 (17-18): 544-50 (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2526733/>)

89 Hypertext44. Sabatier M, Grandvuillemin A, Kastenmayer P, Aeschliman JM, Bouisset F, Arnaud MJ, Dumoulin G, Berthelot A. *Influence of the consumption pattern of magnesium from magnesium-rich mineral water on magnesium bioavailability*. Br J Nutr. 2011 Aug;106(3):331-4 (<http://www.ncbi.nlm.nih.gov/pubmed/21473800>)

90 Hypertext52. Heaney RP. *Absorbability and utility of calcium in mineral waters*. Am J Clin Nutr. 2006 Aug; 84 (2): 371-4 (<http://www.ncbi.nlm.nih.gov/pubmed/16895885>)

91 Hypertext53. Wynn E, Krieg MA, Lanham-New SA, Burckhardt P; *Postgraduate Symposium: Positive influence of nutritional alkalinity on bone health*. Proc Nutr Soc. 2010 Feb;69(1):166-73 (<http://www.ncbi.nlm.nih.gov/pubmed/19954569>)

has no effect on bone re-absorption, whereas an alkaline water rich in bicarbonates results into a reduction of both serum PTH and C-telopeptide. The consumption of bicarbonated water could therefore help prevent osteoporosis and be extremely useful for long-term prevention of bone tissue losses.

Other studies focused on the *antioxidant function* of mineral waters.

Benedetti S. *et al*⁹² investigated the antioxidant effects of consuming sulphurous waters as a beverage after water drinking therapy (500 ml per day for 2 weeks). After 2 weeks, a reduction ($p < 0.05$) of the products of lipid and protein oxidation, such as malonyldialdehyd and carbon breakdown products, as well as an increase ($p < 0.05$) in the antioxidant capability of plasma were recorded in the plasma of subjects consuming these waters through the increase of the plasma levels of thiol vs. the same subjects first used as controls, while tocoferols, carotenoids, and retinol remained unchanged in both groups. This leads to conclude that sulphurous waters have antioxidant properties and can protect from degenerative diseases.

Costantino M. *et al*⁹³ examined the role of water drinking therapy on oxidative stress. Abundant data from the studies associate oxidative stress with several gastrointestinal and metabolic disorders, including diabetes or gastric cancer. In an epidemiological study 57 individuals with type 2 diabetes mellitus were treated with sulphurous mineral water and hypoglycaemic drugs. The evaluated outcomes included fasting plasma glucose and the plasma concentration of oxygen-reactive metabolites. Results showed a statistically significant reduction in fasting plasma glucose ($p < 0.05$) with the intake of hypoglycaemic drugs and sulphurous waters vs. diet and sulphurous waters. Results also showed a statistically significant reduction ($p < 0,05$) of oxygen-reactive metabolite concentration in the group treated with blood glucose lowering drugs and sulphurous water vs. the group treated with the hypoglycaemic drugs only. This shows that sulphurous water combined with antidiabetic drugs provides benefits in terms of improvement of the redox state of the body in patients with type 2 diabetes mellitus.

92 Hypertext61. Benedetti S, Benvenuti F, Nappi G, Fortunati NA, Marino L, Aureli T, De Luca S, Pagliarani S, Canestrari F. *Antioxidative effects of sulfurous mineral water: protection against lipid and protein oxidation*. Dipartimento: Istituto di Istologia e Analisi di Laboratorio, Università di Urbino Carlo Bo, Urbino, Italy, Eur J Clin Nutr, 2007 (<http://www.ncbi.nlm.nih.gov/pubmed/17717532>)

93 Hypertext62. Costantino M, Giampaolo C, Filippelli A.; [*Effects of drinking spa therapy on oxidative stress*]. Clin Ter. 2012;163(1):e13-7 <http://www.ncbi.nlm.nih.gov/pubmed/22362238>

06

Different types of water for different population groups

The role of water should also be evaluated in different groups of the population, particularly children, women, elderly people, athletes, and workers.

It is obviously impossible to examine each of these special cases in-depth, due to their specific subjectivity and to their particular needs, which should be evaluated individually. We will therefore focus on aspects of general importance.

6.1 Children

6.1.1 Young children

Children should drink abundantly for their healthy development and growth. High water consumption in children is crucial for them to carry out mental and physical activities, to counter the onset of diseases, and grow strong.

There is general consensus on the idea that waters intended for child consumption should contain low salt concentrations for very young ones, to then move to water with higher concentrations, proportionally as the child grows.

Moreover, a concentration limit is recommended for nitrates, which should not exceed 10 mg/l, and for sodium, which should best be low. In fact, the presence of nitrates promotes the production of methemoglobin, a toxic product. Sodium levels should also be low, because sodium increases arterial pressure. Some studies showed that a sodium-rich diet in children tends to increase the risk of vascular hypertension for them as adults. The best waters include oligo or medium-mineral calcic-bi-carbonated waters, and, in any case, waters rich in calcium (more than 300 mg/l).

Some studies focused on the food habits of certain *age groups*.

Rudzka-Kantoch Z *et al*⁹⁴ addressed the issue of water in children's diet. In younger children, natural or natural mineral spring water with a low Na content (≤ 20 mg/1 dm³ of Na) or low-mineral water with dissolved minerals (≤ 500 mg/1 dm³) can be administered. In older children, the concentration can be raised to ≤ 1000 mg/1 dm³.

Dehydration is one of the most frequent reasons for child hospitalization. It is therefore extremely important to provide for protocols allowing careful diagnostic evaluation and an appropriate therapeutic approach.

The dehydration diagnosis should solely be made on the ground of clinical parameters including, most importantly, weight loss: a weight loss of less than 5% points out to mild dehydration, a loss between 5 and 10% means moderate dehydration, and a loss

94 Hypertext54. Rudzka-Kantoch Z., Weker H., *Postgraduate Symposium: Positive influence of nutritional alkalinity on bone health*. Med Wieku Rozwoj. 2000; 4 (3 Suppl 1): 109-15 (<http://www.ncbi.nlm.nih.gov/pubmed/11381158>)

of more than 10% occurs in severe forms. Weight is only one of the clinical parameters that need to be evaluated to diagnose possible dehydration and its severity.⁹⁵

The gold standard for evaluation of dehydration would be comparing the present weight with a reliable pre-disorder weight (historical data that is often not available to the parents).

As a good rule of health education, parents should be instructed to weigh their children as soon as the early symptoms appear (episode of vomiting/first episode of diarrhoea), thus providing objective data to help evaluate the child's dehydration state (Table 6-1).

Clinical evaluation of dehydration			
	Mild	Moderate	Severe
Weight loss	<5%	5-10%	>10%
General appearance	Restless	Lethargic	Lethargic/hypothermal
Tears	Not too limited	Very limited	Absent
Skin suppleness	Somewhat reduced	Significantly reduced	Absent
Mucous membranes	Not too moist	Dry	Very dry
Capillary backflow	Slightly delayed	Delayed	Significantly delayed (<4'')
Pressure	Normal	Normal/Low	Low
Diuresis	Slightly reduced	Reduced	Oliguria
Pulse	Slightly accelerated	Rapid	Rapid/weak
Eyes	Slightly deep-set	Deep-set	Significantly deep-set
Front fontanelle	Normal	Hollowed	Significantly hollowed

table 6-1

Whilst the rehydrating therapy should always start orally, indications for i.v. rehydration include uncontrollable vomiting, shock, paralytic ileus, or failure of first oral rehydration. The amount of fluids to be administered orally in the first 4 hours depends on the child's weight (Table 6-2); solutions rich in mineral salts and sugars are generally used.

95 Hypertext68. Hayajneh WA, Jdaitawi H, Al Shurman A, Hayjneh YA. *Comparison of clinical association and laboratory abnormalities in children with moderate and severe dehydration.* J Pediatr Gastroenterol Nutr 2006 July 28 (<http://www.ncbi.nlm.nih.gov/pubmed/19644395>)

Hypertext69. Seokyoung H, YaeJean K, Paul G. *Reduced osmolarity oral rehydration solution for treating dehydration due to diarrhoea in children: systematic review.* BMJ 2001; 323: 81-5. (<http://www.ncbi.nlm.nih.gov/pubmed/11451782>)

Child weight	Amount of fluids to be administered p.o. in the first hours (ml)
<5kg	200-400
5-8 kg	400-600
8-11 kg	600-800
11-16 kg	800-1200
16-50 kg	1200-2200

I.v. rehydration is the primary emergency approach in case of shock.

6.1.2 Newborns

Oligomineral water is strongly recommended to prepare infant formulas and dilute cow's milk for infant nutrition.

Indeed, calcic-bi-carbonated or earthy-alkaline waters for preparation of infant formulas seem to be well tolerated and to promote assimilation, while ensuring a high intake of calcium and other electrolytes that are important at this stage of life when infants grow rapidly in size and weight. In order to ensure an optimal intake of minerals, the use of medium-mineral waters has been considered, and these are now deemed first choice. It should further be noted that, according to some researchers, oligomineral waters are recommended for infants and children for their reduced buffer effect, which ensures a reduced strain on still immature gastric secretions.⁹⁶

At this stage in life, protein intake should be limited, because a nitrogen waste surplus deriving from protein catabolism could cause harm.

An infant's urinary tract, in fact, is hardly capable of compensating and cannot properly concentrate solutes in urine. Moreover, maximum urinary osmolarity (the urinary concentration of solutes) is 400 mOsm/Kg.

Oligomineral waters should therefore be used to keep total electrolyte and metabolic waste disposal below 400 mOsm/Kg.

Water accounts for most of an infant's body weight: 70% at birth, declining to approximately 60% at six months of age. A healthy infant should consume about 75-100 ml/kg of water per day. However, due to a number of factors that increase the risk

96 Hypertext127. Bobulescu IA, Moe OW. *Luminal Na(+)/H (+) exchange in the proximal tubule*. Pflugers Arch. 2009 May;458(1):5-21. doi: 10.1007/s00424-008-0595-1. Epub 2008 Oct 14. (<http://www.ncbi.nlm.nih.gov/pubmed/18853182>)

of dehydration, the recommended consumption is 150 ml/kg of fluids per day.⁹⁷

Later, in the first 6 months or up to 5 kg of body weight, approximately 750 ml of fluids per day are recommended.

This shows that the water requirement of infants is seven times higher than for adults. In fact, infant metabolism is twice faster vs. body weight. Infant kidneys are still underdeveloped and incapable to dispose of solutes properly. The functional development of nephrons in infants is incomplete until after the first month of age and the renal tubuli only develop completely by the fifth month. Moreover, at this stage the production of antidiuretic hormone and vasopressin is limited. When combined, all these factors reduce the infant's ability to reach sufficient urinary concentrations and therefore to preserve the body water content. Hence, at this early stage children are more vulnerable to fluid and electrolyte imbalance.⁹⁸

6.1.3 Kids and adolescents

Water intake and loss is to be carefully balanced in children, particularly early in life, when the child is more vulnerable to fluid and electrolyte imbalances.⁹⁹ Children, like infants and toddlers, are at higher risk of dehydration compared to adults.¹⁰⁰

Although it is hard to give a standard value for water intake, there are recommendations that can be provided to ensure appropriate child rehydration and thus preserve the child's good health.¹⁰¹

The results of the studies on water balance show that water intake doubles from the first month and between the sixth and twelfth month of life. Water consumption increases by 5 to 10% between 2 and 9 years of age.

The recommended daily water intake for children aged 0 to 6 months is 0.7 l, assuming that this amount mostly comes from milk; the requirement from 7 to 12 months is 0.8

97 Hypertext66. Armon K, Stephenson T, MacFaul R, Eccleston P, Werneke U. *An evidence and consensus based guideline for acute diarrhoea management*. Arch Dis Child 2001; 85: 132-42. (<http://www.ncbi.nlm.nih.gov/pubmed/11466188>)

98 Hypertext67. Colletti JE, Brown KM, Sharieff GQ, Barata IA, Ishimine P; ACEP Pediatric Emergency Medicine Committee. *The management of children with gastroenteritis and dehydration in the Emergency Department*. L Emerg Med 2009 April 2 (<http://www.ncbi.nlm.nih.gov/pubmed/19345549>)

99 Hypertext70. Fonseca BK, Holdgate A, Craig JC. *Enteral vs intravenous rehydration therapy for children with gastroenteritis: a meta-analysis of randomized controlled trials*. Arch Pediatr Adolesc Med 2004; 158: 483-90. (<http://www.ncbi.nlm.nih.gov/pubmed/15123483>)

100 Hypertext71. Nager AL, Wang VJ. *Comparison of nasogastric and intravenous methods of rehydration in pediatric patients with acute dehydration*. Pediatrics 2002; 109: 566-72. (<http://www.ncbi.nlm.nih.gov/pubmed/11927697>)

101 Hypertext72. [No authors listed] *Practice parameter: the management of acute gastroenteritis in young children*. American Academy of Pediatrics, Provisional Committee on Quality Improvement, Subcommittee on Acute Gastroenteritis. Pediatrics 1996; 97: 424-35.

(<http://www.ncbi.nlm.nih.gov/pubmed/?term=Practice+parameter%3A+the+management+of+acute+gastroenteritis+in+young+children.+American+Academy+of+Pediatrics%2C+Provisional+Committee+on+Quality+Improvement%2C+Subcommittee+on+Acute+Gastroenteritis>)

l of water, assuming that the intake of breast milk is combined with other foods and beverages.¹⁰²

In older children (4-8 years of age), total average water consumption should be 1,779 ml/day, varying between 1,069 and 2,826 ml/day, with no differences between genders at this age.

At 9 gender-based differences appear. The recommended intake of drinking water is 1.8 l/day for males aged 9 to 13 and 2.6 l/day for those aged 14 to 18. For girls, the following reference parameters apply: 1.6 l/day from 8 to 13 and 1.8 l/d from 14 to 18. Physical activity plays a significant role in child entertainment and translates into increased muscular effort.

The consequences of this activity on the water balance, as well as on energy consumption, differ by age, gender, physical conditions, duration, intensity of exercise, and environmental conditions (temperature, humidity, wind, altitude, whether performed indoor or outdoor).¹⁰³

Adolescents require an abundant intake of water of varying composition, but calcium concentrations should be high to promote growth: calcic-bi-carbonated waters ensure enhanced calcium bioavailability compared to dairy products and raise the pH, while neutralizing the lactic acid produced during physical activity.

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Fluorinated waters, with a fluorine concentration of 0.7 mg per litre, are useful to *prevent dental cavities in youths*, as well as during pregnancy to support tooth formation in the foetus.

Waters that tend to alkalize the mouth pH are also particularly beneficial, in that an acid pH promotes the onset of cavities.

6.2 Women

There are periods in a woman's life when the need for appropriate nutrition is particularly urgent. Puberty, pregnancy, breastfeeding, and menopause are definitely the most critical periods in this respect, when appropriate nutrition and hydration can help prevent a number of illnesses.

At these times, it is therefore necessary to consume calcium-rich waters. In fact, the Italian Society for Human Nutrition recommends an intake of 1000-1200 mg/day of calcium from 7 to 17 years of age; 800-1000 mg/day from 18 and above; 1200 mg/day during pregnancy and breastfeeding. Calcium can also be introduced with dairy

102 Hypertext73. Baker LB1, Jeukendrup AE. *Optimal composition of fluid-replacement beverages*. Compr Physiol. 2014 Apr;4(2):575-620. doi: 10.1002/cphy.c130014. (<http://www.ncbi.nlm.nih.gov/pubmed/24715561>)

103 Hypertext74. Kositzke JA: *A question of balance. Dehydration in the elderly*. J Gerontol Nurs. 1990 May;16(5):4-11. (<http://www.ncbi.nlm.nih.gov/pubmed/2358648>)

products, which are often not consumed in the right amount either for weight-related reasons, considering their generally high fat contents, or due to an intolerance to lactose, the sugar contained in milk.

Moreover, calcium requirements and appropriate intake demand a low-alcohol and low-sodium diet, in that these substances hamper calcium absorption. Calcium-rich, low-sodium waters are therefore recommended, to be consumed in multiple doses throughout the day, in order to reduce the consumption of dairy products.

6.2.1 Menopause

Calcic waters, (with Ca^{++} levels above 150 mg/l) may and should be considered as a nutritional source of calcium. This is supported by recent studies on the bioavailability of the calcium contained in mineral waters. It turned out useful to calculate the rate of calcium in mineral waters that is actually available to satisfy the body's requirements and to carry out the relevant biological and therapeutic action. In one study, the bioavailability of the calcium contained in a high- Ca^{++} and low- Na^+ bicarbonate water, whose effect in terms of reduced calcium absorption is known, was extrapolated from a comparison with milk, acknowledged as a standard of high bioavailability. The findings of the study showed that:

- the calcium contained in the water under study is significantly bioavailable: assimilation is 49% for water vs. 43% for milk;^{104,105}
- calcium bioavailability is also observed in adults of all ages;
- while oestrogens and menopause generally influence assimilation, they do not affect the assimilation of the calcium contained in mineral water.

In the *perimenopausal* period and in the first 10 years after the onset of menopause, calcium intake should be increased to 1200-1500 mg/day. Calcium absorption, in fact, declines in elderly women, and the onset of chronic diseases, such as hypertension, heart disorders, or ictus, calls for a low-fat, low-calorie, low-salt diet, thus generating the risk of poor calcium intake. Illnesses like diabetes, hyperthyroidism, hyperparathyroidism, or drug therapies (e.g. cortisone-based drugs) produce significant calcium losses. Moreover, the intake of waters rich in calcium and magnesium can play a role in osteoporosis prevention and development.

104 Hypertext128. Vezzoli G, Arcidiacono T, Puzzovio M, Mora S. [Comparative study of the short-term effect of mineral water on calcium metabolism]. *G Ital Nefrol.* 2010 Jul-Aug;27(4):391-5. (<http://www.ncbi.nlm.nih.gov/pubmed/20672236>)

105 Hypertext114. Karagülle O, Smorag U, Candir F, Gundermann G, Jonas U, Becker AJ, Gehrke A, Gutenbrunner C. *Clinical study on the effect of mineral waters containing bicarbonate on the risk of urinary stone formation in patients with multiple episodes of CaOx-urolithiasis.* *World J Urol.* 2007 Jun;25(3):315-23. (<http://www.ncbi.nlm.nih.gov/pubmed/17333204>)

Lastly, calcic-bi-carbonated and earthy- alkaline-bi-carbonated waters may reduce the cardiovascular risk in post-menopausal women, in that calcium, sodium, and magnesium participate to the mitigation of post-prandial atherogenic lipemia.

6.2.2 Pregnancy and breastfeeding

Appropriate nutrition and hydration during pregnancy generally benefit the mother's and baby's health.

An insufficient intake of nutritional substances could hamper foetal development and prevent appropriate training of the mother's body for delivery and breastfeeding.

The foetus' growth is affected by the parents' genetic characteristics, as well as by environmental stimuli, such as an appropriate supply of nutrients and an appropriate diet.

The recommendation to *eat for two*, i.e. an inconsiderate increase of food intake, is a by-now outdated myth, which may cause undue weight gains and pave the way for a number of pregnancy-related disorders, such as gestosis and gestational diabetes.

Pregnancy is characterized by changes in the mother's physical status and by an increase of nutritional requirements due to the foetus' growth, to the development of certain organs, including the womb, to the increase of the blood corpuscles, and to preparation for breastfeeding.

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These requirements are partly addressed through adjustments of the mother's body that, by increasing the intestinal absorption of nutrients and reducing waste products, such as faeces and urine, allows to satisfy the mother's energy requirements and provide the necessary nutrients for foetus development.

This physiological phenomenon is not sufficient to ensure appropriate nutrition for the mother and for foetus development, and deficits or surpluses can be harmful for both.

The best general nutritional recommendation is to stick to, or introduce a varied and well-balanced diet allowing to respond to the nutritional demands of pregnancy. However, this necessarily implies appropriate hydration.

Unfortunately, mothers often tend to underestimate the need for appropriate nutrient intake out of their fear of weight gains.

The daily calorie intake varies according to pre-pregnancy weight, expressed as the *body mass index* (BMI) at the onset of pregnancy.

This introduces the concept of appropriate weight gain during pregnancy, which is summarized in Table 6-3: up to 16-18 kg for lean pregnant women; up to 7 or 8 kg for fat/obese pregnant women.

Weight gains up to 12 kg are generally considered as acceptable.

Recommended weight gain during pregnancy

table 6-3

	Pre-pregnancy BMI <18,5 kg/m ²	Pre-pregnancy BMI 18,5-25 kg/m ²	Pre-pregnancy BMI >25 kg/m ²
Weight gain (kg) at the end of pregnancy	12.5-18	11.5-16	7-11.5
Weight gain (kg) at the end of the first trimester	2.3	1.6	0.9
Weekly weight gain (kg) the third trimester	0.5	0.4	0.3

Weight gains should amount to approximately 1 kg per month in the first quarter and approximately 1.5 kg per month in the second and third quarter.

Fatty tissue accounts for at least 4 of these 12 kg of weight gain; the foetus' weight (3 kg on average), the placenta's weight, the womb's weight gain, the increase of circulating blood, etc. make up for the rest.

It should be noted that in the first quarter of pregnancy there is generally no specific need to adjust the diet, whereas in the second and third quarter it is useful to increase food intake due to the increased energy requirement.

In particular, after the 13th week of pregnancy, an increase of approximately 300 kcal per day is recommended to satisfy the metabolic requirements of both the mother and the foetus.

It is therefore best to control the quality of food, rather than its quantity. As far as hydration is concerned, in particular, the consumption of sugar-sweetened beverages should be strictly limited.

Calcium (mineral trace elements)

As described above, a varied and well-balanced diet and appropriate hydration allow to provide a positive response to nutritional requirements.

An increased calcium intake, up to approximately 1200 mg per day, is recommended, particularly in the third quarter.

For pregnant women that do not consume either milk or dairy products, or intolerant to lactose, the intake of waters with a high calcium content is recommended.

Iodine (mineral trace elements)

During pregnancy, the daily iodine requirement increases. Whilst it is mostly contained in dietary vegetables and fish, these can hardly satisfy the daily requirement completely. It is therefore useful to supplement the diet with iodized salt. Mineral waters properties are such as to prevent the need for supplementing the diet with salts, and are particularly useful for pregnant women with thyroid disorders.

Water

Women may happen to feel more thirsty during pregnancy, and this is quite natural, in that fluid intake should increase. The body should never be allowed to be thirsty and the diet should include fresh water, diluted fruit juice, milk (cow or soy milk), and tisanes. Beverages with caffeine (tea, coffee, or cola) should be limited, and alcohol intake should be avoided.

At least 2 l of water should be consumed throughout the day. Fluid intake at meals allows formation of a more even food bolus, although digestion is somewhat delayed.

When breastfeeding, the recommended dose is 2.4 l and up to 3 l per day.

As noted, the properties of the mineral waters can help increase the availability of certain mineral salts. The idea that water is responsible for weight gains should be deemed untrue. Indeed, weight changes due to water intake are just temporary.

Waters classified as medium-mineral based on their fixed total dry residue should be favoured. In case of problems like water retention or bloating, it may be useful to introduce low-sodium waters. To increase calcium availability and intestinal absorption, bicarbonate-calcium water is recommended.

6.3 Elderly people

One major challenge in elderly people is ensuring appropriate fluid intake, even in case of ascertained need. The mechanism of thirst is altered in old people, who therefore consume lower amounts of fluids than youths (after a one-hour water deprivation, an adult consumes about 10 ml/kg, vs only about 3 ml/kg for old people).¹⁰⁶ Water turns out somewhat unpleasant to old people, who therefore prefer other fluids (milk, fruit juice, etc.). This is often associated with ageing and the onset of other disorders, such as degenerative diseases (dementia, Parkinson's disease)¹⁰⁷ or the intake of certain

¹⁰⁶ Hypertext87. Ekblom B, Greenleaf CJ, Greenleaf JE, Hermansen L. *Temperature regulation during exercise dehydration in man*. Acta Physiol Scand 1970; 79: 475-83. (<http://onlinelibrary.wiley.com/doi/10.1111/j.1748-1716.1970.tb04748.x/abstract;jsessionid=8A8D85097E7A699A58326BC7EAAFC4EA.f01t01>)

¹⁰⁷ Hypertext88. Montain SJ, Sawka MN, Latzka WA, Valeri CR. *Thermal and cardiovascular strain from hypohydration: Influence of exercise intensity*. Int J Sports Med 1998; 19: 87-91.

drugs, such as digoxin or anticholinergic drugs¹⁰⁸ for the nervous system. Moreover, frequent use of diuretics or overuse of laxatives can cause an imbalance of sodium, potassium, and other ion concentrations between the extracellular and the intracellular compartment, with the latter attracting water. Diuretics are, on the other hand, often used both to counterbalance the water retention caused by a failure of the heart pump and to counter oedemas, particularly in the lower limbs, as well as to treat hypertension. Unfortunately, these drugs bring about water-electrolyte imbalances, which are secondary to their use and predictable and may include both hypo and hypernatraemia.¹⁰⁹

Besides, elderly people often tend to consume limited amounts of water and other fluids to prevent urinary incontinence, urinary urgency, or nocturia. A combined limited accessibility to fluid intake is also observed in case of other health problems: visual deficit, inability to eat or drink, use of retention systems that prevent movement, immobility, or the presence of architectural barriers.¹¹⁰

Hydration is not crucial in the warm season only, and water should be given the same importance as any other nutrient. Only thus can the problems caused by dehydration be prevented.¹¹¹ Obviously water is not the only substance to ensure hydration. Fruits and vegetables can be consumed as an alternative to other fluids based on individual wishes and requirements.¹¹²

An elderly person should consume fluids gradually throughout the day (drink at least 4-6 glasses of water, as if by medical prescription, like a drug), preferably in the morning rather than in the evening, to prevent any episodes of incontinence or night wakes. In the summer, however, old people should drink some fluid seven when waking up during the night. After each meal (breakfast, lunch, afternoon snack, dinner), they should drink a glass of water to ensure smooth swallowing of the food bolus. Old people should best avoid drinking just before and during meals, because this causes stomach filling and a sense of satiety. Fluid intake (approximately 300-400 ml) on an empty stomach in the morning produces a beneficial effect against constipation after about 10-15 minutes. Moreover, water intake has a diuretic action observed within 20-30 minutes

108 Hypertext89. Baumgartner RN, Stauber PM, McHugh D, Koehler KM, Garry PJ. *Crosssectional age differences in body composition in persons 60+ years of age*. J Gerontol 1995; 50A: M307-16.

109 Hypertext79. Phillips PA, Johnston CI, Gray L: *Disturbed fluid and electrolyte homeostasis following dehydration in elderly people*. Age and Ageing 1993;22:26-33. (<http://www.ncbi.nlm.nih.gov/pubmed/8438652>)

110 Hypertext90. Buffa R1, Floris GU, Putzu PF, Marini E *Body composition variations in ageing Coll Antropol*. 2011 Mar;35(1):259-65. (<http://www.ncbi.nlm.nih.gov/pubmed/21667542>)

111 Hypertext91. Wong, DL. *Balance and Imbalance of Body Fluids*. Winkelstein ML, Kline NE Wilson D. Nursing Care of Infants and Children. 7th. Philadelphia: Mosby; 2003 (<http://www.worldcat.org/title/wongs-nursing-care-of-infants-and-children/oclc/644149977>)

112 Hypertext92. Deveau M. *Contribution of drinking water to dietary requirements of essential metals*. J Toxicol Environ Health A 2010; 73: 235-41.

after ingestion.¹¹³

Hydration in elderly people should be pursued by drinking at least 2 l of water per day, which is the average amount of water required for a 70-kg elderly person.

One typical problem of old age is the difficulty to ensure appropriate water-electrolyte balance, which represents a fundamental homeostasis for life. An altered thirst sensation, a reduced ability to concentrate urine, an impaired adiuretic system, and a reduction of the amount of total body water are the four main causes for dehydration and hypernatraemia in elderly people.¹¹⁴

The pathophysiological reasons by which the thirst sensation is less pronounced in elderly people are unclear. According to some authors, this may be a defence mechanism against pollution from water and hyponatraemia, caused by the reduced ability of the kidneys to dispose of water surpluses.¹¹⁵

The decreased glomerular filtration capacity and tubular efficiency of the kidneys observed upon ageing result into unstable control, but there is no consensus yet on whether this is a normal physiological process or a subclinical disorder.¹¹⁶

Elderly people seem to have higher osmolarity values than adults.¹¹⁷ In practice, water retention is impaired in the kidneys of elderly people, combined with reduced efficiency in disposing of large amounts of water.

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In addition to the impaired homeostatic performance due to old age, many other effects are often correlated or closely correlated with ageing: reduced independence and physical performance result into the inability of an elderly person to respond each time to the stimulus to thirst, particularly in the summer, or when this is only moderate; he or she is not just unwilling, but more simply can hardly reach the bottle and pour the water into the glass for drinking. Dehydration in elderly people is one of the ten most frequent causes for hospitalization and a cause both for higher morbidity and mortality.

According to Warren *et al*¹¹⁸, 1.4% of over 10 million hospitalizations of people above 65 years of age had dehydration as the main cause, and this was a concomitant diagnosis in 6.7% of cases. Following dehydration alone, a 17.4% mortality rate was recorded in the first month after diagnosis, with an additional 30.6% in the following 11 months

113 Hypertext93. Murray B. Hydration and Physical Performance. *J Am Coll Nutr* 2007; 26: 542S-48S.

114 Hypertext75. Rolls BJ, Phillips PA. *Ageing and disturbances of thirst and fluid balance*. *Nutr Rev*. 1990 Mar;48(3):137-44. (<http://www.ncbi.nlm.nih.gov/pubmed/2406645>)

115 Hypertext76. Beck LH: *The ageing kidney. Defending a delicate balance of fluid and electrolytes*. *Geriatrics*. 2000 Apr;55(4):26-8, 31-3. (<http://www.ncbi.nlm.nih.gov/pubmed/10771700>)

116 Hypertext77. Kenney WL, Chiu P: *Influence of age on thirst and fluid intake*. *Med Sci Sports Exerc*. 2001 Sep;33(9):1524-32. (<http://www.ncbi.nlm.nih.gov/pubmed/11528342>)

117 Hypertext78. Silver AJ: *Ageing and risk for dehydration*. *Cleve Clin J Med*. 1990 Jun;57(4):341-4. (<http://www.ncbi.nlm.nih.gov/pubmed/2194700>)

118 Hypertext80. Armstrong LE1, Epstein Y, *Fluid-electrolyte balance during labor and exercise: concepts and misconceptions*. *Int J Sport Nutr*. 1999 Mar;9(1):1-12. (<http://www.ncbi.nlm.nih.gov/pubmed/10036337>)

– almost one death out of two after one year. For almost all the other main diagnoses upon admission (with the sole exception of gastroenteritis), concomitant dehydration increased mortality to a significant extent, both after 1 month and after 1 year.

Signs of dehydration are not so clear in elderly people. No mucosal dryness may be in place, skin suppleness can hardly be evaluated, and body weight is not too reliable.¹¹⁹ One dehydration index is a pulse increase by 10-20 beats/min when changing from the lying to the standing position.

Similarly, a decrease by 20 mmHg or more of systolic arterial pressure, or by 10 mmHg or more of diastolic AP, when changing from the lying to the standing position points out to dehydration.

The specific gravity of urine (urine test) is probably the most popular index to monitor fluid intake. Inappropriate intake forces the kidneys to concentrate urine, thus increasing the SG up to 1.025-1.030, whereas abundant water intake reduces the specific gravity to values close to those of plain water, i.e. around 1.000. Kidney efficiency, however, limits the time span for measurement of fluid intake, of which the SG is an index, to just a few hours before micturition. Urine collected in the morning (as is generally recommended for testing) are physiologically somewhat more concentrated than at other times of the day, with the same body hydration level, and their greater concentration allows easier identification of any pathological agents. Notwithstanding all these strict limits, the urinary density is, alongside sodiemia, the only reliable test index of poor fluid intake. In practice, concentrated urine is definitely a sign of dehydration only if combined with oliguria and hypotension.

The evaluation of electrolytes, Na and K in particular, is extremely useful in patients under diuretic therapy and to assess dehydration, particularly if severe. A value of Na⁺ above 148 points out to dehydration. However it should be noted that sodiemia can only detect hypertonic dehydration – which is anyway most frequent in elderly people – usually due to losses through the skin or lungs or to the failure to drink, but not isotonic dehydration (equal loss of water and Na), as in case of vomiting or diarrhoea, or hypotonic dehydration, where the sodium loss exceeds the water loss and serum sodium levels fall below 135, as in case of diuretic overuse. K plays a different role and is used to evaluate the appropriateness of the diuretic therapy: hyperkalemia points out to potassium-sparing diuretic overuse, while hypokalemia points out to the opposite.¹²⁰

119 Hypertext81. Warren JL, Bacon WE, Harris T, McBean AM, Foley DJ, Phillips C: *The burden and outcomes associated with dehydration among US elderly*, 1991. Am J Public Health 1994 Aug;84(8):1265-8. (<http://www.ncbi.nlm.nih.gov/pubmed/8059883>)

120 Hypertext82. Weinberg AD, Minaker KL: *Evaluation and management in older adults*. JAMA, 1995 Nov;274(19):1552-6. (<http://www.ncbi.nlm.nih.gov/pubmed/7474224>)

Osmolarity: in practice, this parameter follows Na changes, with the same indications and limits, but is less specific, because changes in glycaemia, natraemia, alcoholemia or other metabolites can cause undue changes of this parameter.

In some cases, warning signs may include the observation of high serum concentrations of proteins, albumin or haemoglobin, which point out to blood concentration rather than to increased synthesis. Constipation could also be a sign of dehydration, alongside impaired memory, drowsiness, or lethargy.

Preventing dehydration in elderly people

Elderly people may suffer from two types of dehydration: chronic, due to persistently low fluid intake that causes a permanent state of hypo-dehydration of the body, or acute, with specific events causing severe water imbalance.

Most acute fluid losses in elderly people, potentially worsening any underlying conditions, are generally due to overperspiration in warm and humid climates, not compensated with appropriate water intake, as typically occurs in summer months. Physical activity performed in warm and humid climates greatly increases fluid loss. Intestinal intoxications or infections can also cause significant water (and bicarbonate) losses with faeces, and so does vomiting or a wrong diuretic therapy.

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Water regulation difficulties in elderly people can be addressed, at least partly, by measuring the amount of water introduced in one day. Instead of relying on subjective evaluations (I drank slightly less today, or slightly more), an objective measure should best be introduced. According to the season and to the intake of fluids in other forms, water should only be consumed from a 1.5 l (the minimum target) or 2.0 l bottle, drinking all of it before the end of the day – one bottle per day.

Whilst one may obviously drink even more, compliance with a minimum objectively verifiable target helps an elderly person evaluate how much he or she actually consumes and ensures at least sufficient water intake. A simple calculation to estimate the amount of water an elderly person should drink provides for multiplying the body weight by 30. A 70kg person should drink 2.1 l of water.

Disabled people should be allowed to access these resources easily. Individuals with mental deficits, as well as dysphagia, anorexia, acute illnesses, or with prior dehydration episodes, should be closely monitored.¹²¹

Water regulation in certain clinical conditions, such as kidney failure, calls for specialist medical advice.

121 Hypertext11. Hoffman NB, *Dehydration in the elderly: insidious and manageable*. Geriatrics 1991 Jun;46(6):35-8. (<http://www.jissn.com/content/7/1/7>)

Certain conditions (stress, work, physical activity, increased ambient temperature, fever, fluid loss due to vomiting and/or diarrhoea, uncompensated diabetes, burns, etc.) increase the need for circulating fluids. Elderly people are particularly exposed to these clinical conditions that may affect the urinary tract, the gastrointestinal tract, the skin, and the respiratory tract.¹²²

Except in case of diseases that call for close monitoring, there are some general recommendations that could help prevent dehydration in particular conditions, such as:

- **increased ambient temperature:** add 300 ml of fluids for each degree of temperature above 37°C;
- **digestive tract disorders (vomiting or diarrhoea):** ensure that the minimum recommended daily intake is complied with and increase daily fluid intake by 600 ml;
- **respiratory disorders (including tachypnoea):** increase daily fluid intake by 600 ml.¹²³

In other words, in each condition that implies increased requirements (fever, increased ambient temperature, perspiration, diarrhoea, physical activity, etc.), daily fluid intake should increase up to an assumed average of 45 ml per kg of body weight, or 1.5 ml for each dietary kilocalorie, or approximately 3-4 l of fluids.¹²⁴

6.4 Athletes and sportspeople

Water is a must also in sports, because it greatly helps the body's thermoregulation process.

In sportspeople, the internal body temperature should be kept constant around 37°C because any minor changes of temperature can affect physical and mental performance. The internal body temperature during physical activity depends on the ambient temperature and on the heat produced by the muscles. Therefore, at an ambient temperature of 40°C, a high amount of water is required to disperse heat, and even higher if the body is engaged in muscular effort.

The most efficient mechanism to disperse heat is, in this case, sweat evaporation, which disposes of any caloric energy surplus in the body. However, this mechanism only works in a ventilated and not too humid environment, where vapour can dissolve more easily.

On the other hand, in a very humid and not too ventilated environment this mechanism is hampered and the sweat glands produce sweat without any satisfactory outcome

122 Hypertext84. Maughan RJ, Shirreffs SM, Watson P. *Exercise, Heat, Hydration and the Brain*. J Am Coll Nutr 2007; 26: 604S-12S.

123 Hypertext85. Dennis EA, Flack KD, Davy BM. *Beverage consumption and adult weight management: A review*. Eat Behav 2009; 10: 237-46.

124 Hypertext86. Boulze D, Montastruc P, Cabanac M. *Water intake, pleasure and water temperature in humans*. Physiol Behav 1983; 30: 97-102.

in terms of temperature reduction, rather disposing of high amounts of water and electrolytes that need to be promptly reintegrated.

It should be noted that sweat has a lower electrolyte concentration than blood, which is also subject to changes based on the individual's ability to adjust to high temperatures. Thus the reintegration of calorie-free water and electrolytes is a must and ranges from 2 to 3 l per day according to the sport type and duration, as well as to climatic conditions. The necessary ions include calcium (bones, nerve impulses, muscle contraction), iron (haemoglobin, oxygen), sodium (water balance), combined with salt integration in case of highly demanding physical activity. Hydration should occur with mineral water consumed at regular intervals (200 ml every 15-20 minutes) to make up for fluid losses, rather than with a single large water intake before the physical performance. Full compensation only occurs 48-72 hours after the end of the sport performance.

Appropriate fluid intake in athletes should be fit to reintegrate water and electrolyte losses and to counter the accumulation of effort-related catabolytes. Particularly in professional athletes, accumulation prevention and prompt disposal of acid catabolytes help counter dysmetabolic conditions that, albeit temporary, may result into traumas of endogenous origin. Well-known studies were carried out on the effect of bicarbonate waters on muscular effort. In sportspeople and athletes, severe effort-related haematochemical changes may result into hypernatremia, hyperuricemia, increased lactacidemia and pyruvemia, as well as into an increase of muscle and liver damage markers following membrane alterations (transaminase, CPK, LDH, etc.). Calcium and magnesium, as well as sodium, bicarbonates, and sulphates, perform astabilizing action on cell membranes and the strong buffer effect of bicarbonate waters is involved in neutralizing acids, with reduced production of catabolytes and faster return of the altered values to normal. Medium-mineralized calcic-bi-carbonated and earthy-alkaline waters bring about changes in cardiocirculatory and respiratory response, in maximum aerobic power (maximum oxygen consumption), and in some haematochemical variables (increased brain damage blood indexes) during muscular effort. Additionally, their regular intake may help prevent imbalances.¹²⁵

Some studies evaluated the ratio of the ingested mineral water and fluids to *physical activity*.

In three trials, Ishijima T. *et al*¹²⁶ evaluated adults engaged in physical activity (stationary

125 Hypertext114. Driller MW, Gregory JR, Williams AD, Fell JW. *The effects of chronic sodium bicarbonate ingestion and interval training in highly trained rowers*. Int J Sport Nutr Exerc Metab. 2013 Feb;23(1):40-7. Epub 2012 Aug 14. (<http://www.ncbi.nlm.nih.gov/pubmed/22899814>)

126 Hypertext55. Ishijima T, Hashimoto H, Satou K, Muraoka I, Suzuki K, Higuchi M.; *The different effects*

bicycle) in a warm environment (28°C) with 50% humidity.

In the first trial, the subjects did not ingest any fluids (dehydration), in the second trial they ingested mineral water, and in the third trial they received hypotonic fluids supplemented with carbohydrates. At the end of exercise, the perceived effort was lower in the subjects that received mineral water or hypotonic fluids supplemented with carbohydrates vs. the subjects with dehydration (14.3 ± 1.0 and 13.7 ± 0.6 vs. 17.7 ± 1.0 . $p < 0.05$). This means that good hydration during sustained physical activity reduces the overall perceived effort, while the hypotonic solution supplemented with carbohydrates reduces the perceived effort at lower limb level.

Brouns F. *et al*¹²⁷ evaluated the effect of different rehydrating beverages on electrolyte excretion after physical activity in three well-trained athletes. The three beverages included one beverage with caffeine, a low-Na mineral water, and an isotonic electrolyte-carbohydrate solution. Fluid intake and urine losses amounted to 2.77 kg and 1 kg for the beverage with caffeine; to 2.15 kg and 0.96 kg for mineral water; 2.86 kg and 1.10 kg for the isotonic solution respectively. The consumption of beverage with caffeine and of mineral water with a low electrolyte concentration resulted into a high loss of Na, K, Cl, Mg, Ca. The consumption of the isotonic solution resulted into Na, Mg, Ca retention, while K and Cl remained unchanged. The reduced loss of Na, Mg, and Ca with the isotonic solution is accounted for by a higher level of these electrolytes in the isotonic solution compared to mineral water and beverages with caffeine. Beverages with caffeine increase, in turn, the urinary excretion of Mg and Ca. Ultimately, the ingestion of mineral water or beverages with caffeine after physical activity produces a negative electrolyte balance, beverages with caffeine increase the urinary excretion of Mg and Ca, and the consumption of isotonic solutions with Na, Mg, and Ca easily makes up for the urinary loss of these electrolytes.

As described above, changes at blood level and skin perspiration are the main mechanisms for heat dispersion in man.

In a warm and humid environment, appropriate hydration improves thermoregulation, while keeping the blood volume unchanged and ensuring an appropriate blood flow and subsequently effective perspiration.

It should be noted that there is no specific medical test to come up with a *dehydration*

of fluid with and without carbohydrate ingestion on subjective responses of untrained men during prolonged exercise in a hot environment. J Nutr Sci Vitaminol (Tokyo). 2009 Dec;55(6):506-10 (<http://www.ncbi.nlm.nih.gov/pubmed/20086321>)

¹²⁷ Hypertext56. Brouns F, Kovacs EM, Senden JM.; *The effect of different rehydration drinks on post-exercise electrolyte excretion in trained athletes.* Int J Sports Med. 1998 Jan;19(1):56-60 (http://www.gastronet.it/scientifico/medline/ricerca.html?list_uids=9506802)

diagnosis. As described above, dehydration is a loss of fluids equal to about 2% of body weight.

A dehydration diagnosis requires an accurate review of patient history, investigating the existence of any of the conditions that can result into reduced fluid intake or increased fluid loss through the gastrointestinal tract, the urinary tract, the skin, or the respiratory tract. A careful objective examination allows to highlight typical signs, such as dry skin or reduced skin suppleness, delayed skin fold smoothing or skin fold persistence, dry mucosal tissues, hypotonic eye bulbs, deep-set eyes, hollow cheeks, more or less significant reduction of perfusion, weak pulse, weight loss, uncompensated shock. In general, the severity of the clinical signs matches with the rate of dehydration, with gradual impairment of the state of alertness that may change from confusion to stupor to convulsions and to a coma. The clinical signs are obvious and may also tell about the approximate water deficit.

During physical activity, metabolic heat generation by the muscles causes an increase of internal temperature. The risk of overheating while engaging in physical activity is also enhanced by ambient factors, such as hydrostatic pressure and the humidity rate, which may hamper sweat evaporation. Hyperthermia occurs when heat dispersion with perspiration is not sufficient to make up for the increase of the heat generated by the muscles under effort. During physical activity in a warm and humid environment, heat generation can be up to 15-20 higher compared to values at rest, and could raise body temperature by 1°C every 5 minutes if no perspiration were in place.^{128,129}

The duration and intensity of exercise, the environmental conditions, the state of hydration, and acclimatization influence thermoregulation during physical activity. Some drugs (particularly cardiovascular ones) can also play a role in thermoregulation during physical activity.

Non-professional athletes, in particular, whose physical shape is not so efficient as in professional athletes, are at risk of dehydration and related outcomes (heatstroke, hyperthermia) when engaging in unsupervised physical activity (often on their own) not supported by an appropriate hydration scheme.¹³⁰

In physical activity, perspiration is responsible for dispersing about 80% of the

128 Nadel ER, Wenger CB, Roberts MF, et al. *Physiological defenses against hyperthermia of exercise.* AnnNYAcad Sci. 1977;301:98–109. (<http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1977.tb38190.x/abstract;jsessionid=39984036FDEC8A3DA3A51DEEC56F0A.f01t02>)

129 Hypertext95. Armstrong L, Casa D, Millard-Stafford M, American College of Sports Medicine position stand, et al. *Exertional heat illness during competition.* Med Sci Sports Exerc. 2007;39:556–72 (<http://www.ncbi.nlm.nih.gov/pubmed/17473783>)

130 Hypertext97. Donoghue AM, Sinclair MJ, Bates GP. *Heat exhaustion in a deep underground metalliferous mine.* Occup Environ Med. 2000;57(3):165–74 (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1739920/>)

heat produced by the metabolic activity, while the rest is disposed of through such mechanisms as irradiation, convection, and conduction – passive mechanisms that use the thermal gradient.¹³¹

Certain physiological limits should be taken into account when reintegrating the water content. The first barrier to the willingness to ingest fluids is the gastric emptying speed of 1 litre per hour, which decreases quickly in case of hyperosmotic or high-energy fluids. In sustained aerobic activity, it is very important to drink on the day preceding the competition, then approximately 500 ml of water one or two hours before the start of exercise, so as to promote gastric emptying and intestinal absorption, then 150-350 ml every 15-20 minutes, so as to ensure full and long-lasting body hydration. Losses obviously need to be reintegrated according to the effort required for the activity, the relative ambient temperature and humidity, and the athlete's training level – all factors that affect the amount of perspiration.

Maximum sweat generation is 1.5-2 l/hour, or even 2.5-3 l/hours in well trained athletes and in particular conditions, with peaks of 4 l/hour. Notwithstanding this, heat still accumulates, both because perspiration appears 1-3 minutes after the start of the activity (trigger threshold) and because maximum sweat generation can only disperse up to 80% of the generated heat. Moreover, the maximum stomach depletion capacity of 1 l/hour makes it impossible to reintegrate the fluid loss due to perspiration when this is particularly significant. The 1 l/hour gastric emptying speed can be reached by ensuring the permanence of 500 ml of fluids in the stomach. At lower volumes, depletion is delayed. Dehydration triggers a negative process: sweat generation is reduced and stomach depletion is delayed in a dehydrated body, which risks more severe overheating and dehydration. Hence the importance of excellent hydration ahead of competitions. In case of intense physical activity, hydration should not be limited to satisfaction of thirst by the individual, both because it could be influenced by psychological factors (stress for the competition, concern, etc.) and because thirst only appears when 1-2% of body weight has already been lost, with subsequent dehydration and reduced performance. Hydration should therefore occur according to a pre-established scheme.

In conditions of 100% relative humidity, all efforts should be discontinued or postponed because perspiration would not be able to function. Dripping, instead of evaporating, does not produce heat dispersion, with very serious repercussions on health. Even activities carried out at ambient temperatures above the body temperature should be

131 Hypertext98. Rehrer NJ *The maintenance of fluid balance during exercise* Int J Sports Med. 1994 Apr;15(3):122-5. (<http://www.ncbi.nlm.nih.gov/pubmed/8005723>)

avoided, because in this case irradiation, conduction, and convection mechanisms do not work and heat is even transferred from the outside to the inside of the body. At altitudes above 2500 m, an additional amount of water is lost due to increased ventilation.

Water reintegration following medium-low effort activities can be achieved with plain water. Salt losses – approximately 2-3 g of NaCl per litre of sweat – are usually largely made up for by kidney function through greater reabsorption of both NaCl and potassium/magnesium. In case of abundant and persistent perspiration, *salts should also be reintegrated*. A glass of orange or tomato juice is enough to reintegrate the electrolytes lost with one litre of sweat. Most people add some salt and sugar to water for hydration. This produces a dual benefit: the water and electrolyte levels are more effectively rebalanced and the transit of glucose through the intestinal microvilli is promoted through co-transport with sodium and, vice versa, the presence of small amounts of carbohydrates improves the rate of absorption of Na⁺ and water. The amount of carbohydrates should not exceed 8 g/l to avoid delaying gastric emptying. If carbohydrates need to be supplemented with more than 8g/l, in addition to reintegrating water and electrolytes, maltodextrins can be used instead of saccharose. The higher molecular weight of these polymers supplies a higher amount of glucose with the same induced osmolarity.^{132,133}

6.5 Workers

Whilst water promotes metabolism, cognitive skills and alertness, dehydration reduces the performance at work both in physical and in mental terms. Dehydration should not exceed 2% of body weight in order to prevent a decline of working and cognitive efficiency. The tolerated dehydration value vs. body weight is even lower if tasks are executed in warm environments. As described for athletes, industry workers, who often lack proper hydration for long periods of time, tend to suffer from dehydration. Great care is given to hydration at the work site, because dehydration can negatively affect productivity, safety, costs, and the workers' mood. The workforce includes individuals of varying age, body composition, and physical shape. Therefore, the National Academy of Sciences has specified an appropriate daily water intake of about 3.7 l for males and

132 Hypertext99. Chad Kerksick et. Al., *International Society of Sports Nutrition Position Stand: nutrient timing*, Journal of the International Society of Sports Nutrition 2008, 5:17 (<http://www.ncbi.nlm.nih.gov/pubmed/18834505>)

133 Hypertext100. Asker Jeukendrup, *Nutrition for endurance sports: marathon, triathlon, and road cycling*, Journal of Sports Sciences, 2011; 1–9 American College of Sports, Medicine Position Stand, Exercise and fluid Replacement, Medicine & Science in Sports & Exercise 2007 (<http://www.ncbi.nlm.nih.gov/pubmed/21916794>)

2.7 l for females.¹³⁴ The recommended daily water intake for a sedentary individual is about 1.2 l or 2.5 l^{135,136}, or up to 3.2 l in case of moderate physical activity.^{137,138} Compared to sedentary adults, adults that work in a warm environment should consume up to 6 l of water per day. While only limited studies were carried out on women workers, the available data points out to a lower daily water intake compared to men.¹³⁹ The amount of sweat lost when working in a warm environment mainly depends on the intensity and duration of tasks.¹⁴⁰ It should be noted that in sub-maximal working conditions in a warm environment, dehydration causes increased cardiovascular tension. The heart rate increases by four beats per minute for each percent body weight loss.¹⁴¹ In conditions of dehydration, working in a warm-tempered environment may result into an increase of the heart rate by 16-20 beats. This heart rate increase is usually combined with enhanced individual physical stress, which increases the subject's perceived effort and results into reduced work performance. In this case, water should be consumed in small sips during breaks from work. Dehydration also negatively affects aerobic work performance. The extent of the decrease in performance, albeit subjective, is connected with the ambient temperature and with the type of physical activity. Education is crucial to help workers ensure their own hydration during and after their work shift. Information, particularly to those that work in warm environments, about the evaluation of hydration, the signs and risks, and the strategies to ensure it at the work site, may reduce work-related risks.¹⁴²

134 Hypertext101. Szinnai G et al. (2005) *Effect of water deprivation on cognitive-motor performance in healthy men and women*. Am J Physiol Regul Integr Comp Physiol 289(1):R275-80. (<http://www.ncbi.nlm.nih.gov/pubmed/15845879>)

135 Hypertext103. Benton D (2011) *Dehydration influences mood and cognition: a plausible hypothesis?* Nutrients 3:555-573 (<http://www.ncbi.nlm.nih.gov/pubmed/22254111>)

136 Hypertext104. Carter R 3rd, Chevront SN, Vernieuw CR, Sawka MN (2006) *Hypohydration and prior heat stress exacerbates decreases in cerebral blood flow velocity during standing*. J Appl Physiol 101(6):1744-1750 (<http://www.ncbi.nlm.nih.gov/pubmed/16916922>)

137 Hypertext105. AnaAdan. *Cognitive Performance and Dehydration Journal of the American College of Nutrition*, Vol. 31, No. 2, 71-78 (2012) (http://scholar.google.it/scholar_url?url=http://www.researchgate.net/profile/Ana_Adan/publication/230600141_Cognitive_performance_and_dehydration/links/02e7e51e10db0c0a21000000.pdf&hl=it&sa=X&scisig=AAGBfm3x8beBZFmNN_NfbXMldlrwO4GUA&nossl=1&oi=scholar&ei=oMNIvCVXF8HYU-fQgPAG&ved=0CB8QqAMoADAA)

138 Hypertext106. Shimizu T1, Kosaka M, Fujishima K. *Human thermoregulatory responses during prolonged walking in water at 25, 30 and 35 degrees C*. Eur J Appl Physiol Occup Physiol. 1998 Nov;78(6):473-8. (<http://www.ncbi.nlm.nih.gov/pubmed/9840400>)

139 Hypertext107. Armstrong LE, Ganio MS, Casa DJ et al (2012) *Mild dehydration affects mood in healthy young women*. J Nutr 142:382-388 (<http://www.ncbi.nlm.nih.gov/pubmed/22190027>)

140 Hypertext108. Petri NM, Dropulic N, Kardum G: *Effects of voluntary fluid intake deprivation on mental and psychomotor performance*. Croat Med J 47:855-861, 2006 (<http://www.ncbi.nlm.nih.gov/pubmed/17167858>)

141 Hypertext109. Patel AV, Mihalik JP, Notebaert AJ, Guskiewicz KM, Prentice WE: *Neuropsychological performance, postural stability, and symptoms after dehydration*. J Athl Train 42:66-75, 2007 (<http://www.ncbi.nlm.nih.gov/pubmed/17597946>)

142 Hypertext58. Kenefick RW, Sawka MN. *Hydration at the work site*. J Am Coll Nutr. 2007 Oct;26(5 Suppl):597S-603S. Review. J Am Coll Nutr. 2007 Oct;26(5 Suppl):597S-603S. Hydration at the work site.

07

Water and mineral salts

7.1 Mineral salts

High salt levels are responsible for the peculiarities of waters, which can thus be used to treat different types of diseases.

Mineral salts are necessary both as body constituents and as part of a variety of metabolic functions.

Minerals are classified either as macro-elements or as micro or trace elements.

Macro-elements include sodium, potassium, calcium, magnesium, and sulphur, and their minimum daily requirement is 100 mg.

Calcium is most abundant in our body; 99% is found in the bones and 1% in tissues and extracellular fluids. Calcium requirements vary according to age between 0.5 and 1.5 g/day. Calcium is involved in the development of bones and teeth, blood clotting, nerve conduction, and muscular function, and deficits can cause bone decalcification, tooth cavities, muscle cramps and tetany, impaired heartbeat, and palpitations.

The amount of *magnesium* in the body is 30 g; the daily requirement is 300-500 mg, and absorption is hampered by calcium, phosphor, proteins, and fats. Magnesium is involved in some nervous and muscular enzyme functions and regulates energy and bone metabolism. Deficits can cause cramps, reduced resistance to fatigue, sleeplessness and irritability, arrhythmias, and constipation.

The amount of *sodium* in the body is about 100 g and the daily requirement is less than 3.5 g. However, in certain diseases, such as hypertension or heart and kidney disorders, intake should be significantly reduced. Sodium is involved in water metabolism, nerve conduction, and muscle contraction, and deficits can cause neurological symptoms, cramps, and asthenia.

Potassium is very important for our organism, and the daily requirement is 2 to 6 g. Potassium is involved in water metabolism and in nerve and muscle conduction, and deficits can cause asthenia, sleeplessness, irritability, arrhythmias, constipation, and acne, particularly in youths.

Sulphur concentrations amount to 300 mg. It is required for the health of the skin, nails, and hair, and stimulates bile secretion. Deficits can cause skin, nail, hair, and cartilage disorders.

The main *micro* or *trace elements* include fluorine, iron, manganese, selenium, and zinc, and are defined as micronutrients.

Fluorine concentrations amount to 3-7 mg and daily intake should not exceed 0.7-1 mg. Fluorine strengthens tooth enamel and bone tissue, stimulating calcification. Deficits can cause tooth cavities, bone demineralization, nail and hair disorders.

Iron levels amount to 4 or 5 g: 65% is found in haemoglobin and requirements range from 5 mg in children to 18 mg in adults to 30-40 mg in pregnant and breastfeeding women. Therefore, women in their fertile age often show deficits or poor reserves of this substance.

Iron in ferruginous mineral waters, however, is not absorbed by the body. This is why these waters are not used to address any deficits of this substance.

Iron is involved in oxygen conveyance, protection from infections, and vitamin B metabolism. Deficits can cause asthenia, fatigue and palpitations, anaemia, delayed healing of injuries.

Manganese promotes different metabolic reactions through enzyme activation and, particularly, performs a widely researched antioxidant action. The recommended daily intake of manganese is 2 to 4 mg. Manganese is found in acid mineral waters. It is involved in antioxidant functions, blood coagulation and bone development. Deficits can cause asthenia, neurological disorders and joint pain.

Selenium, like manganese, performs an important antioxidant action, countering the effect of free radicals. The daily amount ranges from 8 mg for infants up to one year of age to 70 mg for pregnant women. The main roles of selenium include an antioxidant function, protection of the cardiovascular system, and pigmentation. Deficits can cause early ageing, arrhythmias, visual impairment, and skin disorders.

Zinc is a trace element found in all tissues and most enzymes, with higher concentrations in the bones, muscles, and skin. The recommended daily intake is 10 mg for men and 7 mg for women. Zinc has a powerful antioxidant action, promotes taste, smell, and sight, helps growth, and heals injuries. Any surplus can reduce the immune defences. On the other hand, deficits can negatively affect the sense organs, injuries, growth, and the skin.

7.2 Water hardness

Hard waters contain high levels of calcium and magnesium residues. Water in nature contains dissolved substances at their ionic state (mineral salts), gaseous state, in non-ionic form, as well as organic compounds.¹⁴³

Water is loaded with minerals, particularly salts, like sodium and calcium carbonate, as well as gases, like CO₂, through contact with the rocks, and develops a taste and, sometimes, a particular colour when it contains iron or tannins.

The main solutes found in mineral waters include: organic substances, silica, and mineral salts made up of:

- cations like sodium, calcium, or magnesium and, less often, potassium, iron, and manganese;
- anions like HCO₃ and CO₃, as well as SO₄ and Cl and, less often, NO₃.

Salts include hard and soft salts. The former include less soluble calcium and magnesium, and the latter include more soluble sodium and potassium.

Salts are also classified as alkaline and neutral based on their ability to release hydroxide ions (OH⁻) in a water-based solution.

Solutions may have acid or alkaline properties, a buffer capacity, and different solubilities at different temperatures, also according to the solutes they contain.

Water hardness is measured in French degrees (°F) and 1°F corresponds to 10 mg of calcium carbonate per litre.

7.3 Mineral water classification

Waters are considered as more or less mineralized according to the amount of minerals they contain. The first classification studies on mineral waters date back to as early as 1670, when a number of investigations were carried out by the French Academy of Sciences with methods that are still in use today. To be considered as mineral, waters should be submitted to chemical, pharmacological, and hydrogeological tests.

The Ministry of Welfare is the institution in charge of approving them as such. To do this there are different methods, but the only *discriminating* one is the calculation of their *total dry residue*, i.e. the amount of substances, particularly inorganic, dissolved in water. One litre of fluid is placed into a platinum evaporating dish then transferred into an oven at a 180° temperature.

The *solid* part of the remaining water is measured and corresponds to the amount of the salts and trace elements it contains.

¹⁴³ World Health Organization (WHO). *Guidelines for drinking-water quality*. 3rd ed. Geneva: WHO, 2008 (http://www.who.int/water_sanitation_health/dwq/fulltext.pdf)

An old, by-now outdated classification divided waters into: oligomineral, medium-mineral, salso-chloride-sodium, salso-iodine and salso-bromine-iodine, sulfurous, bicarbonate, sulfate, arsenous-ferruginous, carbonate, with concentrations above 300 cc of CO₂ per litre, and radioactive, when radioactivity is above one millimicrocurie of radon per litre.¹⁴⁴

At present mineral waters are classified in a variety of ways.

Classification based on the levels of dissolved minerals

The level of dissolved minerals is defined by the total dry residue (the amount of mineral salts deposited after complete evaporation of one litre of water at 180°C).

The classification distinguishes:

- minimally mineralized waters with salt levels up to 50 mg/l;
- oligomineral waters with a dry residue up to 200 mg/l;
- medium-mineral waters with a dry residue from 200 mg/l to 1 g/l;
- mineral waters (in the strictest sense of the word) with a dry residue from 1 g/l to 1500 mg/l;
- highly mineralized waters with a dry residue above 1500 mg/l at 180°C.

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Medium-mineral and mineral waters, in particular, can further be divided into:

MEDIUM-MINERAL WATERS with a dry residue > 0.200 g/l and < 1 g/l at 180°C

- SALINE
 - alkaline-sulphated-saline;
 - earthy-alkaline-sulphated-saline;
 - iodic-bromic-saline;
 - alkaline-sulphated-iodic-saline;
 - sulphurous-earthy-alkaline-iodic-saline.
- SULPHUROUS
 - saline-sulphurous;
 - iodic-saline-sulphurous;
 - alkaline-sulphated-saline-sulphurous.

MINERAL WATERS with a dry residue >1 g/l at 180°C

- ARSENICAL-FERRUGINOUS
 - arsenical;
 - arsenical-ferruginous;

144 *Ibidem*

- BI-CARBONATED
 - alkaline-bi-carbonated;
 - earthy-alkaline-bi-carbonated;
 - alkaline-sulphated-bi-carbonated;
 - earthy-alkaline-sulphated-bi-carbonated.
 - alkaline-sulphated
- SULPHATED
 - earthy-alkaline-sulphated.

Classification based on temperature

Mineral waters are distinguished by the ratio of the mean annual temperatures of water, air, and soil:

- hypothermal waters where: $T_{\text{water}} < T_{\text{air}}$ or $T_{\text{water}} < T_{\text{soil}} - 2^\circ \text{C}$;
- orthothermal waters: where $(T_{\text{air}} < T_{\text{water}} < T_{\text{air}} + 4^\circ \text{C})$ or $(T_{\text{soil}} - 2^\circ \text{C} < T_{\text{water}} < T_{\text{soil}} + 2^\circ \text{C})$;
- thermal waters: where $T_{\text{water}} > (T_{\text{air}} + 4^\circ \text{C})$ or $T_{\text{water}} > (T_{\text{soil}} + 2^\circ \text{C})$.

Classification according to molecular concentration

Mineral waters are distinguished by the freezing point as compared against blood serum ($= -0.56^\circ \text{C}$):

- hypotonic waters with a freezing point of -0.55° or higher;
- isotonic waters with a freezing point from -0.55° to -0.58° ;
- hypertonic waters with a freezing point of -0.58° or lower (52).

Classification according to chemical ion composition

It refers to cation and ion concentrations, which exceed a value of 20 Meq percent.

Waters based on anion and cation levels include:

- bi-carbonated waters if the bicarbonate anion (HCO_3) prevails;
- sulphated waters if the sulphate anion (SO_4)² prevails;
- chlorinated or saline waters if the chloride anion (Cl^-) prevails;
- sulphurous waters if the sulphhydryl anion (SH^-) prevails.

Chemical characterization is integrated with the prevalent cations. These are generally alkaline (Li, Na, K, Rb, Cs, Fr) or earthy-alkaline (Be, Mg, Ca, Sr, Ba, Ra) cations, with a prevalence of Ca, Mg, and Ra.

Classification according to typical physical and chemical properties

Waters are also classified by their typical physical and chemical properties as follows:

- sulphurous waters (at least one sulfhydrometric degree);
- arsenical or bromic or iodic waters, when these elements are contained in significant amounts;
- radioactive if they contain at least one millimicrocurie of radon.

08

Scientific literature

Hypertext_1

Popkin B, Armstrong L, Bray G, Caballero B, Frei B, Willen C. *A new proposed guidance system for beverage consumption in the United States*. Am J Clin Nutr 2006; 83: 529-42.

Abstract

The Beverage Guidance Panel was assembled to provide guidance on the relative health and nutritional benefits and risks of various beverage categories. The beverage panel was initiated by the first author. The Panel's purpose is to attempt to systematically review the literature on beverages and health and provide guidance to the consumer. An additional purpose of the Panel is to develop a deeper dialog among the scientific community on overall beverage consumption patterns in the United States and on the great potential to change this pattern as a way to improve health. Over the past several decades, levels of overweight and obesity have increased across all population groups in the United States. Concurrently, an increased daily intake of 150–300 kcal (for different age-sex groups) has occurred, with approximately 50% of the increased calories coming from the consumption of calorically sweetened beverages. The panel ranked beverages from the lowest to the highest value based on caloric and nutrient contents and related health benefits and risks. Drinking water was ranked as the preferred beverage to fulfill daily water needs and was followed in decreasing value by tea and coffee, low-fat (1.5% or 1%) and skim (nonfat) milk and soy beverages, noncalorically sweetened beverages, beverages with some nutritional benefits (fruit and vegetable juices, whole milk, alcohol, and sports drinks), and calorically sweetened, nutrient-poor beverages. The Panel recommends that the consumption of beverages with no or few calories should take precedence over the consumption of beverages with more calories

Hypertext_2

Raben A, Tagliabue A, Christensen NJ, Madsen J, Holst JJ, Astrup A. *Resistant starch: the effect on postprandial glycemia, hormonal response, and satiety*. Am J Clin Nutr 1994; 60: 544-51.

Abstract

The effect of resistant starch (RS) on postprandial plasma concentrations of glucose, lipids, and hormones, and on subjective satiety and palatability ratings was investigated in 10 healthy, normal-weight, young males. The test meals consisted of 50 g pregelatinized starch (0% RS) (S) or 50 g raw potato starch (54% RS) (R) together with 500 g artificially sweetened syrup. After the R meal postprandial plasma concentrations of glucose, lactate, insulin, gastric inhibitory polypeptide (GIP), glucagon-like peptide-1, and epinephrine were significantly lower compared with after the S meal. Moreover, subjective scores for satiety and fullness were significantly lower after the R meal than after the S meal. Differences in GIP, texture, and palatability may have been involved in these findings. In conclusion, the replacement of digestible starch with RS resulted in significant reductions in postprandial glycemia and insulinemia, and in the subjective sensations of satiety.

Hypertext_3

Mattes RD. *Dietary compensation by humans for supplemental energy provided as ethanol or carbohydrate in fluids*. Physiol Behav 1996; 59: 179-87.

Abstract

Dietary compensation for energy provided as ethanol is reportedly limited. Whether this is a function of the ethanol or other aspect of the medium in which it is ingested is not known. Eight male and eight female adults ingested 1.08 liters of beer (5.0% ethanol w/v, 1891kJ), light beer (2.9% ethanol w/v, 1197kJ), no-alcohol beer (0.1% ethanol w/v, 816kJ), cola (1749kJ) or carbonated water (0kJ) every 3-4 days with a midday meal. Diet records were kept the preceding day and day of beverage ingestion. Energy intake was significantly higher each day an energy-bearing beverage was consumed relative to its preceding day. A literature review revealed dietary compensation for modifications of energy intake via fluids is less precise than when solid foods are manipulated. These findings demonstrate dietary adjustment for energy derived from ethanol is imprecise, but also indicate energy from carbohydrate elicits little dietary response when ingested in a beverage.

Hypertext_4

Di Meglio DP, Mattes RD. *Liquid versus solid carbohydrate: effects on food intake and body weight*. Int J Obes Relat Metab Disord 2000; 24: 794-800.

Abstract

BACKGROUND:

Beverages are contributing an increased proportion of energy to the diet. Because they elicit a weak compensatory dietary response, they may increase risk of positive energy balance.

OBJECTIVES:

This study aimed to document the differential effects of matched liquid and solid carbohydrate loads on diet and body weight.

DESIGN:

In a cross-over design, seven males and eight females consumed dietary carbohydrate loads of 1880 kJ/day as

a liquid (soda) or solid (jelly beans) during two 4 week periods separated by a 4 week washout. Subjects were permitted to consume the loads however they chose. In addition to baseline measurements, diet records were obtained on random days throughout the study, body composition was measured weekly, physical activity was assessed before and after treatments and hunger was assessed during washout and midway through each treatment.

RESULTS:

Free-feeding energy intake during the solid period was significantly lower than intake prior to this period. Dietary energy compensation was precise (118%). No decrease in free-feeding energy intake occurred during the liquid period. Total daily energy intake increased by an amount equal to the load resulting in dietary compensation of -17%. Consequently, body weight and BMI increased significantly only during the liquid period. Physical activity and hunger were unchanged.

CONCLUSIONS:

This study indicates that liquid carbohydrate promotes positive energy balance, whereas a comparable solid carbohydrate elicits precise dietary compensation. Increased consumption of energy-yielding fluids may promote positive energy balance.

Hypertext_5

Brownell KD, Farley T, Willett WC, Popkin BM, Chaloupka FJ, Thompson JW, et al. *The Public Health and Economic Benefits of Taxing Sugar-Sweetened Beverages*. N Engl J Med 2009; 361: 1599-1605.

Abstract

The consumption of sugar-sweetened beverages has been linked to risks for obesity, diabetes, and heart disease¹⁻³; therefore, a compelling case can be made for the need for reduced consumption of these beverages. Sugar-sweetened beverages are beverages that contain added, naturally derived caloric sweeteners such as sucrose (table sugar), high-fructose corn syrup, or fruit-juice concentrates, all of which have similar metabolic effects.

Taxation has been proposed as a means of reducing the intake of these beverages and thereby lowering health care costs, as well as a means of generating revenue that governments can use for health programs.⁴⁻⁷ Currently, 33 states have sales taxes on soft drinks (mean tax rate, 5.2%), but the taxes are too small to affect consumption and the revenues are not earmarked for programs related to health. This article examines trends in the consumption of sugar-sweetened beverages, evidence linking these beverages to adverse health outcomes, and approaches to designing a tax system that could promote good nutrition and help the nation recover health care costs associated with the consumption of sugar-sweetened beverages.

Hypertext_6

Hu FB, Malik VS. *Sugar-sweetened beverages and risk of obesity and type 2 diabetes: epidemiologic evidence*. *Physiol Behav* 2010; 100: 47-54. [Epub 2010 Feb 6].

Abstract

In recent decades, temporal patterns in SSB intake have shown a close parallel between the upsurge in obesity and rising levels of SSB consumption. SSBs are beverages that contain added caloric sweeteners such as sucrose, high-fructose corn syrup or fruit-juice concentrates, all of which result in similar metabolic effects. They include the full spectrum of soft drinks, carbonated soft drinks, fruitades, fruit drinks, sports drinks, energy and vitamin water drinks, sweetened iced tea, cordial, squashes, and lemonade, which collectively are the largest contributor to added sugar intake in the US. It has long been suspected that SSBs have an etiologic role in the obesity epidemic, however only recently have large epidemiological studies been able to quantify the relationship between SSB consumption and long-term weight gain, type 2 diabetes (T2DM) and cardiovascular disease (CVD) risk. Experimental studies have provided important insight into potential underlying biological mechanisms. It is thought that SSBs contribute to weight gain in part by incomplete compensation for energy at subsequent meals following intake of liquid calories. They may also increase risk of T2DM and CVD as a contributor to a high dietary glycemic load leading to inflammation, insulin resistance and impaired beta-cell function. Additional metabolic effects from the fructose fraction of these beverages may also promote accumulation of visceral adiposity, and increased hepatic de novo lipogenesis, and hypertension due to hyperuricemia. Consumption of SSBs should therefore be replaced by healthy alternatives such as water, to reduce risk of obesity and chronic diseases.

Hypertext_7

Duffey KJ, Gordon-Larsen P, Steffen LM, Jacobs DR, Jr, Popkin BM. *Drinking caloric beverages increases the risk of adverse cardiometabolic outcomes in the Coronary Artery Risk Development in Young Adults (CARDIA) Study*. *Am J Clin Nutr*. 2010.

Abstract

BACKGROUND:

Intake of caloric beverages is hypothesized to contribute to adverse health outcomes, but the beverages and populations studied vary considerably.

OBJECTIVE:

Our objective was to examine the relation between consumption of low- and whole-fat milk, fruit juice, and sugar-sweetened beverages (SSBs) and cardiometabolic risk factors.

DESIGN:

We used data from a prospective 20-y cohort of 2774 adults. Data are taken from CARDIA (Coronary Artery Risk Development in Young Adults) Study examination years 0 (1985-1986), 7 (1992-1993), and 20 (2005-2006). Beverage intake was averaged across years 0 and 7, and continuous and categorical (quartile) distributions were used. Incident (year 20) high waist circumference (WC), high triglycerides, high LDL cholesterol, low HDL cholesterol, hypertension, and metabolic syndrome were examined by using multivariable-adjusted Poisson regression models.

RESULTS:

Higher SSB consumption (across quartiles) was associated with higher risk of high WC [adjusted relative risk (aRR): 1.09; 95% CI: 1.04, 1.14; P for trend < 0.001]; high LDL cholesterol (aRR: 1.18; 95% CI: 1.02, 1.35; P for trend = 0.018), high triglycerides (aRR: 1.06; 95% CI: 1.01, 1.13; P for trend = 0.033), and hypertension (aRR: 1.06; 95% CI: 1.01, 1.12; P for trend = 0.023). Whole-fat milk consumption was associated with lower risk of high triglycerides (aRR: 0.91; 95% CI: 0.81, 1.00; P for trend = 0.046). With the use of continuous beverage intake, results were similar. Consumers of whole-fat milk and SSBs were more likely to be younger, black, and male and to have lower levels of physical activity and higher total energy intake in comparison with nonconsumers (P < 0.05).

CONCLUSIONS:

Our findings suggest that higher SSB consumption is associated with cardiometabolic risk. Recommendations to limit consumption of these caloric beverages may help reduce the burden of these risk factors in US adult populations.

Hypertext_8

Johnson RK, Appel LJ, Brands M, Howard BV, Lefevre M, Lustig RH, et al. *Dietary sugars intake and cardiovascular health. A scientific statement from the American Heart Association.* Circulation 2009; 120: 1011-1020.

Abstract

High intakes of dietary sugars in the setting of a worldwide pandemic of obesity and cardiovascular disease have heightened concerns about the adverse effects of excessive consumption of sugars. In 2001 to 2004, the usual intake of added sugars for Americans was 22.2 teaspoons per day (355 calories per day). Between 1970 and 2005, average annual availability of sugars/added sugars increased by 19%, which added 76 calories to Americans' average daily energy intake. Soft drinks and other sugar-sweetened beverages are the primary source of added sugars in Americans' diets. Excessive consumption of sugars has been linked with several metabolic abnormalities and adverse health conditions, as well as shortfalls of essential nutrients. Although trial data are limited, evidence from observational studies indicates that a higher intake of soft drinks is associated with greater energy intake, higher body weight, and lower intake of essential nutrients. National survey data also indicate that excessive consumption of added sugars is contributing to overconsumption of discretionary calories by Americans. On the basis of the 2005 US Dietary Guidelines, intake of added sugars greatly exceeds discretionary calorie allowances, regardless of energy needs. In view of these considerations, the American Heart Association recommends reductions in the intake of added sugars. A prudent upper limit of intake is half of the discretionary calorie allowance, which for most American women is no more than 100 calories per day and for most American men is no more than 150 calories per day from added sugars. PMID: 19704096 [PubMed - indexed for MEDLINE]

Hypertext_9

Muckelbauer R, Libuda L, Clausen K, Toschke AM, Reinehr T, Kersting M. *Promotion and provision of drinking water in schools for overweight prevention: randomized, controlled cluster trial.* Pediatrics 2009; 123: e661-7.

Abstract

OBJECTIVE:

The study tested whether a combined environmental and educational intervention solely promoting water consumption was effective in preventing overweight among children in elementary school.

METHODS:

The participants in this randomized, controlled cluster trial were second- and third-graders from 32 elementary schools in socially deprived areas of 2 German cities. Water fountains were installed and teachers presented 4 prepared classroom lessons in the intervention group schools (N = 17) to promote water consumption. Control group schools (N = 15) did not receive any intervention. The prevalence of overweight (defined according to the International Obesity Task Force criteria), BMI SD scores, and beverage consumption (in glasses per day; 1 glass

was defined as 200 mL) self-reported in 24-hour recall questionnaires, were determined before (baseline) and after the intervention. In addition, the water flow of the fountains was measured during the intervention period of 1 school year (August 2006 to June 2007).

RESULTS:

Data on 2950 children (intervention group: N = 1641; control group: N = 1309; age, mean +/- SD: 8.3 +/- 0.7 years) were analyzed. After the intervention, the risk of overweight was reduced by 31% in the intervention group, compared with the control group, with adjustment for baseline prevalence of overweight and clustering according to school. Changes in BMI SD scores did not differ between the intervention group and the control group. Water consumption after the intervention was 1.1 glasses per day greater in the intervention group. No intervention effect on juice and soft drink consumption was found. Daily water flow of the fountains indicated lasting use during the entire intervention period, but to varying extent.

CONCLUSION:

Our environmental and educational, school-based intervention proved to be effective in the prevention of overweight among children in elementary school, even in a population from socially deprived areas. PMID: 19336356 [PubMed - indexed for MEDLINE]

Hypertext_10

Fernández-Martín JL, Benito Cannata-Andía J. *Agua de bebida como elemento de la nutrición*. Barcelona Med Clin 2008; 131:656-7

(http://apps.elsevier.es/watermark/ctl_servlet? f=10&pident_articulo=13128725&pident_usuario=0&pcontactid=&pident_revista=2&ty=29&accion=L&origen=zonadelectura&web=www.elsevier.es&lan=es&fichero=2v131n17a13128725pdf001.pdf)

Hypertext_11

Jéquier E, Constant F. *Water as an essential nutrient: the physiological basis of hydration*. Eur J Clin Nutr. [Online] September 2, 2009. Disponible en:<http://www.nature.com/ejcn/journal/vaop/ncurrent/pdf/ejcn2009111a.pdf>. doi:10.1038/ejcn.2009.111

Abstract

How much water we really need depends on water functions and the mechanisms of daily water balance regulation. The aim of this review is to describe the physiology of water balance and consequently to highlight the new recommendations with regard to water requirements. Water has numerous roles in the human body. It acts as a building material; as a solvent, reaction medium and reactant; as a carrier for nutrients and waste products; in thermoregulation; and as a lubricant and shock absorber. The regulation of water balance is very precise, as a loss of 1% of body water is usually compensated within 24 h. Both water intake and water losses are controlled to reach water balance. Minute changes in plasma osmolarity are the main factors that trigger these homeostatic mechanisms. Healthy adults regulate water balance with precision, but young infants and elderly people are at greater risk of dehydration. Dehydration can affect consciousness and can induce speech incoherence, extremity weakness, hypotonia of ocular globes, orthostatic hypotension and tachycardia. Human water requirements are not based on a minimal intake because it might lead to a water deficit due to numerous factors that modify water needs (climate, physical activity, diet and so on). Water needs are based on experimentally derived intake levels that are expected to meet the nutritional adequacy of a healthy population. The regulation of water balance is essential for the maintenance of health and life. On an average, a sedentary adult should drink 1.5 l of water per day, as water is the only liquid nutrient that is really essential for body hydration

Hypertext_12

EFSA (2008). *Draft dietary reference values for water. Scientific Opinion of the Panel on Dietetic Products, Nutrition and Allergies*, (agreed on 11 April 2008 for release for public consultation). (<http://www.efsa.europa.eu/it/scdocs/doc/1459.pdf>)

ABSTRACT

This Opinion of the EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA) deals with the setting of dietary reference values for water for specific age groups. Adequate Intakes (AI) have been defined derived from a combination of observed intakes in population groups with desirable osmolarity values of urine and desirable water volumes per energy unit consumed. The reference values for total water intake include water from drinking water, beverages of all kind, and from food moisture and only apply to conditions of moderate environmental temperature and moderate physical activity levels (PAL 1.6). AIs for infants in the first half of the first year of life are estimated to be 100-190 mL/kg per day. For infants 6-12 months of age a total water intake of 800-1000 mL/day is considered adequate. For the second year of life an adequate total water intake of 1100-1200 mL/day is defined by interpolation, as intake data are not available. AIs of water for children are estimated to be 1300 mL/day for boys and girls 2-3 years of age; 1600 mL/day for boys and girls 4-8 years of age; 2100 mL/day for boys

9-13 years of age; 1900 mL/day for girls 9-13 years of age. Adolescents of 14 years and older are considered as adults with respect to adequate water intake. Available data for adults permit the definition of AIs as 2.0 L/day (P 95 3.1 L) for females and 2.5 L/day (P95 4.0 L) for males. The same AIs as for adults are defined for the elderly. For pregnant women the same water intake as in non-pregnant women plus an increase in proportion to the increase in energy intake (300 mL/day) is proposed. For lactating women adequate water intakes of about 700 mL/day above the AIs of non-lactating women of the same age are derived.

Hypertext_13

Sawka MN, Cheuvront SN, Carter III R (2005). *Human water needs*. Nutr Rev 63, S30–S39. (<http://www.ncbi.nlm.nih.gov/pubmed/16028570>)

Abstract

Healthy humans regulate daily water balance remarkably well across their lifespan despite changes in biological development and exposure to stressors on hydration status. Acute or chronic body water deficits result when intakes are reduced or losses increase, but day-to-day hydration is generally well maintained so long as food and fluid are readily available. Total water intake includes drinking water, water in beverages, and water in food. Daily water needs determined from fluid balance, water turnover, or consumption studies provide similar values for a given set of conditions. A daily water intake of 3.7 L for adult men and 2.7 L for adult women meets the needs of the vast majority of persons. However, strenuous physical exercise and heat stress can greatly increase daily water needs, and the individual variability between athletes can be substantial. PMID: 16028570 [PubMed - indexed for MEDLINE]

Hypertext_15

Phillips PA, Rolls BJ, Ledingham JG, Forsling ML, Morton JJ MJ et al (1984). *Reduced thirst after water deprivation in healthy elderly men*. N Engl J Med 311, 753–759. (<http://www.nejm.org/doi/full/10.1056/NEJM198409203111202>)

Abstract

To determine whether responses to dehydration are altered with age, we investigated the thirst, fluid and electrolyte responses, and hormonal responses to 24 hours of water deprivation in seven healthy active elderly men (67 to 75 years old) and seven healthy young men (20 to 31 years old) who were matched for weight loss during water deprivation. After water deprivation, the older men had greater increases in plasma osmolality, sodium concentration, and vasopressin levels. However, their urinary osmolality was lower and they were less thirsty and drank less after water deprivation, so that their plasma and urine were not diluted to predeprivation levels. Regression analysis indicated increased sensitivity of vasopressin osmoreceptors in the older group, although this difference was not statistically significant. We conclude that after 24 hours of water deprivation, there is a deficit in thirst and water intake in healthy elderly men, as compared with younger men, although vasopressin osmoreceptor responsiveness is maintained or even increased. Our findings also suggest that the well-known deficit in urinary concentrating ability that occurs with age reflects renal causes and not a lack of circulating vasopressin. (N Engl J Med 1984; 311:753–9.)

Hypertext_18

Jéquier E, Constant F. *Water as an essential nutrient: the physiological basis of hydration*. European Journal of Clinical Nutrition (2010) 64, 115–123; doi:10.1038/ejcn.2009.111; published online 2 September 2009 (<http://www.nature.com/ejcn/journal/v64/n2/full/ejcn2009111a.html#bib4>)

Abstract

How much water we really need depends on water functions and the mechanisms of daily water balance regulation. The aim of this review is to describe the physiology of water balance and consequently to highlight the new recommendations with regard to water requirements. Water has numerous roles in the human body. It acts as a building material; as a solvent, reaction medium and reactant; as a carrier for nutrients and waste products; in thermoregulation; and as a lubricant and shock absorber. The regulation of water balance is very precise, as a loss of 1% of body water is usually compensated within 24h. Both water intake and water losses are controlled to reach water balance. Minute changes in plasma osmolality are the main factors that trigger these homeostatic mechanisms. Healthy adults regulate water balance with precision, but young infants and elderly people are at greater risk of dehydration. Dehydration can affect consciousness and can induce speech incoherence, extremity weakness, hypotonia of ocular globes, orthostatic hypotension and tachycardia. Human water requirements are not based on a minimal intake because it might lead to a water deficit due to numerous factors that modify water needs (climate, physical activity, diet and so on). Water needs are based on experimentally derived intake levels that are expected to meet the nutritional adequacy of a healthy population. The regulation of water balance is essential for the maintenance of health and life. On an average, a sedentary adult should drink 1.5l of water per day, as water is the only liquid nutrient that is really essential for body hydration.

Hypertext_19

Montain SJ. *Fluid and electrolyte supplementation for exercise heat stress*. Am J Clin Nutr 2000;72(suppl):564S-72S (<http://ajcn.nutrition.org/content/72/2/564s.full.pdf>)

ABSTRACT During exercise in the heat, sweat output often exceeds water intake, resulting in a body water deficit (hypohydration) and electrolyte losses. Because daily water losses can be substantial, persons need to emphasize drinking during exercise as well as at meals. For persons consuming a normal diet, electrolyte supplementation is not warranted except perhaps during the first few days of heat exposure. Aerobic exercise is likely to be adversely affected by heat stress and hypohydration; the warmer the climate the greater the potential for performance decrements. Hypohydration increases heat storage and reduces a person's ability to tolerate heat strain. The increased heat storage is mediated by a lower sweating rate (evaporative heat loss) and reduced skin blood flow (dry heat loss) for a given core temperature. Heat-acclimated persons need to pay particular attention to fluid replacement because heat acclimation increases sweat losses, and hypohydration negates the thermoregulatory advantages conferred by acclimation. It has been suggested that hyperhydration (increased total body water) may reduce physiologic strain during exercise heat stress, but data supporting that notion are not robust. Research is recommended for 3 populations with fluid and electrolyte balance problems: older adults, cystic fibrosis patients, and persons with spinal cord injuries.

Hypertext_20

Häussinger D (1996). *The role of cellular hydration in the regulation of cell function*. Biochem J 313, 697–710. [vhttp://www.biochemj.org/bj/313/bj3130697.htm](http://www.biochemj.org/bj/313/bj3130697.htm)

Abstract

The cellular hydration state is dynamic and changes within minutes under the influence of aniso-osmolarity, hormones, nutrients and oxidative stress. This occurs despite the activity of potent mechanisms for cell volume regulation, which have been observed in virtually all cell types studied so far. These volume-regulatory mechanisms are apparently not designed to maintain absolute cell volume constancy; rather, they act as dampeners in order to prevent excessive cell volume deviations which would otherwise result from cumulative substrate uptake. On the other hand, these volume-regulatory mechanisms can even be activated in the resting state by hormones, and by this means changes in cell hydration are created. Most importantly, small fluctuations of cell hydration, i.e. of cell volume, act as a separate and potent signal for cellular metabolism and gene expression. Accordingly, a simple but elegant method is created for the adaptation of cell function to environmental challenges. In liver, cell swelling and shrinkage lead to certain opposite patterns of cellular metabolic function. Apparently, hormones and amino acids can trigger these patterns by altering cell volume. Thus cell volume homeostasis does not simply mean volume constancy, but rather the integration of events which allow cell hydration to play its physiological role as a regulator of cell function (for reviews see [1–4]). The interaction between cellular hydration and cell function has been most extensively studied in liver cells, but evidence is increasing that regulation of cell function through alterations of cell hydration also occurs in other cell types. This review will largely refer to hepatocytes, but when appropriate other cell types will also be considered. Regulation of mitochondrial function by hormone-induced changes of matrix volume has been established in the past (for reviews see [5,6]); this aspect will only be covered briefly. For further details, the reader is referred to recent surveys [2,4,7,8].

Hypertext_22

Ritz P, Berrut G (2005). *The importance of good hydration for day-today health*. Nutr Rev 63, S6-S13 (<http://www.ncbi.nlm.nih.gov/pubmed/16028567>)

Abstract

The role of hydration in the maintenance of health is increasingly recognized. Studies in healthy adults show that even mild dehydration impairs a number of important aspects of cognitive function such as concentration, alertness, and short-term memory. However, due to the lack of suitable tools for assessment of hydration status, the effects of hydration on other aspects of day-to-day health and well-being remain to be demonstrated. PMID: 16028567 [PubMed - indexed for MEDLINE]

Hypertext_23

Szinnai G, Schachinger H, Arnaud MJ, Linder L, Keller U (2005). *Effect of water deprivation on cognitive-motor performance in healthy men and women*. Am J Physiol Regul Integr Comp Physiol 289, R275–R280. (<http://www.ncbi.nlm.nih.gov/pubmed/15845879>)

Abstract

Whether mental performance is affected by slowly progressive moderate dehydration induced by water deprivation has not been examined previously. Therefore, objective and subjective cognitive-motor function was examined in 16 volunteers (8 females, 8 males, mean age: 26 yr) twice, once after 24 h of water deprivation and once during normal water intake (randomized cross-over design; 7-day interval). Water deprivation resulted in a

2.6% decrease in body weight. Neither cognitive-motor function estimated by a paced auditory serial addition task, an adaptive 5-choice reaction time test, a manual tracking test, and a Stroop word-color conflict test nor neurophysiological function assessed by auditory event-related potentials P300 (oddball paradigm) differed ($P > 0.1$) between the water deprivation and the control study. However, subjective ratings of mental performance changed significantly toward increased tiredness (+1.0 points) and reduced alertness (-0.9 points on a 5-point scale; both: $P < 0.05$), and higher levels of perceived effort (+27 mm) and concentration (+28 mm on a 100-mm scale; both: $P < 0.05$) necessary for test accomplishment during dehydration. Several reaction time-based responses revealed significant interactions between gender and dehydration, with prolonged reaction time in women but shortened in men after water deprivation (Stroop word-color conflict test, reaction time in women: +26 ms, in men: -36 ms, $P < 0.01$; paced auditory serial addition task, reaction time in women +58 ms, in men -31 ms, $P = 0.05$). In conclusion, cognitive-motor function is preserved during water deprivation in young humans up to a moderate dehydration level of 2.6% of body weight. Sexual dimorphism for reaction time-based performance is present. Increased subjective task-related effort suggests that healthy volunteers exhibit cognitive compensating mechanisms for increased tiredness and reduced alertness during slowly progressive moderate dehydration. PMID: 15845879 [PubMed - indexed for MEDLINE]

Hypertext_24

Manz F. *Hydration and Disease*. J Am Coll Nutr 2007; 26 (5): 535S-41S. <http://www.ncbi.nlm.nih.gov/pubmed/17921462>

Abstract

Many diseases have multifactorial origins. There is increasing evidence that mild dehydration plays a role in the development of various morbidities. In this review, effects of hydration status on acute and chronic diseases are depicted (excluding the acute effects of mild dehydration on exercise performance, wellness, cognitive function, and mental performance) and categorized according to four categories of evidence (I-IV). Avoidance of a high fluid intake as a precautionary measure may be indicated in patients with cardiovascular disorders, pronounced chronic renal failure (III), hypoalbuminemia, endocrinopathies, or in tumor patients with cisplatin therapy (IIb) and menace of water intoxication. Acute systemic mild hypohydration or dehydration may be a pathogenic factor in oligohydramnios (IIa), prolonged labor (IIa), cystic fibrosis (III), hypertonic dehydration (II), and renal toxicity of xenobiotics (Ib). Maintaining good hydration status has been shown to positively affect urolithiasis (Ib) and may be beneficial in treating urinary tract infection (IIb), constipation (III), hypertension (II), venous thromboembolism (III), fatal coronary heart disease (III), stroke (III), dental disease (IV), hyperosmolar hyperglycemic diabetic ketoacidosis (IIb), gallstone disease (III), mitral valve prolapse (IIb), and glaucoma (III). Local mild hypohydration or dehydration may play a critical role in the pathogenesis of several broncho-pulmonary disorders like exercise asthma (IIb) or cystic fibrosis (Ib). In bladder and colon cancers, the evidence on hydration status' effects is inconsistent. PMID: 17921462 [PubMed - indexed for MEDLINE]

Hypertext_33

Van Tubergen A., Van der Linden S. *A brief history of spa therapy*. Ann Rheum Dis 2002; 61:273-275 (<http://ard.bmj.com/content/61/3/273.full>)

Abstract

Bathing in thermal water has an impressive history and continuing popularity. In this paper a brief overview of the use of water in medicine over the centuries is given.

Hypertext_115

Coen G, Sardella D, Barbera G, Ferrannini M, Comegna C, Ferazzoli F, Dinnella A, D'Anello E, Simeoni P. *Urinary composition and lithogenic risk in normal subjects following oligomineral versus bicarbonate-alkaline high calcium mineral water intake*. Urol Int. 2001;67(1):49-53. (<http://www.ncbi.nlm.nih.gov/pubmed/11464116>)

Abstract

OBJECTIVE:

A normal dietary calcium intake to reduce intestinal oxalate absorption is essential to avoid recurrence of calcium oxalate stone formation. It is also important in the prevention of osteopenia in idiopathic hypercalcaemia. The calcium content of waters used for hydration may vary from very low to relatively high and is an important factor in prevention or additional risk of stone formation. Therefore, the effect of drinking mineral waters of different calcium concentrations on lithogenic risk factors was studied in normal volunteers.

MATERIALS AND METHODS:

Normal subjects were divided into two groups of 11 and 10 individuals each. All followed a prescribed diet with an average calcium content of 800 mg/day. The water intake for hydration consisted of 2 liters of an oligomineral water with a low calcium content, <20 mg/l (group A) or of a bicarbonate alkaline water with a high calcium content, 370 mg/l (group B).

RESULTS:

Diuresis increased similarly in both groups; urine calcium increased by about 80 mg/day in group B. A rise in urine oxalate was observed in both groups, along with the increased urine volume. Osmolar excretion increased in group B; urine osmolality decreased significantly only in group A. In spite of the increase in calciuria in group B, Ca/citrate ratio was constant, due to an increase in citrate excretion. Inter-group differences in terms of activity products of calcium phosphate, calculated according with Tiselius's methods, were found. The differences in AP(CaP) index 1 and AP(CaP) index 2 were significant, with higher values in group B, who drank the bicarbonate alkaline mineral water.

CONCLUSIONS:

Increased water intake between meals to prevent renal stone recurrence should preferably be achieved with a relatively low calcium water and calcium-rich mineral waters should be avoided. Copyright 2001 S. Karger AG, Basel. PMID: 11464116 [PubMed - indexed for MEDLINE]

Hypertext_116

Wu CL, Doong ML, Wang PS. *Involvement of cholecystokinin receptor in the inhibition of gastrointestinal motility by oxytocin in ovariectomized rats.* Eur J Pharmacol. 2008 Feb 12;580(3):407-15. Epub 2007 Nov 23. (<http://www.ncbi.nlm.nih.gov/pubmed/18078924>)

Abstract

OBJECTIVE:

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CONCLUSIONS:

Increased water intake between meals to prevent renal stone recurrence should preferably be achieved with a relatively low calcium water and calcium-rich mineral waters should be avoided. Copyright 2001 S. Karger AG, Basel. PMID: 11464116 [PubMed - indexed for MEDLINE]

Hypertext_36

Bertaccini A., Borghesi M. *Indications for a medium mineral high bicarbonate water (Cerelia) in urology.* Arch Ital Urol Androl. 2009 Sep; 81 (3): 192-4 (<http://www.ncbi.nlm.nih.gov/pubmed/19911684>)

Abstract

To increase water intake is a useful prophylactic treatment for many urologic diseases, such as urolithiasis or urinary tract infection. An high water intake increases urinary volume with a dilutional effect that involves a consequent decrease of the concentrations of urinary solutes and a reduction of the levels of the salts involved in the lithogenic process. Furthermore the increased flow of urine in the urinary tract also improves the elimination of debris, gravel and bacteria. The intake of a water (Cerelia) with medium mineral (calcium 119.7 mg/l) and high bicarbonate (412 mg/l) content can cause specific changes of urinary composition that can be beneficial for the prevention of stone formation. The bicarbonate load has an alkalinizing effect that increase the urinary pH values and the urinary citrate excretion. This can be helpful to prevent both uric acid lithiasis, as a consequence of the increase of urinary pH (and of the solubility of uric acid), and calcium lithiasis, as a consequence of the increase of urinary citrate (and of inhibition of formation and aggregation of calcium crystals). Experimental studies demonstrated that the administration of a medium mineral high bicarbonate water induced a significant decrease of serum uric acid levels by increasing the urinary excretion of uric acid without risk of stone formation due to the increase of urinary volumes, urinary pH and citrate excretion. PMID: 19911684 [PubMed - indexed for MEDLINE]

Hypertext_37

Di Paolo N, Nicolai GA, Lombardi M, Maccari F, Garosi G. *High doses of water increase the purifying capacity of the kidneys*. Int J Artif Organs. 2007 Dec;30(12):1109-15 (<http://www.ncbi.nlm.nih.gov/pubmed/18203073>)

Abstract

BACKGROUND:

In previous studies we were successful in demonstrating that the administration of water over a short period of time increases the transport capacity in the excretory tract of rabbit ureters by increasing urinary volume in the ureter from 0.3 ml/min to 10 ml/min. This phenomenon may explain the effect of water therapy performed in thermal spas, where the administration of 1-2 liters of mineral water is performed in 30-60 minutes.

OBJECTIVES:

The aim of the present study is to investigate if this increased transport capacity can act also in the renal tubular apparatus to modify the excretion of some endogenous substances.

MATERIALS AND METHODS:

We evaluated daily renal clearances in ten subjects under basal conditions during supplemental administration of 25 ml/kg of mineral water over a 24-hour period and during the administration of the same amount of water over a 30-minute period.

RESULTS:

Subjects who drank a water load of 25 ml/Kg over 30 minutes showed a higher diuresis than that observed in those who drank the same amount over a 24-hour period. Creatinine and urea clearance at 24 hours were significantly higher in subjects who drank the water load over 30 minutes. Serum magnesium levels and folic acid levels were also significantly higher in subjects who drank the water load over 30 minutes.

CONCLUSIONS:

Water administration over a short period of time seems to modify the daily excretion of some endogenous metabolites. PMID: 18203073 [PubMed - indexed for MEDLINE]

Hypertext_117

Siener R, Jahn A, Hesse A. *Influence of a mineral water rich in calcium, magnesium and bicarbonate on urine composition and the risk of calcium oxalate crystallization*. Eur J Clin Nutr. 2004 Feb;58(2):270-6. (<http://www.ncbi.nlm.nih.gov/pubmed/14749747>)

Abstract

OBJECTIVE:

To evaluate the effect of a mineral water rich in magnesium (337 mg/l), calcium (232 mg/l) and bicarbonate (3388 mg/l) on urine composition and the risk of calcium oxalate crystallization.

DESIGN:

A total of 12 healthy male volunteers participated in the study. During the baseline phase, subjects collected two 24-h urine samples while on their usual diet. Throughout the control and test phases, lasting 5 days each, the subjects received a standardized diet calculated according to the recommendations. During the control phase, subjects consumed 1.4 l/day of a neutral fruit tea, which was replaced by an equal volume of a mineral water during the test phase. On the follow-up phase, subjects continued to drink 1.4 l/day of the mineral water on their usual diet and collected 24-h urine samples weekly.

RESULTS:

During the intake of mineral water, urinary pH, magnesium and citrate excretion increased significantly on both standardized and normal dietary conditions. The mineral water led to a significant increase in urinary calcium excretion only on the standardized diet, and to a significantly higher urinary volume and decreased supersaturation with calcium oxalate only on the usual diet.

CONCLUSIONS:

The magnesium and bicarbonate content of the mineral water resulted in favorable changes in urinary pH, magnesium and citrate excretion, inhibitors of calcium oxalate stone formation, counterbalancing increased calcium excretion. Since urinary oxalate excretion did not diminish, further studies are necessary to evaluate whether the ingestion of calcium-rich mineral water with, rather than between, meals may complex oxalate in the gut thus limiting intestinal absorption and urinary excretion of calcium and oxalate. PMID: 14749747 [PubMed - indexed for MEDLINE]

Hypertext_38

Zubkova SM, Varakina NI, Mikhaïlik LV, Bobkova AS, Chabanenko SS. *Experimental study of the role of essential trace elements of mineral waters in prevention of atherosclerosis risk factors*. Vopr Kurortol Fizioter Lech Fiz Kult. 2001 Mar-Apr;(2):8-11 (<http://www.biomeddefine.com/sdx/t4/all/100/intent+for+prophylaxis+mineral+nos.html>)

Abstract

Hormonal and lipid spectra of the blood serum; antioxidant, biosynthetic, microcirculatory and elastic-inhibitory

activity in the myocardium and liver; proliferative and genetic activity in the thymus; microcirculation and destruction in rats with atherosclerosis drinking Khadyzhenskaya mineral water and solution of natural macro- and trace elements in the spring water (temarox) in two dilutions. It was found that elimination of atherosclerosis risk factors in rats was most complete in a course temarox drinking in dilution 1/8000.
PMID: 11544735 [PubMed - indexed for MEDLINE]

Hypertext_39

Rylander R, Arnaud MJ. *Mineral water intake reduces blood pressure among subjects with low urinary magnesium and calcium levels.* BMC Public Health. 2004 Nov 30;4:56 (<http://www.ncbi.nlm.nih.gov/pubmed/15571635>)

Abstract

BACKGROUND:

Several previous epidemiological studies have shown a relation between drinking water quality and death in cardiovascular disease whereas others have not found such a relationship. An intervention study was undertaken to evaluate the effect of water with added magnesium and natural mineral water on blood pressure.

METHODS:

A group of 70 subjects with borderline hypertension was recruited and consumed 1) a water low in minerals, 2) magnesium enriched water or 3) natural mineral water, in a random, double blind fashion during four weeks.

RESULTS:

Among persons with an initial low excretion of magnesium or calcium in the urine, the urinary excretion of magnesium was increased in the groups consuming the two waters containing magnesium after 4 weeks. A significant decrease in blood pressure was found in the group consuming mineral water at 2 and 4 weeks.

CONCLUSION:

The results suggest that minerals taken in water are significant for the body burden and that an intake of mineral water among persons with a low urinary excretion of magnesium or calcium may decrease the blood pressure. Further studies should investigate the extent of mineral deficiency in different populations and the efficiency of different vehicles for supplying minerals, particularly magnesium and calcium. PMID: 15571635 [PubMed - indexed for MEDLINE] PMCID: PMC535900 Free PMC Article

Hypertext_118

Santos A, Martins MJ, Guimarães JT, Severo M, Azevedo I. *Sodium-rich carbonated natural mineral water ingestion and blood pressure.* Rev Port Cardiol. 2010 Feb;29(2):159-72. (<http://www.ncbi.nlm.nih.gov/pubmed/20545244>)

Abstract

INTRODUCTION:

There is a strong positive correlation between sodium chloride intake and hypertension. In industrialized countries the ingestion of carbonated and non-carbonated mineral water is an important source of calorie-free fluids. The mineral content of these waters varies greatly, with many brands containing high levels of sodium. However, some mineral waters contain greater amounts of bicarbonate instead of chloride as the anion associated with the sodium cation. This is relevant because it is well established that the effect of sodium on blood pressure depends on the corresponding anion. Additionally the pressor effect of sodium bicarbonate is much lower than that of equivalent amounts of sodium chloride. The aim of our work was to evaluate the effect of ingesting a sodium-rich carbonated mineral water (Água das Pedras) on blood pressure values in normotensive individuals.

METHODS:

This crossover, non-blinded study evaluated 17 individuals (9 female and 8 male), aged 24-53 years, median body mass index (BMI) < 23, randomly allocated in two groups, ingesting 500 ml/day of Água das Pedras or Água Vitalis. Each arm of the study lasted 7 weeks, with 6 weeks of washout between them. Twenty-four hour urinary samples were collected at the beginning and end of each arm to determine pH and sodium and potassium excretion. Blood pressure and body weight were measured weekly throughout the study. A mixed-effects model was used to compare groups ($p < 0.05$). The Wilcoxon test was used to analyze electrolyte excretion.

RESULTS:

No differences were observed in blood pressure values between treatments or from baseline values. We found a positive correlation between BMI and blood pressure.

DISCUSSION AND CONCLUSIONS:

The daily ingestion of 500 ml of Água das Pedras had no effect on blood pressure. A study by Schorr and co-workers found that the ingestion of bicarbonate-rich water (1.5 l/day) had hypotensive effects in an elderly population. However, these results should be verified in hypertensive subjects, who are more likely to be salt sensitive, since in some of these individuals blood pressure rises even when sodium is ingested as sodium bicarbonate. PMID: 20545244 [PubMed - indexed for MEDLINE]

Hypertext_119

Melgar S, Engström K, Jägervall A, Martinez V. *Psychological stress reactivates dextran sulfate sodium-induced chronic colitis in mice*. *Stress*. 2008 Sep;11(5):348-62. (<http://www.ncbi.nlm.nih.gov/pubmed/18666024>)

Abstract

Inflammatory bowel disease (IBD) is a chronic condition with alternating active and quiescent phases of inflammation. Stress has been suggested as a factor triggering a relapse of IBD. We investigated the role of repetitive psychological stress [water avoidance stress (WAS)] in reactivating colonic inflammation in a murine model of dextran sulfate sodium (DSS)-induced chronic colitis. Colitis was induced in C57BL/6 female mice by exposure to 3% DSS (5 days). During chronic inflammation (day 34), mice underwent repetitive WAS (1 h/day/7 days) and were given a sub-threshold concentration of DSS (1%, 5 days) or normal water to drink. At euthanasia (day 40), inflammatory parameters were assessed (colon inflammatory score, levels of inflammatory markers and histology). Mice with chronic colitis exposed to WAS had higher macroscopic and microscopic colonic inflammatory scores and levels of inflammatory markers (mainly IL-1 β , IL12p40 and CCL5) than non-stressed mice. Inflammatory responses were further enhanced by the presence of a sub-threshold concentration of DSS (1%). In mice without chronic inflammation, neither WAS nor 1% DSS, individually or in combination, elicited any inflammation. Hence stress, per se, reactivates a quiescent chronic inflammation, but does not initiate inflammation in healthy mice. Stress should be regarded as an environmental factor triggering IBD relapses in humans. PMID: 18666024 [PubMed - indexed for MEDLINE]

Hypertext_40

Guliaeva SF, Pomaskina TV, Guliaev PV, Martusevich AK, Aistov VI. [*Efficacy of sulfate calcium mineral water in disorders of motor evacuatory function of the stomach and gallbladder*]. *Vopr Kurortol Fizioter Lech Fiz Kult*. 2004 Nov-Dec;(6):20-2 (<http://www.ncbi.nlm.nih.gov/pubmed/15717533>)

Abstract

Patients with disorders of motor-evacuatory gastric function and those of the gallbladder received sanatorium spa treatment with Nizhnevinskaya 2K mineral water. It was found that both course and single intake of the above mineral water induce clinical remission of the disease, normalization of the echoscopic picture of the stomach and gallbladder, their motor function, tesiocystalloscopic characteristics of the saliva. Therefore, spa treatment with mineral water Nizhnevinskaya is effective in rehabilitation of patients with gastric and gallbladder motor-evacuatory dysfunction. PMID: 15717533 [PubMed - indexed for MEDLINE]

Hypertext_120

Fornai M, Colucci R, Antonioli L, Ghisu N, Tuccori M, Gori G, Blandizzi C, Del Tacca M. *Effects of a bicarbonate-alkaline mineral water on digestive motility in experimental models of functional and inflammatory gastrointestinal disorders*. *Methods Find Exp Clin Pharmacol*. 2008 May;30(4):261-9. doi: 10.1358/mf.2008.30.4.1159650 (<http://www.ncbi.nlm.nih.gov/pubmed/18773120>)

Abstract

This study investigates the effects of Uliveto, a bicarbonate-alkaline mineral water, in experimental models of diarrhea, constipation and colitis. Rats were allowed to drink Uliveto or oligomineral water (control) for 30 days. Diarrhea and constipation were evoked by 16,16-dimethyl-prostaglandin E(2) (dmPGE(2)) or loperamide, respectively. Colitis was induced by 2,4-dinitrobenzenesulfonic acid (DNBS) or acetic acid. Gastric emptying, small-intestinal and colonic transit were evaluated. dmPGE(2)-induced diarrhea reduced gastric emptying and increased small-intestinal and colonic transit. In this setting, Uliveto water enhanced gastric emptying, and this effect was prevented by L-365,260 (gastrin receptor antagonist). Loperamide-induced constipation reduced gastric emptying, small-intestinal and colonic transit, and these effects were prevented by Uliveto water. L-365,260 counteracted the effects of Uliveto on gastric emptying, while alosetron (serotonin 5-HT(3) receptor antagonist) blunted the effect of Uliveto on colonic transit. Gastric emptying, small-intestinal and colonic transit were reduced in DNBS-induced colitis, and Uliveto water enhanced gastric emptying and normalized small-intestinal and colonic transit. Gastric emptying, small-intestinal and colonic transit were also reduced in acetic acid-induced colitis, and Uliveto increased both gastric emptying and small-intestinal transit. In conclusion, Uliveto water exerts beneficial effects on gastrointestinal motility in the presence of bowel motor dysfunctions. The effects of Uliveto water on gastric emptying depend on gastrin-mediated mechanisms, whereas the activation of serotonergic pathways accounts for the modulation of colonic functions.

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Hypertext_121

Beglinger C. *Effect of cholecystokinin on gastric motility in humans*. *Ann N Y Acad Sci*. 1994 Mar 23;713:219-25. (<http://www.ncbi.nlm.nih.gov/pubmed/8185162>)

Abstract

Gastric emptying after food ingestion is regulated by neural and hormonal factors. However, the relative contributions of each pathway is not yet clearly defined. The classic gut hormone CCK seems to be involved in the regulation of gastric emptying in humans. Experimental evidence is best for gastric emptying of liquid meals that release CCK from the duodenum: (1) CCK infused at postprandial plasma concentrations inhibits gastric emptying of a liquid and a semisolid meal. (2) Administration of the CCK antagonist loxiglumide significantly accelerated gastric emptying of a liquid mixed meal and a glucose meal. Discrepant results with the antagonist MK329 are difficult to explain considering the marked acceleration of gastric emptying rates by the specific and potent antagonist MK329 shown in several animal studies. Taken together, current information favors the conclusion, however, that CCK mainly controls gastric emptying of the liquid but not the solid components. Thus, CCK is involved in the physiologic regulation of gastric emptying and gastric motility in man. Blocking CCK-A receptors accelerates gastric emptying of liquid meals and abolishes the gastrocolonic reflex. Therefore, CCK may play a role as a common regulator of postprandial gallbladder contraction and pancreatic enzyme secretion as well as of gastric emptying rates under certain conditions. Such common control would optimize the nutrient-to-digestive juices concentration ratio. The importance of endogenous CCK on gastric emptying of solid meals, however, is poorly understood and remains to be defined. Only very limited information is available on gastric motility. Much more work has to be done before a clear concept can be developed. PMID: 8185162 [PubMed - indexed for MEDLINE]

Hypertext_41

Bertoni M, Olivieri F, Manghetti M, Boccolini E, Bellomini MG, Blandizzi C, Bonino F, Del Tacca M. *Effects of a bicarbonate-alkaline mineral water on gastric functions and functional dyspepsia: a preclinical and clinical study*. Pharmacol Res. 2002 Dec;46(6):525-31. <http://www.ncbi.nlm.nih.gov/pubmed/12457626>

Abstract

The present study was performed in order to evaluate: (1) the influence of a bicarbonate-alkaline mineral water (Uliveto) on digestive symptoms in patients with functional dyspepsia; (2) the effects of Uliveto on preclinical models of gastric functions. Selected patients complained of dyspeptic symptoms in the absence of digestive lesions or *Helicobacter pylori* infection within the previous 3 months. They were treated with Uliveto water (1.5 l day⁻¹) for 30 days. Frequency and severity of symptoms were assessed at baseline and day 30 by a score system. Preclinical experiments were carried out on rats, allowed to drink Uliveto or oligomineral water for 30 days. Animals then underwent pylorus ligation to evaluate gastric secretion of acid, pepsinogen, and mucus. In separate experiments, gastric emptying was assessed. Crenotherapy was associated with a relief of epigastric pain, retrosternal pyrosis, postprandial fullness and gastric distention. At preclinical level, Uliveto water increased acid and pepsinogen secretions as well as gastric emptying, without changes in bound mucus. The enhancing actions of Uliveto on gastric secretions and emptying were prevented by L-365,260, an antagonist of gastrin/CCK-2 receptors. These findings indicate that a regular intake of Uliveto favors an improvement of dyspeptic symptoms. The preclinical study suggests that the clinical actions of Uliveto water depend mainly on its ability to enhance gastric motor and secretory functions. PMID: 12457626 [PubMed - indexed for MEDLINE]

Hypertext_122

Newton CR, Gonvers JJ, McIntyre PB, Preston DM, Lennard-Jones JE. *Effect of different drinks on fluid and electrolyte losses from a jejunostomy*. J R Soc Med. 1985 Jan;78(1):27-34. (<http://www.ncbi.nlm.nih.gov/pubmed/3968667>)

Abstract

The effectiveness of 5 different solutions on the absorption of fluid and electrolytes was tested in 7 patients with a proximal intestinal stoma and large fluid losses, all of whom previously needed intravenous infusions to maintain balance. In 4 patients it proved possible to replace the intravenous infusions with an enteral supplement. The WHO glucose/electrolyte solution without added potassium (NaCl 3.5 g, NaHCO₃ 2.5 g, glucose 20 g/l) gave satisfactory results, though was slightly less effective than a solution containing more sodium in which maltose was substituted for glucose. Neither sucrose nor an oligosaccharide (Caloreen) gave an advantage over glucose in the formulations used. In 3 patients losses were so great, and absorption of sodium from oral solutions so small, that intravenous supplements had to be continued. These 3 patients could be distinguished from the other 4 by the fact that more than 250 ml emerged from the stoma during the 3 hours after a drink of 500 ml of glucose/electrolyte solution. In all patients a drink of water or tea led to a loss of sodium from the stoma; water should be restricted in such patients and replaced by a glucose/electrolyte solution. PMID: 3968667 [PubMed - indexed for MEDLINE] PMID: PMC1289541

Hypertext_123

Flemström G, Mäkelä K, Purhonen AK, Sjöblom M, Jedstedt G, Walkowiak J, Herzig KH. *Apelin stimulation of duodenal bicarbonate secretion: feeding-dependent and mediated via apelin-induced release of enteric cholecystokinin*. Acta Physiol (Oxf). 2011 Jan;201(1):141-50. (<http://www.ncbi.nlm.nih.gov/pubmed/20726845>)

Abstract

AIMS:

Apelin peptides are the endogenous ligand of the G protein-coupled receptor APJ. Proposed actions include involvement in control of cardiovascular functions, appetite and body metabolism. We have investigated the effects of apelin peptides on duodenal bicarbonate secretion *in vivo* and the release of cholecystokinin (CCK) from acutely isolated mucosal cells and the neuroendocrine cell line STC-1.

METHODS:

Lewis × Dark Agouti rats had free access to water and, unless fasted overnight, free access to food. A segment of proximal duodenum was cannulated *in situ* in anaesthetized animals. Mucosal bicarbonate secretion was titrated (pH stat) and apelin was administered to the duodenum by close intra-arterial infusion. Total RNA was extracted from mucosal specimens, reverse transcribed to cDNA and the expression of the APJ receptor measured by quantitative real-time PCR. Apelin-induced release of CCK was measured using (1) cells prepared from proximal small intestine and (2) STC-1 cells.

RESULTS:

Even the lowest dose of apelin-13 ($6 \text{ pmol kg}^{-1} \text{ h}^{-1}$) caused a significant rise in bicarbonate secretion. Stimulation occurred only in continuously fed animals and even a 100-fold greater dose ($600 \text{ pmol kg}^{-1} \text{ h}^{-1}$) of apelin was without effect in overnight food-deprived animals. Fasting also induced an eightfold decrease in the expression of APJ receptor mRNA. Apelin induced significant release of CCK from both mucosal and STC-1 cells, and the CCK(A) receptor antagonist devazepide abolished bicarbonate secretory responses to apelin.

CONCLUSION:

Apelin-induced stimulation of duodenal electrolyte secretion is feeding-dependent and mediated by local mucosal release of CCK.

© 2010 The Authors. Acta Physiologica © 2010 Scandinavian Physiological Society. PMID: 20726845 [PubMed - indexed for MEDLINE]

Hypertext_43

Kastrikinia TF, Vavilova GL. [Endocrine intestinal low molecular weight factor inhibits Na^+, K^+ -ATPase activity of enterocytes]. Ukr Biokhim Zh; 1989 Sep-Oct;61(5):96-8 (<http://www.ncbi.nlm.nih.gov/pubmed/2555953>)

Abstract

The biological activity of the endocrine secretum fraction isolated from the rat duodenum is determined. The fraction with the molecular weight about 3 kDa is found to possess the factor which inhibits the Na^+, K^+ -ATPase activity of enterocytes. It is found that the inhibitory factor secretum depends on the solution which irrigates the duodenum cavity. The possible regulatory role of the intestine inhibitory factor is under discussion. PMID: 2555953 [PubMed - indexed for MEDLINE]

Hypertext_45

Fornai M., Colucci R., Antonioli L., Ghisu M., Tuccori M., Gori G., Blandizzi C., Del Tacca M. *Effects of a bicarbonate-alkaline mineral water on digestive motility in experimental models of functional and inflammatory gastrointestinal disorders*. Methods Find Exp Clin Pharmacol. 2008 May; 30 (4): 261-9 (<http://www.ncbi.nlm.nih.gov/pubmed/18773120>)

Abstract

This study investigates the effects of Uliveto, a bicarbonate-alkaline mineral water, in experimental models of diarrhea, constipation and colitis. Rats were allowed to drink Uliveto or oligomineral water (control) for 30 days. Diarrhea and constipation were evoked by 16,16-dimethyl-prostaglandin E(2) (dmPGE(2)) or loperamide, respectively. Colitis was induced by 2,4-dinitrobenzenesulfonic acid (DNBS) or acetic acid. Gastric emptying, small-intestinal and colonic transit were evaluated. dmPGE(2)-induced diarrhea reduced gastric emptying and increased small-intestinal and colonic transit. In this setting, Uliveto water enhanced gastric emptying, and this effect was prevented by L-365,260 (gastrin receptor antagonist). Loperamide-induced constipation reduced gastric emptying, small-intestinal and colonic transit, and these effects were prevented by Uliveto water. L-365,260 counteracted the effects of Uliveto on gastric emptying, while alosetron (serotonin 5-HT(3) receptor antagonist) blunted the effect of Uliveto on colonic transit. Gastric emptying, small-intestinal and colonic transit were reduced in DNBS-induced colitis, and Uliveto water enhanced gastric emptying and normalized small-intestinal and colonic transit. Gastric emptying, small-intestinal and colonic transit were also reduced in acetic acid-induced colitis, and Uliveto increased both gastric emptying and small-intestinal transit. In conclusion, Uliveto water exerts beneficial effects on gastrointestinal motility in the presence of bowel motor dysfunctions. The effects of Uliveto water on gastric emptying depend on gastrin-mediated mechanisms, whereas the activation of serotonergic pathways accounts for the modulation of colonic functions. PMID: 18773120 [PubMed - indexed for MEDLINE]

Hypertext_124

Toussaint C, Peuchant E, Nguyen BC, Jensen R, Canellas J. [Influence of calcic and magnesic sulphurous thermal water on the metabolism of lipoproteins in the rat]. Arch Int Physiol Biochim. 1986 Jun;94(2):65-76. (<http://www.ncbi.nlm.nih.gov/pubmed/?term=water+sulphurous+hepatic>)

Abstract

We have studied in rats fed hypercholesterolemic diet the action of calcic and magnesic sulphurous water from Capvern on the modification of the lipoproteins metabolism caused by hypercholesterolemia. The rats subjected to a hypercholesterolemic diet with thermal water of Capvern was found to have a plasma level of cholesterol significantly less increased (P less than 0.01) compared to those subjected to the same diet with ordinary drinking water (25%). We demonstrated after 105 days of experimentation on tested rats that thermal water may affect the cholesterol catabolism by increased level of cholesterol HDL (52%) and stabilizing level of cholesterol LDL comparatively to the controls. These data suggest that the thermal water from Capvern enhanced the transformation of cholesterol to biliary acids and their biliary secretion. A possible relationship between the influence of the thermal water and the metabolism of lipoproteins would be explained by a possible increase of hepatic receptors which identify apolipoproteins B (LDL) and E (HDLc) on cholesterol fed rats, suggesting a great synthesis of nascent apolipoproteins HDL which are antiatherogenic. PMID: 2430538 [PubMed - indexed for MEDLINE]

Hypertext_47

Gutenbrunner C, El-Cherid A, Gehrke A, Fink M. Circadian variations in the responsiveness of human gallbladder to sulfated mineral water. Chronobiol Int. 2001 Nov;18(6):1029-39 (http://www.pneumonet.it/scientifico/medline/ricerca.html?list_uids=11777077)

Abstract

It is well known that the intake of sulfate-containing natural mineral waters leads to contraction of the gallbladder, probably induced by the release of cholecystokinin (CCK). As early as 1959, there were some hints in the literature of circadian variations in gallbladder response; to find out whether this applies with sulfate as a stimulus, a pretest for basic information about gallbladder reaction to sulfate-containing mineral water was carried out on 19 healthy volunteers. On this basis, 15 healthy subjects of both sexes were then studied. After 6h of fasting, 500 mL of a sulfate-containing mineral water (2,800 mg SO₄(2-)/L) were ingested within 5 min. The size of the gallbladder was registered ultrasonographically before and 15, 30, 60, and 120 min after drinking. The experiments were carried out seven times at different hours of the day for each volunteer. After the intake of the mineral water, the mean gallbladder size decreased significantly, followed by an increase after 60 min (P < .001). Significant circadian spontaneous variation in gallbladder size was detected (acrophase around 09:00; amplitude was 30.0% of daily average, P < .001). The contraction induced by the sulfate-containing water was most marked in the early morning hours and minimal around mid-day; the amplitude of this variation accounting for 29.0% of the daily average (P < .01). In contrast, the postdrinking relaxation was maximal around 18:00 and minimal around 9:00 (amplitude 38.5%. P < .001). These results show that the basal size of the gallbladder and its reaction to stimuli show a marked circadian variation: Whereas contractibility is maximal in the morning, dilatation is stronger in the afternoon. PMID: 11777077

Hypertext_49

Gorbunov IuV, Korepanov AM. [The treatment of patients with chronic cholecystitis and hypomotor biliary dyskinesia at a sanatorium]. Vopr Kurortol Fizioter Lech Fiz Kult. 1997 Sep-Oct;(5):32-4 (<http://www.ncbi.nlm.nih.gov/pubmed/9446306>)

Abstract

Efficacy of spa treatment with moderately mineralized mineral water from the spring utilized by balneological sanatorium Uva in the Republic of Udmurtia was studied in 524 patients with chronic atrophic gastritis concomitant with chronic cholecystitis and hypokinesia of the biliary ducts. Drinking water proved beneficial for hepatobiliary tract, clinical symptoms regressed, the ability of the gallbladder to concentrate and expel bile improved. PMID: 9446306 [PubMed - indexed for MEDLINE]

Hypertext_48

Tierney S., Pitt HA., Lillemoie KD. Physiology and pathophysiology of gallbladder motility. Surg Clin North Am. 1993 Dec;73(6):1267-90. (<http://www.ncbi.nlm.nih.gov/pubmed/8248838>)

Abstract

Most significant gallbladder disease is associated with gallbladder stasis. Gallbladder motility is controlled by a complex interplay of hormonal and neural factors. Experimental and clinical studies have demonstrated impaired motility in gallstone disease, and experimental evidence indicates that motility disturbances precede gallstone formation. The ability to measure gallbladder motility clinically has also resulted in better diagnosis and treatment for patients with chronic a calculous cholecystitis. PMID: 8248838 [PubMed - indexed for MEDLINE]

Hypertext_129

Erceg-Rukavina T, Stefanovski M. *Balneotherapy in treatment of spastic upper limb after stroke*. Med Arch. 2015 Feb;69(1):31-3. doi: 10.5455/medarch.2015.69.31-33. Epub 2015 Feb 21. (<http://www.ncbi.nlm.nih.gov/pubmed/25870474>)

Abstract

INTRODUCTION:

After stroke, spasticity is often the main problem that prevents functional recovery. Pain occurs in up to 70% of patients during the first year post-stroke.

MATERIALS AND METHODS:

A total of 70 patients (30 female and 45 male) mean age (65.67) participated in prospective, controlled study.

INCLUSION CRITERIA:

ischaemic stroke, developed spasticity of upper limb, post-stroke interval <6 months.

EXCLUSION CRITERIA:

contraindications for balneotherapy and inability to follow commands. Experimental group (Ex) (n=35) was treated with sulphurous baths (31°-33°C) and controlled group (Co) with taped water baths, during 21 days. All patients were additionally treated with kinesitherapy and cryotherapy. The outcome was evaluated using Modified Ashworth scale for spasticity and VAS scale for pain. The significance value was sat at p<0.05.

GOAL:

To find out the effects of balneotherapy with sulphurous bath on spasticity and pain in affected upper limb.

RESULTS:

Reduction in tone of affected upper limb muscles was significant in Ex group (p<0.05). Pain decreased significantly in Ex-group (p<0.01).

CONCLUSION:

Our results show that balneotherapy with sulphurous water reduces spasticity and pain significantly and can help in treatment of post-stroke patients.

KEYWORDS:

balneotherapy; spasticity; stroke PMID: 25870474 [PubMed - in process] PMCID: PMC4384865

Hypertext_130

Soria M, González-Haro C, Esteva S, Escanero JF, Pina JR. *Effect of sulphurous mineral water in haematological and biochemical markers of muscle damage after an endurance exercise in well-trained athletes*. J Sports Sci. 2014;32(10):954-62. doi: 10.1080/02640414.2013.868921. Epub 2014 Feb 6. (<http://www.ncbi.nlm.nih.gov/pubmed/24499262>)

Abstract

To investigate the effects of sulphurous mineral water (SMW) after a hydroponic treatment on muscle damage, antioxidant activity and peripheral blood changes induced by submaximal exercise. Thirty well-trained male triathletes were supplemented with SMW or placebo: 3 weeks of placebo, 30 days of wash out and 3 weeks of SMW. After both periods, participants ran for 2 h at 70% maximal aerobic speed. Antioxidant enzymes, lipid peroxidation, antioxidant capacity and blood cell markers were compared between placebo and SMW at pre-exercise (T0), immediately post-exercise (T1), 24 h post-exercise (T2) and 48 h post-exercise (T3). Total thiols decreased until T3 vs. T0 for both placebo and SMW; transient red blood cells, haemoglobin and haematocrit increased were shown at T1 vs. T0 and for leucocytes until T2 vs. T0, only for placebo group. Total thiols increased significantly in SMW vs. placebo at T0; Thiobarbituric acid reactive species was significantly higher at T0, T1, T2 and T3; catalase increased significantly at T1; creatine phosphokinase decreased significantly at T1, T2 and T3, although no significant differences were found at T0. Furthermore, red blood cells, haemoglobin and haematocrit were significantly higher and leucocytes were significantly lower at T0 and T1 in SMW group vs. placebo group. This study suggests that three weeks of SMW supplementation may protect from exercise-induced muscle damage. PMID: 24499262 [PubMed - indexed for MEDLINE]

Hypertext_51

Antoniuk MV, Ivanova IL, Khasina EI. *[The effect of the internal intake of carbonate mineral waters on lipid and carbohydrate metabolism in the development of experimental obesity]*. Vopr Kurortol Fizioter Lech Fiz Kult. 1996 Jan-Feb;(1):23-5 (<http://www.ncbi.nlm.nih.gov/pubmed/8686219>)

Abstract

Experimental alimentary obesity was treated with hydrocarbonate magnesium-calcium water from Shmakovskoe deposit and hydrocarbonate-chloride sodium arsenous boric iodine-bromine water from springs in Sinogorsk. The study of lipid and carbohydrate metabolism proved the ability of the waters to prevent complex metabolic disorders typical for obesity. PMID: 8686219 [PubMed - indexed for MEDLINE]

Hypertext_125

Adeva-Andany MM, Carneiro-Freire N, Donapetry-García C¹, Rañal-Muñio E, López-Pereiro Y. *The importance of the ionic product for water to understand the physiology of the acid-base balance in humans*. Biomed Res Int. 2014;2014:695281. (<http://www.ncbi.nlm.nih.gov/pubmed/24877130>)

Abstract

Human plasma is an aqueous solution that has to abide by chemical rules such as the principle of electrical neutrality and the constancy of the ionic product for water. These rules define the acid-base balance in the human body. According to the electroneutrality principle, plasma has to be electrically neutral and the sum of its cations equals the sum of its anions. In addition, the ionic product for water has to be constant. Therefore, the plasma concentration of hydrogen ions depends on the plasma ionic composition. Variations in the concentration of plasma ions that alter the relative proportion of anions and cations predictably lead to a change in the plasma concentration of hydrogen ions by driving adaptive adjustments in water ionization that allow plasma electroneutrality while maintaining constant the ionic product for water. The accumulation of plasma anions out of proportion of cations induces an electrical imbalance compensated by a fall of hydroxide ions that brings about a rise in hydrogen ions (acidosis). By contrast, the deficiency of chloride relative to sodium generates plasma alkalosis by increasing hydroxide ions. The adjustment of plasma bicarbonate concentration to these changes is an important compensatory mechanism that protects plasma pH from severe deviations.

PMID: 24877130 [PubMed - indexed for MEDLINE] PMCID: PMC4022011

Hypertext_126

Prandelli C, Parola C, Buizza L, Delbarba A, Marziano M, Salvi V, Zacchi V, Memo M, Sozzani S, Calza S, Uberti D, Bosisio D. *Sulphurous thermal water increases the release of the anti-inflammatory cytokine IL-10 and modulates antioxidant enzyme activity*. Int J Immunopathol Pharmacol. 2013 Jul-Sep;26(3):633-46. (<http://www.ncbi.nlm.nih.gov/pubmed/24067460>)

Abstract

The beneficial effects of hot springs have been known for centuries and treatments with sulphurous thermal waters are recommended in a number of chronic pathologies as well as acute recurrent infections. However, the positive effects of the therapy are often evaluated in terms of subjective sense of wellbeing and symptomatic clinical improvements. Here, the effects of an S-based compound (NaSH) and of a specific sulphurous thermal water characterized by additional ions such as sodium chloride, bromine and iodine (STW) were investigated in terms of cytokine release and anti-oxidant enzyme activity in primary human monocytes and in saliva from 50 airway disease patients subjected to thermal treatments. In vitro, NaSH efficiently blocked the induction of pro-inflammatory cytokines and counterbalanced the formation of ROS. Despite STW not recapitulating these results, possibly due to the low concentration of S-based compounds reached at the minimum non-toxic dilution, we found that it enhanced the release of IL-10, a potent anti-inflammatory cytokine. Notably, higher levels of IL-10 were also observed in patients' saliva following STW treatment and this increase correlated positively with salivary catalase activity ($r^2 = 0.19$, *p less than 0.01). To our knowledge, these results represent the first evidence suggesting that S-based compounds and STW may prove useful in facing chronic inflammatory and age-related illness due to combined anti-inflammatory and anti-oxidant properties. PMID: 24067460 [PubMed - indexed for MEDLINE]

Hypertext_63

Toussaint C, Peuchant E, Nguyen BC, Jensen R, Canellas J. *Influence of calcic and magnestic sulphurous thermal water on the metabolism of lipoproteins in the rat*. Arch Int Physiol Biochim. 1986 Jun;94(2):65-76 (<http://www.ncbi.nlm.nih.gov/pubmed/2430538>) Arch Int Physiol Biochim. 1986 Jun;94(2):65-76.

Abstract

We have studied in rats fed hypercholesterolemic diet the action of calcic and magnestic sulphurous water from Capvern on the modification of the lipoproteins metabolism caused by hypercholesterolemia. The rats subjected to a hypercholesterolemic diet with thermal water of Capvern was found to have a plasma level of cholesterol significantly less increased (P less than 0.01) compared to those subjected to the same diet with ordinary drinking water (25%). We demonstrated after 105 days of experimentation on tested rats that thermal water may affect the cholesterol catabolism by increased level of cholesterol HDL (52%) and stabilizing level of cholesterol LDL comparatively to the controls. These data suggest that the thermal water from Capvern enhanced the transformation of cholesterol to biliary acids and their biliary secretion. A possible relationship between the influence of the thermal water and the metabolism of lipoproteins would be explained by a possible increase of hepatic receptors which identify apolipoproteins B (LDL) and E (HDLc) on cholesterol fed rats, suggesting a great synthesis of nascent apolipoproteins HDL which are antiatherogenic. PMID: 2430538 [PubMed - indexed for MEDLINE]

Hypertext_64

Kolesnikov O.L., Selianina G.A., Dolgushin I.I., Kolesnikova A.A. [The question of mechanisms of the immunotropic effect of mineral drinking waters]. Vopr Kurortol Fizioter Lech Fiz Kult. 2002 May-Jun; (3): 15-7 (<http://www.ncbi.nlm.nih.gov/pubmed/12221837>)

Abstract

Drinking of mineral waters influences human immune system. Among the mechanisms of this action is a stress effect confirmed by increasing levels of glucocorticoids, catecholamines, by hyperglycemia, etc. Regular drinking of mineral water brings about adaptation. Development of long-term adaptation provokes defensive cross effects. It is suggested that an immunotropic action of mineral waters may be a manifestation of a defensive cross effect of the organism adaptation. Immunostimulation may also be related to suppression of T-suppressors activity and changes in cytokines levels. PMID: 12221837 [PubMed - indexed for MEDLINE]

Hypertext_59

Garzon P, Eisenberg MJ. *Variation in the mineral content of commercially available bottled waters: implications for health and disease*. Am J Med. 1998 Aug; 105 (2): 125-30 (<http://www.ncbi.nlm.nih.gov/pubmed/9727819>)

Abstract

PURPOSE:

Although the annual consumption of bottled water in North America is 12.7 gallons per capita, little is known about the potential health effects of these waters. We reviewed the amounts of major minerals found in commercially available bottled waters, the recommended daily allowances for these minerals, and their beneficial and harmful effects.

METHODS:

We obtained the mineral content of various commercially available bottled waters in North America and Europe from The Pocket Guide to Bottled Water. We then conducted a Medline search to identify articles examining the beneficial and harmful effects of magnesium, sodium, and calcium.

RESULTS:

Great variation exists in the mineral content of commercially available bottled waters. Among the bottled waters that we reviewed, the magnesium content ranges from 0 to 126 mg per liter, the sodium content ranges from 0 to 1,200 mg per liter, and the calcium content ranges from 0 to 546 mg per liter. Epidemiologic and clinical studies suggest that magnesium may reduce the frequency of sudden death, that sodium contributes to the occurrence of hypertension, and that calcium may help prevent osteoporosis.

CONCLUSION:

The ideal bottled water should be rich in magnesium and calcium and have a low sodium content. Because there is great variation in the mineral content of commercially available bottled waters, the actual mineral content of bottled water should be considered when selecting one for consumption. PMID: 9727819 [PubMed - indexed for MEDLINE]

Hypertext_44

Sabatier M, Grandvuillemin A, Kastenmayer P, Aeschliman JM, Bouisset F, Arnaud MJ, Dumoulin G, Berthelot A. *Influence of the consumption pattern of magnesium from magnesium-rich mineral water on magnesium bioavailability*. Br J Nutr. 2011 Aug;106(3):331-4 (<http://www.ncbi.nlm.nih.gov/pubmed/21473800>)

Abstract

It is generally considered that the absorption of Mg is inversely related to the ingested dose. The objective of the present study was to determine if the mode of administration (bolus v. consumption throughout the day) could influence Mg bioavailability from Mg-rich natural mineral water comparing the same nutritional Mg amount (126 mg). Using a 2 d cross-over design, twelve healthy men were asked to drink 1.5 litres Mg-rich mineral water either as 2 × 750 ml or 7 × 212 ml throughout the day. Two stable isotopes (²⁵Mg and ²⁶Mg) were used to label the water in order to distinguish both regimens. Fractional apparent Mg absorption was determined by faecal monitoring and Mg retention was determined by measuring urinary excretion of Mg isotopes. Higher Mg absorption (50.7 (SD 12.7) v. 32.4 (SD 8.1) %; P = 0.0007) and retention (47.5 (SD 12.9) v. 29.0 (SD 7.5) %; P = 0.0008) from Mg-rich mineral water were observed when it was consumed in seven servings compared with larger servings. Thus, regular water consumption throughout the day is an effective way to increase Mg bioavailability from Mg-rich mineral water. PMID: 21473800 [PubMed - indexed for MEDLINE]

Hypertext_52

Heaney RP. *Absorbability and utility of calcium in mineral waters*. Am J Clin Nutr. 2006 Aug; 84 (2): 371-4 (<http://www.ncbi.nlm.nih.gov/pubmed/16895885>)

Abstract

BACKGROUND:

Calcium intake in North America remains substantially below recommended amounts. Bottled waters high in

calcium could help close that gap.

OBJECTIVES:

The objectives were to summarize and integrate published absorbability and biodynamic data concerning high-calcium mineral waters and to combine these data with hitherto unpublished analyses from my laboratory.

DESIGN:

The usual library database was searched. The absorbability of calcium from a high-mineral water labeled with tracer quantities of (⁴⁵)Ca was measured in human volunteers as a part of an otherwise low-calcium test meal. Published reports that used differing load sizes and meal conditions were harmonized by making corrections based on published calcium absorbability data.

RESULTS:

All the high-calcium mineral waters had absorbabilities equal to milk calcium or slightly better. When tested, all produced biodynamic responses indicative of absorption of appreciable quantities of calcium (ie, increased urinary calcium, decreased serum parathyroid hormone, decreased bone resorption biomarkers, and protection of bone mass).

CONCLUSION:

High-calcium mineral waters could provide useful quantities of bioavailable calcium. PMID: 16895885 [PubMed - indexed for MEDLINE]

Hypertext_53

Wynn E, Krieg MA, Lanham-New SA, Burckhardt P. *Postgraduate Symposium: Positive influence of nutritional alkalinity on bone health*. Proc Nutr Soc. 2010 Feb;69(1):166-73 (<http://www.ncbi.nlm.nih.gov/pubmed/19954569>) Abstract

There is growing evidence that consumption of a Western diet is a risk factor for osteoporosis through excess acid supply, while fruits and vegetables balance the excess acidity, mostly by providing K-rich bicarbonate-rich foods. Western diets consumed by adults generate approximately 50-100 mEq acid/d; therefore, healthy adults consuming such a diet are at risk of chronic low-grade metabolic acidosis, which worsens with age as a result of declining kidney function. Bone buffers the excess acid by delivering cations and it is considered that with time an overstimulation of this process will lead to the dissolution of the bone mineral content and hence to reduced bone mass. Intakes of K, Mg and fruit and vegetables have been associated with a higher alkaline status and a subsequent beneficial effect on bone health. In healthy male volunteers an acid-forming diet increases urinary Ca excretion by 74% and urinary C-terminal telopeptide of type I collagen (C-telopeptide) excretion by 19% when compared with an alkali (base-forming) diet. Cross-sectional studies have shown that there is a correlation between the nutritional acid load and bone health measured by bone ultrasound or dual-energy X-ray absorptiometry. Few studies have been undertaken in very elderly women (>75 years), whose osteoporosis risk is very pertinent. The EVALuation of Nutrients Intakes and Bone Ultra Sound Study has developed and validated (n 51) an FFQ for use in a very elderly Swiss population (mean age 80.4 (sd 2.99) years), which has shown intakes of key nutrients (energy, fat, carbohydrate, Ca, Mg, vitamin C, D and E) to be low in 401 subjects. A subsequent study to assess net endogenous acid production (NEAP) and bone ultrasound results in 256 women aged > or = 75 years has shown that lower NEAP (P=0.023) and higher K intake (P=0.033) are correlated with higher bone ultrasound results. High acid load may be an important additional risk factor that may be particularly relevant in very elderly patients with an already-high fracture risk. The latter study adds to knowledge by confirming a positive link between dietary alkalinity and bone health indices in the very elderly. In a further study to complement these findings it has also been shown in a group of thirty young women that in Ca sufficiency an acid Ca-rich water has no effect on bone resorption, while an alkaline bicarbonate-rich water leads to a decrease in both serum parathyroid hormone and serum C-telopeptide. Further investigations need to be undertaken to study whether these positive effects on bone loss are maintained over long-term treatment. Mineral-water consumption could be an easy and inexpensive way of helping to prevent osteoporosis and could be of major interest for long-term prevention of bone loss. PMID: 19954569 [PubMed - indexed for MEDLINE]

Hypertext_61

Benedetti S, Benvenuti F, Nappi G, Fortunati NA, Marino L, Aureli T, De Luca S, Pagliarani S, Canestrari F. *Antioxidative effects of sulfurous mineral water: protection against lipid and protein oxidation*. Dipartimento: Istituto di Istologia e Analisi di Laboratorio, Università di Urbino Carlo Bo, Urbino, Italy, Eur J Clin Nutr. 2007 (<http://www.ncbi.nlm.nih.gov/pubmed/17717532>)

Abstract

OBJECTIVES:

To investigate the antioxidative properties of sulfurous drinking water after a standard hydropinic treatment (500 ml day(-1) for 2 weeks).

SUBJECTS/METHODS:

Forty apparently healthy adults, 18 men and 22 women, age 41-55 years old. The antioxidant profile and the

oxidative condition were evaluated in healthy subjects supplemented for 2 weeks with (study group) or without (controls) sulfurous mineral water both before (T0) and after (T1) treatment.

RESULTS:

At T1, a significant decrease ($P<0.05$) in both lipid and protein oxidation products, namely malondialdehyde, carbonyls and AOPP, was found in plasma samples from subjects drinking sulfurous water with respect to controls. Concomitantly, a significant increment ($P<0.05$) of the total antioxidant capacity of plasma as well as of total plasmatic thiol levels was evidenced. Tocopherols, carotenoids and retinol remained almost unchanged before and after treatment in both groups.

CONCLUSIONS:

The improved body redox status in healthy volunteers undergoing a cycle of hydropinic therapy suggests major benefits from sulfurous water consumption in reducing biomolecule oxidation, possibly furnishing valid protection against oxidative damage commonly associated with aging and age-related degenerative diseases.

PMID: 17717532 [PubMed - indexed for MEDLINE]

Hypertext_62

Costantino M, Giampaolo C, Filippelli A. [Effects of drinking spa therapy on oxidative stress]. Clin Ter. 2012;163(1):e13-7 <http://www.ncbi.nlm.nih.gov/pubmed/22362238>

Abstract

OBJECTIVES:

Data of literature have shown the correlation between oxidative stress and some diseases of gastrointestinal and metabolic relevance such as diabetes mellitus, gastric cancer, gastritis, etc.. Studies have also shown that sulfurous mineral water may be useful in the treatment of gastrointestinal diseases. The aim of our research was to evaluate the antioxidant effect of sulphurous mineral water, administered by drinking method, in type 2 diabetes mellitus, a chronic disease with a high social and economic impact.

PATIENTS AND METHODS:

The study has been performed on 57 subjects (25% women and 75% males; mean age: 60 ± 1.1 years; BMI: 27 ± 0.4) affected by type 2 Diabetes Mellitus. The subjects were divided in four groups: A (subjected to glucose-lowering diet therapy), B (subjected to antihyperglycaemic therapy), C (exposed to glucose-lowering diet therapy + drinking SPA therapy) and D (exposed to antihyperglycaemic therapy + drinking SPA therapy). Drinking SPA treatment was effected with sulphurous mineral water from Terme di Teleso SpA (Benevento - Italy) and the pharmacological treatment provided the use of hypoglycemic drugs normally used in diabetic disease. After two weeks of therapy with treatments considered were evaluated fasting blood glycaemia and plasma concentration of ROMs (reactive oxygen metabolites) (d-ROMs test-Diacron International srl®-Grosseto - Italy).

RESULTS:

The results of our study have shown a significant ($p<0.05$) reduction of the fasting blood glycaemia when to hypoglycemic drugs or diet therapy was associated the sulphurous drinking SPA therapy. It was also observed a reduction of plasma ROMs levels, significant ($p <0.05$) in group D versus group B.

CONCLUSIONS:

The data from this preliminary investigation suggest that the drinking SPA therapy with sulphurous mineral water, especially in combination with antidiabetic drug treatment, may be useful in type 2 diabetes mellitus for the improvement redox state of the organism. PMID: 22362238 [PubMed - indexed for MEDLINE]

Hypertext_54

Rudzka-Kantoch Z., Weker H. *Postgraduate Symposium: Positive influence of nutritional alkalinity on bone health*. Med Wieku Rozwoj. 2000; 4 (3 Suppl 1): 109-15 (<http://www.ncbi.nlm.nih.gov/pubmed/11381158>)

Abstract

There is growing evidence that consumption of a Western diet is a risk factor for osteoporosis through excess acid supply, while fruits and vegetables balance the excess acidity, mostly by providing K-rich bicarbonate-rich foods. Western diets consumed by adults generate approximately 50-100 mEq acid/d; therefore, healthy adults consuming such a diet are at risk of chronic low-grade metabolic acidosis, which worsens with age as a result of declining kidney function. Bone buffers the excess acid by delivering cations and it is considered that with time an overstimulation of this process will lead to the dissolution of the bone mineral content and hence to reduced bone mass. Intakes of K, Mg and fruit and vegetables have been associated with a higher alkaline status and a subsequent beneficial effect on bone health. In healthy male volunteers an acid-forming diet increases urinary Ca excretion by 74% and urinary C-terminal telopeptide of type I collagen (C-telopeptide) excretion by 19% when compared with an alkali (base-forming) diet. Cross-sectional studies have shown that there is a correlation between the nutritional acid load and bone health measured by bone ultrasound or dual-energy X-ray absorptiometry. Few studies have been undertaken in very elderly women (>75 years), whose osteoporosis risk is very pertinent. The EVALuation of Nutrients Intakes and Bone Ultra Sound Study has developed and validated (n 51) an FFQ for use in a very elderly Swiss population (mean age 80.4 (sd 2.99) years),

which has shown intakes of key nutrients (energy, fat, carbohydrate, Ca, Mg, vitamin C, D and E) to be low in 401 subjects. A subsequent study to assess net endogenous acid production (NEAP) and bone ultrasound results in 256 women aged ≥ 75 years has shown that lower NEAP ($P=0.023$) and higher K intake ($P=0.033$) are correlated with higher bone ultrasound results. High acid load may be an important additional risk factor that may be particularly relevant in very elderly patients with an already-high fracture risk. The latter study adds to knowledge by confirming a positive link between dietary alkalinity and bone health indices in the very elderly. In a further study to complement these findings it has also been shown in a group of thirty young women that in Ca sufficiency an acid Ca-rich water has no effect on bone resorption, while an alkaline bicarbonate-rich water leads to a decrease in both serum parathyroid hormone and serum C-telopeptide. Further investigations need to be undertaken to study whether these positive effects on bone loss are maintained over long-term treatment. Mineral-water consumption could be an easy and inexpensive way of helping to prevent osteoporosis and could be of major interest for long-term prevention of bone loss. PMID: 19954569 [PubMed - indexed for MEDLINE]

Hypertext_68

Hayajneh WA, Jdaitawi H, Al Shurman A, Hayjneh YA. *Comparison of clinical association and laboratory abnormalities in children with moderate and severe dehydration*. J Pediatr Gastroenterol Nutr 2006 July 28 (<http://www.ncbi.nlm.nih.gov/pubmed/19644395>)

Abstract

OBJECTIVES:

To search for possible early clinical associations and laboratory abnormalities in children with severe dehydration in northern Jordan.

PATIENTS AND METHODS:

We prospectively evaluated 251 children with acute gastroenteritis. Dehydration assessment was done following a known clinical scheme. Probable clinical associations and laboratory abnormalities were examined against the preassigned dehydration status.

RESULTS:

Children with severe dehydration had significantly more hypernatremia and hyperkalemia, less isonatremia, and higher mean levels of urea, creatinine, and glucose ($P < 0.005$). Receiver operating characteristic curves showed statistically significant area under the curve values for laboratory variables. These area under the curve values were 0.991 (95% confidence interval [CI] 0.980-1.001) for serum urea, 0.862 (95% CI 0.746-0.978) for sodium, 0.850 (95% CI 0.751-0.949) for creatinine, 0.69 (95% CI 0.555-0.824) for potassium, and 0.684 (95% CI 0.574-0.795) for glucose ($P < 0.05$ for all). Certain independent serum cutoff levels of urea, creatinine, sodium, glucose, and potassium had high negative predictive value (100%), whereas other cutoff values for each, except potassium, had high positive predictive value (100%) for severe dehydration. Historic clinical characteristics of patients did not correlate to dehydration degree.

CONCLUSIONS:

Serum urea, creatinine, sodium, potassium, and glucose were useful independently in augmenting clinical examination to diagnose the degree of dehydration status among children presenting with gastroenteritis. Serum urea performed the best among all. On the contrary, none of the examined historical clinical patterns could be correlated to the dehydration status. Larger and multicenter studies are needed to validate our results and to examine their impact on final outcomes. PMID: 19644395 [PubMed - indexed for MEDLINE]

Hypertext_69

Seokyoung H, YaeJean K, Paul G. *Reduced osmolarity oral rehydration solution for treating dehydration due to diarrhoea in children: systematic review*. BMJ 2001; 323: 81-5. (<http://www.ncbi.nlm.nih.gov/pubmed/11451782>)

Abstract

OBJECTIVES:

To compare reduced osmolarity oral rehydration solution with standard World Health Organization oral rehydration solution in children with acute diarrhoea.

DESIGN:

Systematic review of randomised controlled trials.

STUDIES:

15 randomised controlled trials including 2397 randomised patients.

OUTCOMES:

The primary outcome was unscheduled intravenous infusion; secondary outcomes were stool output, vomiting, and hyponatraemia.

RESULTS:

In a meta-analysis of nine trials for the primary outcome, reduced osmolarity rehydration solution was associated with fewer unscheduled intravenous infusions compared with standard WHO rehydration solution (odds ratio 0.61, 95% confidence interval 0.47 to 0.81). Three trials reported that no patients required unscheduled

intravenous infusion. Trials reporting secondary outcomes suggested that in the reduced osmolarity rehydration solution group, stool output was lower (standardised mean difference in the log scale -0.214 (95% confidence interval -0.305 to -0.123; 13 trials) and vomiting was less frequent (odds ratio 0.71, 0.55 to 0.92; six trials). Six trials sought presence of hyponatraemia, with events in three studies, but no significant difference between the two arms.

CONCLUSION:

In children admitted to hospital with dehydration associated with diarrhoea, reduced osmolarity rehydration solution is associated with reduced need for unscheduled intravenous infusions, lower stool volume, and less vomiting compared with standard WHO rehydration solution. PMID: 11451782 [PubMed - indexed for MEDLINE] PMID: PMC34542 Free PMC Article

Hypertext_127

Bobulescu IA, Moe OW. *Luminal Na(+)/H(+) exchange in the proximal tubule*. Pflugers Arch. 2009 May;458(1):5-21. doi: 10.1007/s00424-008-0595-1. Epub 2008 Oct 14. (<http://www.ncbi.nlm.nih.gov/pubmed/18853182>)

Abstract

The proximal tubule is critical for whole-organism volume and acid-base homeostasis by reabsorbing filtered water, NaCl, bicarbonate, and citrate, as well as by excreting acid in the form of hydrogen and ammonium ions and producing new bicarbonate in the process. Filtered organic solutes such as amino acids, oligopeptides, and proteins are also retrieved by the proximal tubule. Luminal membrane Na(+)/H(+) exchangers either directly mediate or indirectly contribute to each of these processes. Na(+)/H(+) exchangers are a family of secondary active transporters with diverse tissue and subcellular distributions. Two isoforms, NHE3 and NHE8, are expressed at the luminal membrane of the proximal tubule. NHE3 is the prevalent isoform in adults, is the most extensively studied, and is tightly regulated by a large number of agonists and physiological conditions acting via partially defined molecular mechanisms. Comparatively little is known about NHE8, which is highly expressed at the lumen of the neonatal proximal tubule and is mostly intracellular in adults. This article discusses the physiology of proximal Na(+)/H(+) exchange, the multiple mechanisms of NHE3 regulation, and the reciprocal relationship between NHE3 and NHE8 at the lumen of the proximal tubule.

PMID: 18853182 [PubMed - indexed for MEDLINE] PMID: PMC2878283

Hypertext_66

Armon K, Stephenson T, MacFaul R, Eccleston P, Werneke U. *An evidence and consensus based guideline for acute diarrhoea management*. Arch Dis Child 2001; 85: 132-42. (<http://www.ncbi.nlm.nih.gov/pubmed/11466188>)

Abstract

OBJECTIVE:

To develop an evidence and consensus based guideline for the management of the child who presents to hospital with diarrhoea (with or without vomiting), a common problem representing 16% of all paediatric medical attenders at an accident and emergency department. Clinical assessment, investigations (biochemistry and stool culture in particular), admission, and treatment are addressed. The guideline aims to aid junior doctors in recognising children who need admission for observation and treatment and those who may safely go home.

EVIDENCE:

A systematic review of the literature was performed. Selected articles were appraised, graded, and synthesised qualitatively. Statements on recommendation were generated.

CONSENSUS:

An anonymous, postal Delphi consensus process was used. A panel of 39 selected medical and nursing staff were asked to grade their agreement with the generated statements. They were sent the papers, appraisals, and literature review. On the second and third rounds they were asked to re-grade their agreement in the light of other panelists' responses. Consensus was predefined as 83% of panelists agreeing with the statement.

RECOMMENDATIONS:

Clinical signs useful in assessment of level of dehydration were agreed. Admission to a paediatric facility is advised for children who show signs of dehydration. For those with mild to moderate dehydration, estimated deficit is replaced over four hours with oral rehydration solution (glucose based, 200-250 mOsm/l) given "little and often". A nasogastric tube should be used if fluid is refused and normal feeds started following rehydration. Children at high risk of dehydration should be observed to ensure at least maintenance fluid is tolerated. Management of more severe dehydration is detailed. Antidiarrhoeal medication is not indicated.

VALIDATION:

The guideline has been successfully implemented and evaluated in a paediatric accident and emergency department. PMID: 11466188 [PubMed - indexed for MEDLINE] PMID: PMC1718867

Hypertext_67

Colletti JE, Brown KM Sharieff GQ, Barata IA, Ishimine P; ACEP Pediatric Emergency Medicine Committee. *The*

management of children with gastroenteritis and dehydration in the Emergency Department. L Emerg Med 2009 April 2 (<http://www.ncbi.nlm.nih.gov/pubmed/19345549>) Abstract

BACKGROUND:

Acute gastroenteritis is characterized by diarrhea, which may be accompanied by nausea, vomiting, fever, and abdominal pain.

OBJECTIVE:

To review the evidence on the assessment of dehydration, methods of rehydration, and the utility of antiemetics in the child presenting with acute gastroenteritis.

DISCUSSION:

The evidence suggests that the three most useful predictors of 5% or more dehydration are abnormal capillary refill, abnormal skin turgor, and abnormal respiratory pattern. Studies are conflicting on whether blood urea nitrogen (BUN) or BUN/creatinine ratio correlates with dehydration, but several studies found that low serum bicarbonate combined with certain clinical parameters predicts dehydration. In most studies, oral or nasogastric rehydration with an oral rehydration solution was equally efficacious as intravenous (i.v.) rehydration. Many experts discourage the routine use of antiemetics in young children. However, children receiving ondansetron are less likely to vomit, have greater oral intake, and are less likely to be treated by intravenous rehydration. Mean length of Emergency Department (ED) stay is also less, and very few serious side effects have been reported.

CONCLUSIONS:

In the ED, dehydration is evaluated by synthesizing the historical and physical examination, and obtaining laboratory data points in select patients. No single laboratory value has been found to be accurate in predicting the degree of dehydration and this is not routinely recommended. The evidence suggests that the majority of children with mild to moderate dehydration can be treated successfully with oral rehydration therapy. Ondansetron (orally or intravenously) may be effective in decreasing the rate of vomiting, improving the success rate of oral hydration, preventing the need for i.v. hydration, and preventing the need for hospital admission in those receiving i.v. hydration. PMID: 19345549 [PubMed - indexed for MEDLINE]

Hypertext_70

Fonseca BK, Holdgate A, Craig JC. *Enteral vs intravenous rehydration therapy for children with gastroenteritis: a meta-analysis of randomized controlled trials.* Arch Pediatr Adolesc Med 2004; 158: 483-90. (<http://www.ncbi.nlm.nih.gov/pubmed/15123483>)

Abstract

OBJECTIVE:

To review the relative efficacy and safety of enteral vs intravenous (IV) rehydration therapy in treating childhood gastroenteritis.

DATA SOURCES:

MEDLINE, EMBASE, and the Cochrane Controlled Trials Register databases were searched. Known investigators and expert bodies were contacted to locate unpublished and ongoing studies.

STUDY SELECTION:

Studies were selected based on the following criteria: randomized or quasi-randomized trials; children younger than 15 years with a clinical diagnosis of gastroenteritis of less than 1-week duration; interventions comprising enteral and IV treatment arms; and at least 1 of the following: major adverse event rates, treatment failure rates, weight gain with treatment, measurement of ongoing losses, length of hospital stay, costs of treatment, and satisfaction with treatment.

DATA EXTRACTION:

Data were extracted from eligible studies, which were then combined using a random-effects model.

DATA SYNTHESIS:

Sixteen trials involving 1545 children and conducted in 11 countries were identified. Compared with children treated with IV rehydration, children treated with oral rehydration had significantly fewer major adverse events, including death or seizures (relative risk, 0.36; 95% confidence interval [CI], 0.14-0.89), and a significant reduction in length of hospital stay (mean, 21 hours; 95% CI, 8-35 hours). There was no difference in weight gain between the 2 groups (mean, -26 g; 95% CI, -61 to 10 g). The overall failure rate of enteral therapy was 4.0% (95% CI, 3.0%-5.0%).

CONCLUSIONS:

For childhood gastroenteritis, enteral rehydration is as effective if not better than IV rehydration. Enteral rehydration by the oral or nasogastric route is associated with significantly fewer major adverse events and a shorter hospital stay compared with IV therapy and is successful in most children. PMID: 15123483 [PubMed - indexed for MEDLINE]

Hypertext_71

Nager AL, Wang VJ. *Comparison of nasogastric and intravenous methods of rehydration in pediatric patients*

with acute dehydration. *Pediatrics* 2002; 109: 566-72. (<http://www.ncbi.nlm.nih.gov/pubmed/11927697>)

Abstract

OBJECTIVE:

To assess the safety, efficacy, and cost-effectiveness of rapid nasogastric hydration (RNG) and rapid intravenous hydration (RIV) administered in the emergency department (ED) to young children suffering with uncomplicated, acute moderate dehydration.

METHODS:

Ninety-six children aged 3 to 36 months, who presented with signs and symptoms of uncomplicated, acute moderate dehydration caused by vomiting and/or diarrhea, presumed to be caused by viral gastroenteritis, were randomly assigned to receive either RNG with a standard oral rehydration solution or RIV with normal saline. Each solution was administered at a rate of 50 mL/kg of body weight, delivered over a 3-hour period in our urban pediatric ED. All participants were weighed pretreatment and posttreatment and underwent initial and final measurements of their serum electrolytes, blood urea nitrogen, creatinine, and glucose levels, along with urine chemistry and urine specific gravity. Telephone follow-up by completion of a standardized questionnaire was obtained approximately 24 hours after discharge from the ED.

RESULTS:

Ninety-two of 96 enrolled patients completed the study. Three patients failed treatment (2 RIV and 1 RNG) and were excluded and hospitalized because of severe, intractable vomiting, and 1 patient was withdrawn secondary to an intussusception. Among 92 evaluable patients, 2 were found to be severely dehydrated (>10% change in body weight) and were excluded from analysis, leaving 90 patients (RNG: N = 46 and RIV: N = 44), who completed the study. Both RNG and RIV were found to be a safe and efficacious means of treating uncomplicated, acute moderate dehydration in the ED. Determinations of electrolytes, blood urea nitrogen, creatinine, or glucose were not found to be of value on an intent-to-treat basis in the care of these patients. The urine specific gravity and incidence of ketonuria declined from levels commensurate with moderate dehydration in the RNG group, but not as consistently so in the RIV group. Both RNG and RIV were substantially less expensive to administer than standard care with intravenous fluid deficit therapy in-hospital, and RNG was more cost-effective to administer over RIV in the outpatient setting.

CONCLUSION:

RNG and RIV administered in the ED are safe, efficacious, and cost-effective alternatives to the standard treatment for uncomplicated, acute moderate dehydration in young children. RNG is as efficacious as RIV, is no more labor intensive than RIV, and is associated with fewer complications. In addition, we found that most routine laboratory testing is of little value in these patients and should be avoided, except when clearly clinically indicated. PMID: 11927697 [PubMed - indexed for MEDLINE]

Hypertext_72

[No authors listed]. Practice parameter: the management of acute gastroenteritis in young children. American Academy of Pediatrics, Provisional Committee on Quality Improvement, Subcommittee on Acute Gastroenteritis. *Pediatrics* 1996; 97: 424-35. (<http://www.ncbi.nlm.nih.gov/pubmed/?term=Practice+parameter+3A+the+management+of+acute+gastroenteritis+in+young+children.+American+Academy+of+Pediatrics+2C+Provisional+Committee+on+Quality+Improvement%2C+Subcommittee+on+Acute+Gastroenteritis>)

Abstract

This practice parameter formulates recommendations for health care providers about the management of acute diarrhea in children ages 1 month to 5 years. It was developed through a comprehensive search and analysis of the medical literature. Expert consensus opinion was used to enhance or formulate recommendations where data were insufficient. The Provisional Committee on Quality Improvement of the American Academy of Pediatrics (AAP) selected a subcommittee composed of pediatricians with expertise in the fields of gastroenterology, infectious diseases, pediatric practice, and epidemiology to develop the parameter. The subcommittee, the Provisional Committee on Quality Improvement, a review panel of practitioners, and other groups of experts within and outside the AAP reviewed and revised the parameter. Three specific management issues were considered: (1) methods of rehydration, (2) refeeding after rehydration, and (3) the use of antidiarrheal agents. Main outcomes considered were success or failure of rehydration, resolution of diarrhea, and adverse effects from various treatment options. A comprehensive bibliography of literature on gastroenteritis and diarrhea was compiled and reduced to articles amenable to analysis. Oral rehydration therapy was studied in depth; inconsistency in the outcomes measured in the studies interfered with meta-analysis but allowed for formulation of strong conclusions. Oral rehydration was found to be as effective as intravenous therapy in rehydrating children with mild to moderate dehydration and is the therapy of first choice in these patients. Refeeding was supported by enough comparable studies to permit a valid meta-analysis. Early refeeding with milk or food after rehydration does not prolong diarrhea; there is evidence that it may reduce the duration of diarrhea by approximately half a day and is recommended to restore nutritional balance as soon as possible. Data on

antidiarrheal agents were not sufficient to demonstrate efficacy; therefore, the routine use of antidiarrheal agents is not recommended, because many of these agents have potentially serious adverse effects in infants and young children. This practice parameter is not intended as a sole source of guidance in the treatment of acute gastroenteritis in children. It is designed to assist pediatricians by providing an analytic framework for the evaluation and treatment of this condition. It is not intended to replace clinical judgment or to establish a protocol for all patients with this condition. It rarely will provide the only appropriate approach to the problem. A technical report describing the analyses used to prepare this parameter and a patient education brochure are available through the Publications Department of the AAP. PMID: 8604285 [PubMed - indexed for MEDLINE]

Hypertext_73

Baker LB¹, Jeukendrup AE. *Optimal composition of fluid-replacement beverages*. *Compr Physiol*. 2014 Apr;4(2):575-620. doi: 10.1002/cphy.c130014. (<http://www.ncbi.nlm.nih.gov/pubmed/24715561>)

Abstract

The objective of this article is to provide a review of the fundamental aspects of body fluid balance and the physiological consequences of water imbalances, as well as discuss considerations for the optimal composition of a fluid replacement beverage across a broad range of applications. Early pioneering research involving fluid replacement in persons suffering from diarrheal disease and in military, occupational, and athlete populations incurring exercise- and/or heat-induced sweat losses has provided much of the insight regarding basic principles on beverage palatability, voluntary fluid intake, fluid absorption, and fluid retention. We review this work and also discuss more recent advances in the understanding of fluid replacement as it applies to various populations (military, athletes, occupational, men, women, children, and older adults) and situations (pathophysiological factors, spaceflight, bed rest, long plane flights, heat stress, altitude/cold exposure, and recreational exercise). We discuss how beverage carbohydrate and electrolytes impact fluid replacement. We also discuss nutrients and compounds that are often included in fluid-replacement beverages to augment physiological functions unrelated to hydration, such as the provision of energy. The optimal composition of a fluid-replacement beverage depends upon the source of the fluid loss, whether from sweat, urine, respiration, or diarrhea/vomiting. It is also apparent that the optimal fluid-replacement beverage is one that is customized according to specific physiological needs, environmental conditions, desired benefits, and individual characteristics and taste preferences. PMID: 24715561 [PubMed - indexed for MEDLINE]

Hypertext_74

Kositzke JA. *A question of balance. Dehydration in the elderly*. *J Gerontol Nurs*. 1990 May;16(5):4-11. (<http://www.ncbi.nlm.nih.gov/pubmed/2358648>)

Abstract

The maintenance of optimal water balance is a priority for homeostasis; unfortunately, the aging process adversely affects the mechanisms of water balance, making it more difficult for the body to adequately defend itself against water loss. Four major age-related changes predispose the elderly to dehydration and hypernatremia: a decrease in total body water, an altered sense of thirst, a decrease in the renal urine concentrating ability, and a decrease in the effectiveness of ADH. In the case of fluid balance, careful assessment cannot be overemphasized due to the fact that there are few symptoms unique to dehydration that readily allow a nurse to know that fluid imbalances are involved. PMID: 2358648 [PubMed - indexed for MEDLINE]

Hypertext_128

Vezzoli G, Arcidiacono T, Puzovio M, Mora S. [*Comparative study of the short-term effect of mineral water on calcium metabolism*]. *G Ital Nefrol*. 2010 Jul-Aug;27(4):391-5. (<http://www.ncbi.nlm.nih.gov/pubmed/20672236>)

Abstract

Mineral water may be a useful means to achieve optimal dietary calcium intake, but the effect of different mineral waters on calcium metabolism is unknown. We therefore evaluated calcium excretion in 24-hour urine in 10 healthy individuals (5 women and 5 men) after two weeks of drinking at least 1500 mL/day of mineral water with a low electrolyte content or 1500 mL/day of mineral water rich in calcium and bicarbonate but with a different sodium content. The low-sodium water Sangemini was one of these two mineral waters. Calcium excretion did not significantly increase after intake of the Sangemini mineral water in comparison with the baseline period of low-electrolyte mineral water intake. Conversely, the calcium excretion increased significantly after intake of the second mineral water. The plasma concentration of C-terminal telopeptide of type I collagen and the urinary phosphate excretion decreased after intake of the second mineral water in comparison with the baseline period, whereas they did not decrease after intake of Sangemini water. Therefore, phosphate excretion was higher after drinking Sangemini water than the other studied mineral water. Drinking Sangemini water may have a slight effect on calcium excretion and may not inhibit bone turnover in the short term. The lesser effect of Sangemini water on calcium excretion could be useful in the treatment of osteoporosis. PMID: 20672236 [PubMed - indexed for MEDLINE]

Hypertext_114

Karagülle O, Smorag U, Candir F, Gundermann G, Jonas U, Becker AJ, Gehrke A, Gutenbrunner C. *Clinical study on the effect of mineral waters containing bicarbonate on the risk of urinary stone formation in patients with multiple episodes of CaOx-urolithiasis*. World J Urol. 2007 Jun;25(3):315-23. (<http://www.ncbi.nlm.nih.gov/pubmed/17333204>)

Abstract

Investigations in healthy persons have shown that drinking mineral water containing HCO₃ has a positive effect on urine supersaturated with calcium oxalate (SS(CaOx)). The present study evaluates in a common setting whether these effects are also relevant in patients with multiphasic urinary stone formation. A total of 34 patients with evident multiphasic CaOx-urolithiasis were included in the study. Patients with hyperparathyroidism, renal tubular acidosis, Wilson's disease, Cushing disease, osteoporosis and malignant diseases were excluded. In a cross-over design and double-blinded the patients received 1.5 l of a mineral water with 2.673 mg HCO₃/l (test water) or the same amount of water with a low mineral content (98 mg HCO₃/l) (control water) daily for 3 days. During the study period the patients diet was recorded in a protocol, but not standardised. The main target parameter was SS(CaOx) in 24 h urine. In addition, urinary pH and the most important inhibiting and promoting factors were measured in 24 h urine (Ca, Ox, Mg, Cit). Both waters tested led to a highly significant increase in 24 h urine volume without a difference between each other. In the group, drinking the water containing HCO₃ the urinary pH increased significantly and was within a range relevant for metaphylaxis of calcium oxalate stone formation ($x=6.73$). This change was highly significant compared to the control group. In addition, significantly increased magnesium and citrate concentration were also observed. Supersaturation with calcium oxalate decreased significantly and to a relevant extent; however, there was no difference between the waters tested. As expected, the risk of uric acid precipitation also decreased significantly under bicarbonate water intake. However, an increase of the risk of calcium phosphate stone formation was observed. It is evident that both waters tested are able to lower significantly and to a relevant extent the risk of urinary stone formation in patients with multiphasic CaOx-urolithiasis. In addition, the bicarbonate water increases the inhibitory factors citrate and magnesium due to its content of HCO₃ and Mg. Thus, it can be recommended for metaphylaxis of calcium oxalate and uric acid urinary stones. PMID: 17333204 [PubMed - indexed for MEDLINE]

Hypertext_87

Eklblom B, Greenleaf CJ, Greenleaf JE, Hermansen L. *Temperature regulation during exercise dehydration in man*. Acta Physiol Scand 1970; 79: 475-83. (<http://onlinelibrary.wiley.com/doi/10.1111/j.1748-1716.1970.tb04748.x/abstract;jsessionid=8A8D85097E7A699A58326BC7EAAFC4EA.f01t01>)

Abstract

The effects of mild exercise dehydration (1 % of the body weight) on temperature regulation were investigated in 3 men during continuous and intermittent exercise of 1 hr duration on a Krogh bicycle ergometer with the same average heat production at a relative O₂ uptake of 62 % in the environment-independent zone (22° C Ta and 38 % rh). In both hydration and dehydration, during intermittent work, equilibrium levels of rectal temperature (Tre) were 0.3° C higher than during continuous work. Progressive dehydration elevated equilibrium levels of Tre and mean body temperatures 0.3 to 0.4° C above hydration control values while mean skin temperatures (Ts) were essentially constant at 30±0.2° C. The elevation of Tre with dehydration was due, predominantly, to reduced sweating. It is suggested the sweat depression was due to reduced stimuli from the central nervous system to the glands. These results emphasize the sensitivity of the thermoregulatory system to dehydration and point up the need to control water intake during such experiments.

Hypertext_88

Montain SJ, Sawka MN, Latzka WA, Valeri CR. *Thermal and cardiovascular strain from hypohydration: Influence of exercise intensity*. Int J Sports Med 1998; 19: 87-91.

Abstract

This study determined the effects of exercise intensity on the physiologic (thermal and cardiovascular) strain induced from hypohydration during heat stress. We hypothesized that the added thermal and cardiovascular strain induced by hypohydration would be greater during high intensity than low intensity exercise. Nine heat-acclimated men completed a matrix of nine trials: three exercise intensities, 25%, 45% and 65% VO₂ max; and three hydration levels, euhydration and hypohydration at 3% and 5% body weight loss (BWL). During each trial, subjects attempted 50 min of treadmill exercise in a hot room (30 degrees C db, 50% rh) while body temperatures and cardiac output were measured. Hypohydration was achieved by exercise and fluid restriction the day preceding the trials. Core temperature increased (P<0.05) 0.12 degrees C per%BWL at each hypohydration level and was not affected by exercise intensity. Cardiac output was reduced (P<0.05) compared to euhydration levels and was reduced more during high compared to low intensity exercise after 5% BWL. It was concluded that: a) the thermal penalty (core temperature increase) accompanying hypohydration is not altered by exercise intensity; and b) at severe hypohydration levels, the cardiovascular penalty (cardiac output

reduction) increases with exercise intensity. PMID: 9562215 [PubMed - indexed for MEDLINE]

Hypertext_89

Baumgartner RN, Stauber PM, McHugh D, Koehler KM, Garry PJ. *Crosssectional age differences in body composition in persons 60+ years of age*. J Gerontol 1995; 50A: M307-16.

Abstract

BACKGROUND:

There is little information for age differences in body composition in elderly people > 65 years of age, especially for those > 80 years. As the proportion of people older than 65 years is expected to nearly double during the next few decades, this information is needed.

METHODS:

Age differences in body composition and anthropometry were examined in 316 men and women aged 60 to 95 years. Multiple components of body composition were quantified using dual energy X-ray absorptiometry and isotope dilution methods, and expressed in molecular and cellular models. Analysis of variance was used to test for differences between age groups 60 to 70, 71 to 80, and > 80 years in each sex. Body composition components were regressed on age, controlling for knee height, fat-free mass, or total body fat. Age-adjusted correlations were calculated with anthropometric variables.

RESULTS:

Fat-free mass (FFM), body cell mass (BCM), and appendicular skeletal muscle (ASM) decreased with age in both sexes. ASM decreased relative to FFM in both the men and the women, while BCM decreased relative to FFM in the women only. Total fat mass and percent body fat decreased with age in the women, but not in the men. Body fat distribution did not appear to change with age. Anthropometric indices, muscle area and waist/hip ratio, had low correlations with muscle mass and fat distribution.

CONCLUSIONS:

"Sarcopenia," or muscle loss, continues to occur into old age, and may have significant impacts on physical function and health status. New anthropometric techniques are needed for assessing muscle loss with age. PMID: 7583802 [PubMed - indexed for MEDLINE]

Hypertext_79

Phillips PA, Johnston CI, Gray L. *Disturbed fluid and electrolyte homeostasis following dehydration in elderly people*. Age and Ageing 1993;22:26-33. (<http://www.ncbi.nlm.nih.gov/pubmed/8438652>)

Abstract

Disturbances in homeostatic capacity are typical of the ageing process. Changes in the neuroendocrine controls of salt and water homeostasis with age make elderly people more susceptible to fluid and electrolyte disturbances such as dehydration and overhydration. Not only do elderly subjects show reduced thirst and water intake following dehydration, but their kidneys are less able to retain water. This reduced thirst and water intake is not dependent on palatability of the liquids offered as the amounts drunk are no different if water alone or a variety of beverages are offered to healthy elderly dehydrated men. It is of interest that the arginine vasopressin (AVP) response to dehydration is maintained in elderly subjects, indicating that their reduced renal water retentive capacity is due to relative renal resistance to vasopressin. The mechanism underlying the reduced thirst is unclear. Dehydration causes plasma hypertonicity and reduced extracellular fluid (ECF) volume, both of which stimulate thirst and AVP secretion. Elderly subjects show deficits in sensing the reduced ECF volume through reduced low and high pressure baroreceptor sensitivity. In contrast, while the AVP responses to hypertonicity are maintained, the thirst responses seem to be reduced. It seems unlikely that the primary sensing 'osmoreceptor' neurons in the hypothalamus leading to AVP secretion or thirst would be differentially affected by age. Therefore the thirst deficit may result from changes with age in the more poorly defined pathways that bring thirst to consciousness. Following rehydration, thirst and AVP secretion are inhibited in young individuals thus avoiding overhydration. PMID: 8438652 [PubMed - indexed for MEDLINE]

Hypertext_90

Buffa R, Floris GU, Putzu PF, Marini E. *Body composition variations in ageing*. Coll Antropol. 2011 Mar;35(1):259-65. (<http://www.ncbi.nlm.nih.gov/pubmed/21667542>)

Abstract

Age-related physiological variations of body composition concern both the fat-free mass (FFM) and the fat mass (FM). These variations expose the elderly person to the risk of malnutrition and could lead to conditions of disability. This paper aims to review the current state of knowledge on body composition in the aged population. The pattern of qualitative variations in body composition in old age is fairly well defined. In adulthood, the physiological variation of body mass involves a first increasing phase followed by a decreasing trend. The reduction is due mainly to the loss of fat-free mass, especially muscle mass. Total body water and bone mass also decrease. Fat mass tends to decrease and the reduction seems to be due mainly to the loss of subcutaneous

fat. The quantitative aspects of the age of onset, rate and intensity of the physiological variations are still not completely clear. This poor quantitative definition is due to the variable and multifactorial phenomenology of ageing, the heterogeneity of assessment techniques and sampling models, and the limited number of empirical observations in oldest-old individuals. PMID: 21667542 [PubMed - indexed for MEDLINE]

Hypertext_91

Wong, DL. *Balance and Imbalance of Body Fluids*. In Winkelste ML, Kline NE Wilson D. *Nursing Care of Infants and Children*. 7th. Philadelphia: Mosby; 2003 (<http://www.worldcat.org/title/wongs-nursing-care-of-infants-and-children/oclc/644149977>)

Abstract

Features a unique "age and stage" approach that covers child development and health promotion as well as specific health problems organized by age-groups and body systems. This edition focuses on patient-centered outcomes and includes updates on current topics such as the late-preterm infant, immunizations, the H1N1 virus, and childhood obesity.

Hypertext_92

Deveau M. *Contribution of drinking water to dietary requirements of essential metals*. J Toxicol Environ Health A 2010; 73: 235-41.

Abstract

Drinking water can be a source of essential metals, but only one study published thus far has compared the intake of essential metals in drinking water to dietary reference intakes. This assessment compares the ingestion of chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), selenium (Se), and zinc (Zn) from drinking water at the maximum concentrations that should be found in water, or at concentrations that are potentially more likely to be found in Canadian water, to the recommended dietary allowance or adequate intake values established by the Institute of Medicine. At guideline limits, water provides sufficient Cr and Cu to meet nutritional requirements, and Mn and Zn levels are sufficient for some age categories to meet nutritional requirements. At concentrations that are more likely to be found in Canadian water, adequate intakes for Cr and Mn may be met by water alone for bottle-fed infants, and water was estimated to provide 23-66% of daily Cu requirements. Drinking water might become a significant source of some essential metals in individuals whose diets are low in these metals, especially in the case of Cu. PMID: 20077293 [PubMed - indexed for MEDLINE]

Hypertext_93

Murray B. *Hydration and Physical Performance*. J Am Coll Nutr 2007; 26: 542S-48S.

Abstract

There is a rich scientific literature regarding hydration status and physical function that began in the late 1800s, although the relationship was likely apparent centuries before that. A decrease in body water from normal levels (often referred to as dehydration or hypohydration) provokes changes in cardiovascular, thermoregulatory, metabolic, and central nervous function that become increasingly greater as dehydration worsens. Similarly, performance impairment often reported with modest dehydration (e.g., -2% body mass) is also exacerbated by greater fluid loss. Dehydration during physical activity in the heat provokes greater performance decrements than similar activity in cooler conditions, a difference thought to be due, at least in part, to greater cardiovascular and thermoregulatory strain associated with heat exposure. There is little doubt that performance during prolonged, continuous exercise in the heat is impaired by levels of dehydration \geq -2% body mass, and there is some evidence that lower levels of dehydration can also impair performance even during relatively short-duration, intermittent exercise. Although additional research is needed to more fully understand low-level dehydration's effects on physical performance, one can generalize that when performance is at stake, it is better to be well-hydrated than dehydrated. This generalization holds true in the occupational, military, and sports settings. PMID: 17921463 [PubMed - indexed for MEDLINE]

Hypertext_75

Rolls BJ, Phillips PA. *Aging and disturbances of thirst and fluid balance*. Nutr Rev. 1990 Mar;48(3):137-44. (<http://www.ncbi.nlm.nih.gov/pubmed/2406645>)

Abstract

Fluid and electrolyte homeostasis depend on a balance between the intake and output of water. Aging is characterized by reduced homeostatic capacity. Changes in the control of both water intake and excretion accompany aging and may predispose the elderly to disturbances in sodium and water balance. Reduced thirst and water intake in response to water deprivation and thermal dehydration have been observed in healthy elderly persons. This reduction, combined with reduced renal water-conservation capacity, may predispose the elderly to dangerous dehydration when illness increases water losses or physical incapacity prevents access to water. The reasons for the thirst deficit are not clear. The elderly have a reduced capacity to excrete a water load,

which means they are predisposed to water overload and hyponatremia. Furthermore, various neuroendocrine changes in the elderly affect fluid and electrolyte homeostasis. More studies are needed to understand the etiology of the disturbances of fluid intake and output so that they can be better prevented and treated. PMID: 2406645 [PubMed - indexed for MEDLINE]

Hypertext_76

Beck LH. *The aging kidney. Defending a delicate balance of fluid and electrolytes.* Geriatrics. 2000 Apr;55(4):26-8, 31-3. (<http://www.ncbi.nlm.nih.gov/pubmed/10771700>)

Abstract

The aging kidney is characterized by reduced glomerular filtration rate, loss of tubular volume, and narrowed homeostatic control of water and electrolyte balance. It is unclear whether these physiologic changes represent normal aging or subclinical disease. With aging, there is an increased risk of hyper- or hypovolemia. Sluggish control of potassium concentration also makes hyperkalemia more common, particularly when the patient is using certain drugs. Water metabolism is particularly vulnerable in older patients, resulting in a frequent tendency toward dehydration and hyperosmolality. Understanding these limitations on fluid and electrolyte homeostasis can help the clinician recognize and prevent complications when caring for older patients. PMID: 10771700 [PubMed - indexed for MEDLINE]

Hypertext_77

Kenney WL, Chiu P. *Influence of age on thirst and fluid intake.* Med Sci Sports Exerc. 2001 Sep;33(9):1524-32. (<http://www.ncbi.nlm.nih.gov/pubmed/11528342>)

Abstract

Independently living older adults (over the age of 65 yr) consume adequate volumes of fluids on a daily basis. However, when challenged by fluid deprivation, a hyperosmotic stimulus, or exercise in a warm environment (all of which combine hypovolemia and hyperosmolality), older adults exhibit decreased thirst sensation and reduced fluid intake. Full fluid restoration eventually occurs, but full restoration of fluid balance is slowed. The aging process alters important physiological control systems associated with thirst and satiety. Recent evidence suggests that older men and women (i) have a higher baseline osmolality and thus a higher osmotic operating point for thirst sensation (with little or no change in sensitivity), and (ii) exhibit diminished thirst and satiety in response to the unloading (hypovolemia) and loading (hypervolemia) of baroreceptors. A diminished sensation of thirst in the elderly relative to young adults is generally absent when a volume stimulus is absent, despite higher baseline plasma osmolalities. Compared with the elderly, there are scant data associated with homeostatic control of thirst in children. Nonhomeostatic control of thirst and drinking behavior may likewise be different for children (as it is for the elderly), as compared with young adults; however, little empirical data exist on this topic. Children rarely exhibit voluntary dehydration for activities lasting 45 min or less; however, drink flavoring and sodium chloride are important promoters of drinking in active children. PMID: 11528342 [PubMed - indexed for MEDLINE]

Hypertext_78

Silver AJ. *Aging and risk for dehydration.* Cleve Clin J Med. 1990 Jun;57(4):341-4. (<http://www.ncbi.nlm.nih.gov/pubmed/2194700>)

Abstract

The elderly are at increased risk for dehydration and associated fluid and electrolyte imbalances. Changes in functional and mental status, medication effects, and changes in the aging renal system all may be factors. Furthermore, hypodipsia, or insensibility to thirst, may be a physiologic process of aging. These and other risk factors are presented, along with a guide to the management of dehydration in the elderly. PMID: 2194700 [PubMed - indexed for MEDLINE]

Hypertext_80

Armstrong LE1, Epstein Y. *Fluid-electrolyte balance during labor and exercise: concepts and misconceptions.* Int J Sport Nutr. 1999 Mar;9(1):1-12. (<http://www.ncbi.nlm.nih.gov/pubmed/10036337>)

Abstract

Body water and electrolyte balance are essential to optimal physiological function and health. During exercise, work, or high temperatures, a significant level of dehydration can develop, and the ratio of extracellular to intracellular fluid can change, despite an ample supply of water. Physical and cognitive performance are impaired at 1-2% dehydration, and the body can collapse when water loss approaches 7%. Because fluid needs and intakes vary, formulating one general guideline for fluid replacement is difficult. Knowing the amount of water lost in sweat may enable predicting fluid needs via mathematical models for industrial, athletic, and military scenarios. Sodium imbalance might result from excessive Na⁺ loss or from gross overhydration. In most work or exercise lasting < 3-4 hr, the major concern is that fluid be available to prevent heat-related illnesses, which

can be prevented if fluid and electrolyte losses are balanced with intake, using the recommendations presented. PMID: 10036337 [PubMed - indexed for MEDLINE]

Hypertext_81

Warren JL, Bacon WE, Harris T, McBean AM, Foley DJ, Phillips C. *The burden and outcomes associated with dehydration among US elderly*. 1991. *Am J Public Health* 1994 Aug;84(8):1265-8. (<http://www.ncbi.nlm.nih.gov/pubmed/8059883>)

Abstract

OBJECTIVES:

Dehydration has been underappreciated as a cause of hospitalization and increased hospital-associated mortality in older people. This study used national data to analyze the burden and outcomes following hospitalizations with dehydration in the elderly.

METHODS:

Data from 1991 Medicare files were used to calculate rates of hospitalization with dehydration, to examine demographic characteristics and concomitant diagnoses associated with dehydration, and to analyze the contribution of dehydration to mortality.

RESULTS:

In 1991, 6.7% (731,695) of Medicare hospitalizations had dehydration listed as one of the five reported diagnoses, a rate of 236.2/10,000 elderly Medicare beneficiaries. In 1991, Medicare reimbursed over \$446 million for hospitalizations with dehydration as the principal diagnosis. Older people, men, and Blacks had elevated risks for hospitalization with dehydration. Acute infections, such as pneumonia and urinary tract infections, were frequent concomitant diagnoses. About 50% of elderly Medicare beneficiaries hospitalized with dehydration died within a year of admission.

CONCLUSIONS:

Hospitalization of elderly people with dehydration is a serious and costly medical problem. Attention should be focused on understanding predisposing factors and devising strategies for prevention.

PMID: 8059883 [PubMed - indexed for MEDLINE] PMCID: PMC1615468

Hypertext_82

Weinberg AD, Minaker KL. *Evaluation and management in older adults*. *JAMA*, 1995 Nov;274(19):1552-6. (<http://www.ncbi.nlm.nih.gov/pubmed/7474224>)

Abstract

OBJECTIVE:

To review published literature regarding dehydration in older individuals and formulate a consensus on the evaluation and treatment of this unrecognized cause of hospitalizations, morbidity, and mortality.

DATA SOURCES AND STUDY SELECTION:

The literature concerning dehydration in the elderly population from MEDLINE was reviewed from 1976 through 1995. Search terms included dehydration, elderly, evaluation, hospitalization, and treatment. Particular emphasis was placed on articles describing original research leading to the development of new information on the evaluation and treatment of dehydration and review articles relating to the epidemiology, detection, treatment and health outcomes of this syndrome common in the geriatric population, including frail, institutionalized individuals.

DATA EXTRACTION:

Data contributing to a broad scientific understanding of dehydration were initially grouped according to topic areas of the physiology of normal aging, illness-associated clinical reports of dehydration in the elderly population, and diagnostic and therapeutic interventions. The authors developed a consensus based on the weight of evidence presented and the authors' experience in the field.

CONCLUSIONS:

Early diagnosis is sometimes difficult because the classical physical signs of dehydration may be absent or misleading in an older patient. Many different etiologies place the elderly at particular risk. In patients identified as being at risk for possible dehydration, an interdisciplinary care plan with regard to prevention of clinically significant dehydration is critical if maximum benefit is to result. PMID: 7474224 [PubMed - indexed for MEDLINE]

Hypertext_11

Jéquier E, Constant F. *Water as an essential nutrient: the physiological basis of hydration*. *Eur J Clin Nutr*. [Online] September 2, 2009. Disponible en:<http://www.nature.com/ejcn/journal/vaop/ncurrent/pdf/ejcn2009111a.pdf>. doi:10.1038/ejcn.2009.111

Abstract

How much water we really need depends on water functions and the mechanisms of daily water balance regulation. The aim of this review is to describe the physiology of water balance and consequently to highlight

the new recommendations with regard to water requirements. Water has numerous roles in the human body. It acts as a building material; as a solvent, reaction medium and reactant; as a carrier for nutrients and waste products; in thermoregulation; and as a lubricant and shock absorber. The regulation of water balance is very precise, as a loss of 1% of body water is usually compensated within 24 h. Both water intake and water losses are controlled to reach water balance. Minute changes in plasma osmolarity are the main factors that trigger these homeostatic mechanisms. Healthy adults regulate water balance with precision, but young infants and elderly people are at greater risk of dehydration. Dehydration can affect consciousness and can induce speech incoherence, extremity weakness, hypotonia of ocular globes, orthostatic hypotension and tachycardia. Human water requirements are not based on a minimal intake because it might lead to a water deficit due to numerous factors that modify water needs (climate, physical activity, diet and so on). Water needs are based on experimentally derived intake levels that are expected to meet the nutritional adequacy of a healthy population. The regulation of water balance is essential for the maintenance of health and life. On an average, a sedentary adult should drink 1.5 l of water per day, as water is the only liquid nutrient that is really essential for body hydration

Hypertext_84

Maughan RJ, Shirreffs SM, Watson P. *Exercise, Heat, Hydration and the Brain*. J Am Coll Nutr 2007; 26: 604S-12S. Abstract

The performance of both physical and mental tasks can be adversely affected by heat and by dehydration. There are well-recognized effects of heat and hydration status on the cardiovascular and thermoregulatory systems that can account for the decreased performance and increased sensation of effort that are experienced in the heat. Provision of fluids of appropriate composition in appropriate amounts can prevent dehydration and can greatly reduce the adverse effects of heat stress. There is growing evidence that the effects of high ambient temperature and dehydration on exercise performance may be mediated by effects on the central nervous system. This seems to involve serotonergic and dopaminergic functions. Recent evidence suggests that the integrity of the blood brain barrier may be compromised by combined heat stress and dehydration, and this may play a role in limiting performance in the heat. PMID: 17921473 [PubMed - indexed for MEDLINE]

Hypertext_85

Dennis EA, Flack KD, Davy BM. *Beverage consumption and adult weight management: A review*. Eat Behav 2009; 10: 237-46. Abstract

Total energy consumption among United States adults has increased in recent decades, and energy-containing beverages are a significant contributor to this increase. Because beverages are less satiating than solid foods, consumption of energy-containing beverages may increase energy intake and lead to weight gain; trends in food and beverage consumption coinciding with increases in overweight and obesity support this possibility. The purpose of this review is to present what is known about the effect of beverage consumption on short-term (i.e., meal) energy intake, as well as longer-term effects on body weight. Specific beverages addressed include water, other energy-free beverages (diet soft drinks, coffee and tea), and energy-containing beverages (soft drinks, juices and juice drinks, milk and soy beverages, alcohol). Existing evidence, albeit limited, suggests that encouraging water consumption, and substituting water and other energy-free beverages (diet soft drinks, coffee and tea) for energy-containing beverages may facilitate weight management. Energy-containing beverages acutely increase energy intake, however long-term effects on body weight are uncertain. While there may be health benefits for some beverage categories, additional energy provided by beverages should be compensated for by reduced consumption of other foods in the diet. PMID: 19778754 [PubMed - indexed for MEDLINE] PMID: PMC2864136

Hypertext_86

Boulze D, Montastruc P, Cabanac M. *Water intake, pleasure and water temperature in humans*. Physiol Behav 1983; 30: 97-102. Abstract

The influence of water temperature on intake and affective ratings was explored in human subjects. Dehydration whether by profuse sweating (body weight loss: 289 +/- 11 g, N = 20) or mountain climbing (body weight loss: 1660 +/- 58 g, N = 20) resulted in the same intake. Maximal intake was observed for water at 15 degrees C with respectively 199.0 +/- 17.0 ml and 222.7 +/- 17.4 ml. Colder and warmer water was ingested to a lesser extent. When 20 subjects were allowed to mix water to their preferred temperature, they chose 14.9 +/- 1 degree C and drunk 211.0 +/- 19.5 ml. Votes on a pleasure/displeasure scale increased from 50 degrees C to 0 degree C. Cold water was therefore both more pleasurable and less drunk. Dehydration resulted in a negative alliesthesia for warm water. Positive alliesthesia for cold water was probably the result of hyperthermia rather than dehydration. PMID: 6836049 [PubMed - indexed for MEDLINE]

Hypertext_55

Ishijima T, Hashimoto H, Satou K, Muraoka I, Suzuki K, Higuchi M. *The different effects of fluid with and without carbohydrate ingestion on subjective responses of untrained men during prolonged exercise in a hot environment.* J Nutr Sci Vitaminol (Tokyo). 2009 Dec;55(6):506-10 (<http://www.ncbi.nlm.nih.gov/pubmed/20086321>)

Abstract

This study examined the effects of maintaining euhydration by ingesting fluids with or without carbohydrate on subjective responses of untrained men during prolonged exercise in a hot environment. Six healthy untrained subjects completed 90 min of cycling exercises at 55% maximal oxygen consumption ($V(O_2\text{max})$) in a hot environment (temperature: 28(°)C, humidity: 50%) under three different experimental conditions. During the first trial, subjects did not ingest fluids during exercise (dehydration (DH) trial). In the second and third trials, subjects received mineral water (MW) and hypotonic fluid containing carbohydrate (HF), respectively, in amounts equaling their weight loss in the DH trial. At the end of exercise, the overall rating of perceived exertion (RPE-O) was lower in the MW and HF trials than in the DH trial (14.3+/-1.0 and 13.7+/-0.6 vs 17.7+/-1.0, $p<0.05$, respectively). RPE-cardiovascular and RPE-legs were lower at the end of exercise in the HF trial compared with the DH trial ($V(O_2)$, heart rate (HR), and rectal temperature increased during exercise in the three trials. At the end of exercise, the drift in $V(O_2)$ was lower in the MW and HF trials than in the DH trial (304+/-41 and 339+/-40 vs 458+/-33 mL, $p<0.05$, respectively). HR at the end of exercise in the HF trial was lower than in the DH trial (158+/-5 vs 173+/-7 bpm, $p<0.05$). These results suggest that maintaining euhydration during prolonged exercise in untrained men could attenuate RPE-O and that hypotonic electrolyte-carbohydrate solution could attenuate RPE-legs during exercise. PMID: 20086321 [PubMed - indexed for MEDLINE]

Hypertext_56

Brouns F, Kovacs EM, Senden JM. *The effect of different rehydration drinks on post-exercise electrolyte excretion in trained athletes.* Int J Sports Med. 1998 Jan;19(1):56-60 (http://www.gastronet.it/scientifico/medline/ricerca.html?list_uids=9506802)

Abstract

Eight well-trained cyclists were dehydrated (median [P25-P75 percentiles]) 3.21 [2.97-3.56]% of body mass by cycling in the heat (28 C). During the first 2 h of recovery, the subjects randomly ingested ad libitum either a caffeinated soft drink (CC), a low Na^+ mineral water (MW), or an isotonic carbohydrate-electrolyte solution (CES). Fluid intake and urine loss amounted respectively to 2.77 [2.34-2.85] kg, 1.00 [0.82-1.20] kg for CC, 2.15 [1.86-2.79] kg, 0.96 [0.40-1.49] kg for MW, and 2.86 [2.15-3.58] kg, 1.10 [0.86- 1.50] kg for CES. Electrolyte retention was calculated from electrolyte intake with the drink and loss with the urine. Consumption of CC and MW which were low in electrolytes resulted in marked loss of Na^+ , K^+ , Cl^- , Mg^{2+} and Ca^{2+} . Consumption of CES resulted in Na^+ , Mg^{2+} and Ca^{2+} retention while K^+ and Cl^- loss were not influenced. The significantly lower Na^+ , Mg^{2+} and Ca^{2+} loss with CES compared to both CC and MW may be explained by its higher electrolyte content in CES, compared to CC and MW, which only had minor amounts of these electrolytes. Furthermore, it was shown that CC potentiated urinary Mg^{2+} and Ca^{2+} excretion. It is concluded that: 1) Post-exercise MW or CC ingestion results in a negative electrolyte balance, 2) Caffeine containing beverages potentiate Mg^{2+} and Ca^{2+} excretion; 3) Consumption of CES containing moderate amounts of Na^+ , Mg^{2+} and Ca^{2+} results in sufficient replacement to compensate for urinary losses. PMID: 9506802

Hypertext_95

Armstrong L, Casa D, Millard-Stafford M, American College of Sports Medicine position stand, et al *Exertional heat illness during competition.* Med Sci Sports Exerc. 2007;39:556-72 (<http://www.ncbi.nlm.nih.gov/pubmed/17473783>)

Abstract

Exertional heat illness can affect athletes during high-intensity or long-duration exercise and result in withdrawal from activity or collapse during or soon after activity. These maladies include exercise associated muscle cramping, heat exhaustion, or exertional heatstroke. While certain individuals are more prone to collapse from exhaustion in the heat (i.e., not acclimatized, using certain medications, dehydrated, or recently ill), exertional heatstroke (EHS) can affect seemingly healthy athletes even when the environment is relatively cool. EHS is defined as a rectal temperature greater than 40 degrees C accompanied by symptoms or signs of organ system failure, most frequently central nervous system dysfunction. Early recognition and rapid cooling can reduce both the morbidity and mortality associated with EHS. The clinical changes associated with EHS can be subtle and easy to miss if coaches, medical personnel, and athletes do not maintain a high level of awareness and monitor at-risk athletes closely. Fatigue and exhaustion during exercise occur more rapidly as heat stress increases and are the most common causes of withdrawal from activity in hot conditions. When athletes collapse from exhaustion in hot conditions, the term heat exhaustion is often applied. In some cases, rectal temperature is the only discernable difference between severe heat exhaustion and EHS in on-site evaluations. Heat exhaustion will generally resolve with symptomatic care and oral fluid support. Exercise associated muscle cramping can

occur with exhaustive work in any temperature range, but appears to be more prevalent in hot and humid conditions. Muscle cramping usually responds to rest and replacement of fluid and salt (sodium). Prevention strategies are essential to reducing the incidence of EHS, heat exhaustion, and exercise associated muscle cramping. PMID: 17473783 [PubMed - indexed for MEDLINE]

Hypertext_97

Donoghue AM, Sinclair MJ, Bates GP. *Heat exhaustion in a deep underground metalliferous mine*. Occup Environ Med. 2000;57(3):165-74 (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1739920/>)

Abstract

OBJECTIVES—To examine the incidence, clinical state, personal risk factors, haematology, and biochemistry of heat exhaustion occurring at a deep underground metalliferous mine. To describe the underground thermal conditions associated with the occurrence of heat exhaustion. **METHODS**—A 1 year prospective case series of acute heat exhaustion was undertaken. A history was obtained with a structured questionnaire. Pulse rate, blood pressure, tympanic temperature, and specific gravity of urine were measured before treatment. Venous blood was analysed for haematological and biochemical variables, during the acute presentation and after recovery. Body mass index (BMI) and maximum O₂ consumption (VO₂ max) were measured after recovery. Psychrometric wet bulb temperature, dry bulb temperature, and air velocity were measured at the underground sites where heat exhaustion had occurred. Air cooling power and psychrometric wet bulb globe temperature were derived from these data. **RESULTS**—106 Cases were studied. The incidence of heat exhaustion during the year was 43.0 cases / million man-hours. In February it was 147 cases / million man-hours. The incidence rate ratio for mines operating below 1200 m compared with those operating above 1200 m was 3.17. Mean estimated fluid intake was 0.64 l/h (SD 0.29, range 0.08-1.50). The following data were increased in acute presentation compared with recovery (p value, % of acute cases above the normal clinical range): neutrophils (p<0.001, 36%), anion gap (p<0.001, 63%), urea (p<0.001, 21%), creatinine (p<0.001, 30%), glucose (p<0.001, 15%), serum osmolality (p=0.030, 71%), creatine kinase (p=0.002, 45%), aspartate transaminase (p<0.001, 14%), lactate dehydrogenase (p<0.001, 9.5%), and ferritin (p<0.001, 26%). The following data were depressed in acute presentation compared with recovery (p value, % of acute cases below the normal clinical range): eosinophils (p=0.003, 38%) and bicarbonate (p=0.011, 32%). Urea and creatinine were significantly increased in miners with heat cramps compared with miners without this symptom (p<0.001), but there was no significant difference in sodium concentration (p=0.384). Mean psychrometric wet bulb temperature was 29.0°C (SD 2.2, range 21.0-34.0). Mean dry bulb temperature was 37.4°C (SD 2.4, range 31.0-43.0). Mean air velocity was 0.54 m/s (SD 0.57, range 0.00-4.00). Mean air cooling power was 148 W/m² (SD 49, range 33-290) Mean psychrometric wet bulb globe temperature was 31.5°C (SD 2.0, range 25.2-35.3). Few cases (<5%) occurred at psychrometric wet bulb temperature <25.0°C, dry bulb temperature <33.8°C, air velocity >1.56 m/s, air cooling power >248 W/m², or psychrometric wet bulb globe temperature <28.5°C. **CONCLUSION**—Heat exhaustion in underground miners is associated with dehydration, neutrophil leukocytosis, eosinopenia, metabolic acidosis, increased glucose and ferritin, and a mild rise in creatine kinase, aspartate transaminase, and lactate dehydrogenase. Heat cramps are associated with dehydration but not hyponatraemia. The incidence of heat exhaustion increases during summer and at depth. An increased fluid intake is required. Heat exhaustion would be unlikely to occur if ventilation and refrigeration achieved air cooling power >250 W/m² at all underground work sites. **Keywords:** heat; mining; ventilation

Hypertext_98

Rehrer NJ. *The maintenance of fluid balance during exercise*. Int J Sports Med. 1994 Apr;15(3):122-5. (<http://www.ncbi.nlm.nih.gov/pubmed/8005723>)

Abstract

Fluid supplementation is necessary for exercise in which fluid losses must be offset by intake to avoid the negative effects of hypohydration on health and performance. Several aspects of gastrointestinal function have been studied to gain information concerning the assimilation of ingested fluids to maintain fluid balance during exercise. Research results with regards to gastric emptying and secretion, intestinal absorption and secretion, and aspects of fluid retention, including urine production and plasma volume changes, can be utilised to formulate an appropriate fluid supplementation regimen. Increasing the volume of ingestate and decreasing the carbohydrate concentration promote gastric emptying of fluids. By maintaining a low osmolality secretion is reduced, thus leading to a greater rate of net fluid absorption. Adding sodium and carbohydrate (up to approximately 7%) increases the net intestinal absorption rate. Increasing carbohydrate concentration above this level begins to have a deleterious effect on intestinal absorption of fluid. Sodium also promotes retention of ingested fluids and leads to an increased plasma volume response during rehydration. The primary goal of supplementation should be considered, fluid vs carbohydrate provision, and the beverage composition altered accordingly. Beverage composition to maximise fluid provision will not maximise carbohydrate availability.

PMID: 8005723 [PubMed - indexed for MEDLINE]

Hypertext_99

Chad Kerkisick et al. *International Society of Sports Nutrition Position Stand: nutrient timing*. Journal of the International Society of Sports Nutrition 2008, 5:17 (<http://www.ncbi.nlm.nih.gov/pubmed/18834505>)

Abstract

Position Statement: The position of the Society regarding nutrient timing and the intake of carbohydrates, proteins, and fats in reference to healthy, exercising individuals is summarized by the following eight points: 1.) Maximal endogenous glycogen stores are best promoted by following a high-glycemic, high-carbohydrate (CHO) diet (600 - 1000 grams CHO or ~8 - 10 g CHO/kg/d), and ingestion of free amino acids and protein (PRO) alone or in combination with CHO before resistance exercise can maximally stimulate protein synthesis. 2.) During exercise, CHO should be consumed at a rate of 30 - 60 grams of CHO/hour in a 6 - 8% CHO solution (8 - 16 fluid ounces) every 10 - 15 minutes. Adding PRO to create a CHO:PRO ratio of 3 - 4:1 may increase endurance performance and maximally promotes glycogen re-synthesis during acute and subsequent bouts of endurance exercise. 3.) Ingesting CHO alone or in combination with PRO during resistance exercise increases muscle glycogen, offsets muscle damage, and facilitates greater training adaptations after either acute or prolonged periods of supplementation with resistance training. 4.) Post-exercise (within 30 minutes) consumption of CHO at high dosages (8 - 10 g CHO/kg/day) have been shown to stimulate muscle glycogen re-synthesis, while adding PRO (0.2 g - 0.5 g PRO/kg/day) to CHO at a ratio of 3 - 4:1 (CHO: PRO) may further enhance glycogen re-synthesis. 5.) Post-exercise ingestion (immediately to 3 h post) of amino acids, primarily essential amino acids, has been shown to stimulate robust increases in muscle protein synthesis, while the addition of CHO may stimulate even greater levels of protein synthesis. Additionally, pre-exercise consumption of a CHO + PRO supplement may result in peak levels of protein synthesis. 6.) During consistent, prolonged resistance training, post-exercise consumption of varying doses of CHO + PRO supplements in varying dosages have been shown to stimulate improvements in strength and body composition when compared to control or placebo conditions. 7.) The addition of creatine (Cr) (0.1 g Cr/kg/day) to a CHO + PRO supplement may facilitate even greater adaptations to resistance training. 8.) Nutrient timing incorporates the use of methodical planning and eating of whole foods, nutrients extracted from food, and other sources. The timing of the energy intake and the ratio of certain ingested macronutrients are likely the attributes which allow for enhanced recovery and tissue repair following high-volume exercise, augmented muscle protein synthesis, and improved mood states when compared with unplanned or traditional strategies of nutrient intake. PMID: 18834505 [PubMed] PMCID: PMC2575187

Hypertext_100

Asker Jeukendrup. *Nutrition for endurance sports: marathon, triathlon, and road cycling*. Journal of Sports Sciences, 2011; 1-9 American College of Sports, Medicine Position Stand, Exercise and fluid Replacement, Medicine & Science in Sports & Exercise 2007(<http://www.ncbi.nlm.nih.gov/pubmed/21916794>)

Abstract

Endurance sports are increasing in popularity and athletes at all levels are looking for ways to optimize their performance by training and nutrition. For endurance exercise lasting 30 min or more, the most likely contributors to fatigue are dehydration and carbohydrate depletion, whereas gastrointestinal problems, hyperthermia, and hyponatraemia can reduce endurance exercise performance and are potentially health threatening, especially in longer events (>4 h). Although high muscle glycogen concentrations at the start may be beneficial for endurance exercise, this does not necessarily have to be achieved by the traditional supercompensation protocol. An individualized nutritional strategy can be developed that aims to deliver carbohydrate to the working muscle at a rate that is dependent on the absolute exercise intensity as well as the duration of the event. Endurance athletes should attempt to minimize dehydration and limit body mass losses through sweating to 2-3% of body mass. Gastrointestinal problems occur frequently, especially in long-distance races. Problems seem to be highly individual and perhaps genetically determined but may also be related to the intake of highly concentrated carbohydrate solutions, hyperosmotic drinks, as well as the intake of fibre, fat, and protein. Hyponatraemia has occasionally been reported, especially among slower competitors with very high intakes of water or other low sodium drinks. Here I provide a comprehensive overview of recent research findings and suggest several new guidelines for the endurance athlete on the basis of this. These guidelines are more detailed and allow a more individualized approach. PMID: 21916794 [PubMed - indexed for MEDLINE]

Hypertext_101

Szinnai G et al (2005). *Effect of water deprivation on cognitive-motor performance in healthy men and women*. Am J Physiol Regul Integr Comp Physiol 289(1):R275-80. (<http://www.ncbi.nlm.nih.gov/pubmed/15845879>)

Abstract

Whether mental performance is affected by slowly progressive moderate dehydration induced by water deprivation has not been examined previously. Therefore, objective and subjective cognitive-motor function was

examined in 16 volunteers (8 females, 8 males, mean age: 26 yr) twice, once after 24 h of water deprivation and once during normal water intake (randomized cross-over design; 7-day interval). Water deprivation resulted in a 2.6% decrease in body weight. Neither cognitive-motor function estimated by a paced auditory serial addition task, an adaptive 5-choice reaction time test, a manual tracking test, and a Stroop word-color conflict test nor neurophysiological function assessed by auditory event-related potentials P300 (oddball paradigm) differed ($P > 0.1$) between the water deprivation and the control study. However, subjective ratings of mental performance changed significantly toward increased tiredness (+1.0 points) and reduced alertness (-0.9 points on a 5-point scale; both: $P < 0.05$), and higher levels of perceived effort (+27 mm) and concentration (+28 mm on a 100-mm scale; both: $P < 0.05$) necessary for test accomplishment during dehydration. Several reaction time-based responses revealed significant interactions between gender and dehydration, with prolonged reaction time in women but shortened in men after water deprivation (Stroop word-color conflict test, reaction time in women: +26 ms, in men: -36 ms, $P < 0.01$; paced auditory serial addition task, reaction time in women +58 ms, in men -31 ms, $P = 0.05$). In conclusion, cognitive-motor function is preserved during water deprivation in young humans up to a moderate dehydration level of 2.6% of body weight. Sexual dimorphism for reaction time-based performance is present. Increased subjective task-related effort suggests that healthy volunteers exhibit cognitive compensating mechanisms for increased tiredness and reduced alertness during slowly progressive moderate dehydration. PMID: 15845879 [PubMed - indexed for MEDLINE]

Hypertext_103

Benton D (2011). *Dehydration influences mood and cognition: a plausible hypothesis?* *Nutrients* 3:555-573 (<http://www.ncbi.nlm.nih.gov/pubmed/22254111>)

Abstract

The hypothesis was considered that a low fluid intake disrupts cognition and mood. Most research has been carried out on young fit adults, who typically have exercised, often in heat. The results of these studies are inconsistent, preventing any conclusion. Even if the findings had been consistent, confounding variables such as fatigue and increased temperature make it unwise to extrapolate these findings. Thus in young adults there is little evidence that under normal living conditions dehydration disrupts cognition, although this may simply reflect a lack of relevant evidence. There remains the possibility that particular populations are at high risk of dehydration. It is known that renal function declines in many older individuals and thirst mechanisms become less effective. Although there are a few reports that more dehydrated older adults perform cognitive tasks less well, the body of information is limited and there have been little attempt to improve functioning by increasing hydration status. Although children are another potentially vulnerable group that have also been subject to little study, they are the group that has produced the only consistent findings in this area. Four intervention studies have found improved performance in children aged 7 to 9 years. In these studies children, eating and drinking as normal, have been tested on occasions when they have and not have consumed a drink. After a drink both memory and attention have been found to be improved.

KEYWORDS:

children; cognition; dehydration; elderly; hydration; mood. PMID: 22254111 [PubMed - indexed for MEDLINE] PMCID: PMC3257694

Hypertext_104

Carter R 3rd, Chevront SN, Vernieuw CR, Sawka MN (2006). *Hypohydration and prior heat stress exacerbates decreases in cerebral blood flow velocity during standing.* *J Appl Physiol* 101(6):1744-1750 (<http://www.ncbi.nlm.nih.gov/pubmed/16916922>)

Abstract

Hypohydration is associated with orthostatic intolerance; however, little is known about cerebrovascular mechanisms responsible. This study examined whether hypohydration reduces cerebral blood flow velocity (CBFV) in response to an orthostatic challenge. Eight subjects completed four orthostatic challenges (temperate conditions) twice before (Pre-EU and Pre-Hyp) and following recovery from passive heat stress (approximately 3 h at 45 degrees C, 50% relative humidity, 1 m/s air speed) with (Post-EU) or without (Post-Hyp) fluid replacement of sweat losses (-3% body mass loss). Measurements included CBFV, mean arterial pressure (MAP), heart rate (HR), end-tidal CO₂, and core and skin temperatures. Test sessions included being seated (20 min) followed by standing (60 s) then resitting (60 s) with metronomic breathing (15 breaths/min). CBFV and MAP responses to standing were similar during Pre-EU and Pre-Hyp. Standing Post-Hyp exacerbated the magnitude (-28.0 +/- 1.4% of baseline) and duration (9.0 +/- 1.6 s) of CBFV reductions and increased cerebrovascular resistance (CVR) compared with Post-EU (-20.0 +/- 2.1% and 6.6 +/- 0.9 s). Standing Post-EU also resulted in a reduction in CBFV, and a smaller decrease in CVR compared with Pre-EU. MAP decreases were similar for Post-EU (-18 +/- 4 mmHg) and Post-Hyp (-21 +/- 5 mmHg) from seated to standing. These data demonstrate that despite similar MAP decreases, hypohydration, and prior heat stress (despite apparent recovery) produce greater CBFV reduction when standing. These observations suggest that hypohydration and prior heat stress are associated

with greater reductions in CBFV with greater CVR, which likely contribute to orthostatic intolerance. PMID: 16916922 [PubMed - indexed for MEDLINE]

Hypertext_105

Ana Adan, *Cognitive Performance and Dehydration* Journal of the American College of Nutrition, Vol. 31, No. 2, 71–78 (2012) (http://scholar.google.it/scholar_url?url=http://www.researchgate.net/profile/Ana_Adan/publication/230600141_Cognitive_performance_and_dehydration/links/02e7e51e10db0c0a21000000.pdf&hl=it&sa=X&scisig=AAGBfm3x8beBZFmNN_NfbXMldlrwO4GUA&nossl=1&oi=scholarrr&oi=MNIIVcvXF8HYU-fQgPAG&ved=0CB8QgAMoADAA)

No matter how mild, dehydration is not a desirable condition because there is an imbalance in the homeostatic function of the internal environment. This can adversely affect cognitive performance, not only in groups more vulnerable to dehydration, such as children and the elderly, but also in young adults. However, few studies have examined the impact of mild or moderate dehydration on cognitive performance. This paper reviews the principal findings from studies published to date examining cognitive skills. Being dehydrated by just 2% impairs performance in tasks that require attention, psychomotor, and immediate memory skills, as well as assessment of the subjective state. In contrast, the performance of long-term and working memory tasks and executive functions is more preserved, especially if the cause of dehydration is moderate physical exercise. The lack of consistency in the evidence published to date is largely due to the different methodology applied, and an attempt should be made to standardize methods for future studies. These differences relate to the assessment of cognitive performance, the method used to cause dehydration, and the characteristics of the participants.

Hypertext_106

Shimizu T¹, Kosaka M, Fujishima K. *Human thermoregulatory responses during prolonged walking in water at 25, 30 and 35 degrees C*. Eur J Appl Physiol Occup Physiol. 1998 Nov;78(6):473-8. (<http://www.ncbi.nlm.nih.gov/pubmed/9840400>)

Abstract

Eight healthy and physically well-trained male students exercised on a treadmill for 60 min while being immersed in water to the middle of the chest in a laboratory flowmill. The water velocity was adjusted so that the intensity of exercise correspond to 50% maximal oxygen uptake of each subject, and experiments were performed once at each of three water temperatures: 25, 30, 35 degrees C, following a 30-min control period in air at 25 degrees C, and on a treadmill in air at an ambient temperature of 25 degrees C. Thermal states during rest and exercise were determined by measuring rectal and skin temperatures at various points, and mean skin temperatures were calculated. The intensity of exercise was monitored by measuring oxygen consumption, and heart rate was monitored as an indicator for cardiovascular function. At each water temperature, identical oxygen consumption levels were attained during exercise, indicating that no extra heat was produced by shivering at the lowest water temperature. The slight rise in rectal temperature during exercise was not influenced by the water temperature. The temperatures of skin exposed to air rose slightly during exercise at 25 degrees C and 30 degrees C water temperature and markedly at 35 degrees C. The loss of body mass increased with water temperature indicating that both skin blood flow and sweating during exercise increased with the rise in water temperature. The rise in body temperature provided the thermoregulatory drive for the loss of the heat generated during exercise. Heart rate increased most during exercise in water at 35 degrees C, most likely due to enhanced requirements for skin blood flow. Although such requirements were certainly smallest at 25 degrees C water temperature, heart rate at this temperature was slightly higher than at 30 degrees C suggesting reflex activation of sympathetic control by cold signals from the skin. There was a significantly greater increase in mean skin and rectal temperatures in subjects exercising on the treadmill in air, compared to those exercising in water at 25 degrees C. PMID: 9840400 [PubMed - indexed for MEDLINE]

Hypertext_107

Armstrong LE, Ganio MS, Casa DJ et al (2012) *Mild dehydration affects mood in healthy young women*. J Nutr 142:382–388 (<http://www.ncbi.nlm.nih.gov/pubmed/22190027>)

Abstract

Limited information is available regarding the effects of mild dehydration on cognitive function. Therefore, mild dehydration was produced by intermittent moderate exercise without hyperthermia and its effects on cognitive function of women were investigated. Twenty-five females (age 23.0 ± 0.6 y) participated in three 8-h, placebo-controlled experiments involving a different hydration state each day: exercise-induced dehydration with no diuretic (DN), exercise-induced dehydration plus diuretic (DD; furosemide, 40 mg), and euhydration (EU). Cognitive performance, mood, and symptoms of dehydration were assessed during each experiment, 3 times at rest and during each of 3 exercise sessions. The DN and DD trials in which a volunteer attained a ≥1% level of dehydration were pooled and compared to that volunteer's equivalent EU trials. Mean dehydration achieved during these DN and DD trials was -1.36 ± 0.16% of body mass. Significant adverse effects of dehydration were

present at rest and during exercise for vigor-activity, fatigue-inertia, and total mood disturbance scores of the Profile of Mood States and for task difficulty, concentration, and headache as assessed by questionnaire. Most aspects of cognitive performance were not affected by dehydration. Serum osmolality, a marker of hydration, was greater in the mean of the dehydrated trials in which a $\geq 1\%$ level of dehydration was achieved ($P = 0.006$) compared to EU. In conclusion, degraded mood, increased perception of task difficulty, lower concentration, and headache symptoms resulted from 1.36% dehydration in females. Increased emphasis on optimal hydration is warranted, especially during and after moderate exercise. PMID: 22190027 [PubMed - indexed for MEDLINE]

Hypertext_108

Petri NM, Dropulic N, Kardum G: *Effects of voluntary fluid intake deprivation on mental and psychomotor performance*. Croat Med J 47:855–861, 2006 (<http://www.ncbi.nlm.nih.gov/pubmed/17167858>)

Abstract

AIM:

To assess if there is deterioration in mental and psychomotor performance during 24-hour voluntary fluid intake deprivation.

METHODS:

A battery of computer generated psychological tests (Complex Reactionmeter Drenovac-series) was applied to 10 subjects to test light signal position discrimination, short-term memory, simple visual orientation, simple arithmetics, and complex motor coordination. We measured total test solving time, minimum (best) single task solving time, total ballast time, and total number of errors. Mood self-estimate scales of depression, working energy, anxiety, and self-confidence were used to determine the emotional status of subjects. During the first day of the experiment, subjects had free access to drinks. After a 48-hour interval, subjects voluntarily abstained from fluid intake for 24 hours. During that period, the testing was performed 7 times a day, at 3-hour intervals, except during the night. Z-transformation of the results enabled the comparison of 50 dependent measurements on the same subjects.

RESULTS:

During dehydration, there was significant deterioration in total test solving time, minimum single task solving time, and total ballast time. No significant deterioration was found by mood self-estimate scales, except on the scale of energy at 23:00 hours.

CONCLUSION:

Voluntary 24-hour fluid intake deprivation led to deterioration in objective parameters of psychological processing, but not in subjective parameters. The results suggest that the duration of fluid intake deprivation can be a useful indicator of mental and psychomotor deterioration level but not of mood self-estimates. PMID: 17167858 [PubMed - indexed for MEDLINE] PMCID: PMC2080479

Hypertext_109

Patel AV, Mihalik JP, Notebaert AJ, Guskiewicz KM, Prentice WE: *Neuropsychological performance, postural stability, and symptoms after dehydration*. J Athl Train 42:66–75, 2007 (<http://www.ncbi.nlm.nih.gov/pubmed/17597946>)

Abstract

CONTEXT:

Dehydration and concussion are common in athletic performance. Some experts have speculated that dehydration may negatively influence performance on tests commonly used for concussion assessment.

OBJECTIVE:

To determine how the signs and symptoms, neuropsychological performance, and postural stability are affected by dehydration.

DESIGN:

Repeated-measures design assessing subjects in the euhydrated and dehydrated conditions.

SETTING:

Sports Medicine Research Laboratory.

PATIENTS OR OTHER PARTICIPANTS:

Twenty-four healthy, male recreational athletes participated in the study.

INTERVENTION(S):

Subjects participated in 2 counterbalanced sessions (euhydrated and dehydrated) separated by at least 7 days. Subjects were dehydrated using fluid restriction and an exercise task. No direct intervention was provided for the euhydrated condition.

MAIN OUTCOME MEASURE(S):

We used the Standardized Assessment of Concussion to test mental status, the Automated Neuropsychological Assessment Metrics (ANAM) to evaluate neuropsychological performance, the NeuroCom Sensory Organization Test and Balance Error Scoring System to test postural stability, the Graded Symptom Checklist to assess

symptom presence and severity in our participants, and urine specific gravity and body mass to determine hydration status.

RESULTS:

No differences were noted for the Standardized Assessment of Concussion, total Balance Error Scoring System errors, composite Sensory Organization Test, and composite ANAM scores between conditions. Subjects in the dehydrated condition had significant deterioration in visual memory ($t(23) = 2.130, P < .001$) and fatigue measures ($t(23) = -7.880, P < .001$) as assessed by ANAM. The dehydrated condition resulted in subjects reporting a significantly higher number ($t(23) = -8.585, P < .001$) and severity ($t(23) = -7.673, P < .001$) of symptoms than the euhydrated subjects on the Graded Symptom Checklist.

CONCLUSIONS:

Our results suggest that moderate dehydration ($-2.5 \pm 0.63\%$) significantly influenced the self-report of symptoms commonly associated with concussion. Dehydration resulted in a deterioration of visual memory and increases in the self-report of fatigue. Despite these findings, dehydration did not affect other neuropsychological and postural stability objective testing measures for concussion. PMID: 17597946 [PubMed - indexed for MEDLINE] PMID: PMC1896077

Hypertext_110

Gopinathan PM, Pichan G, Sharma VM (1988). Role of dehydration in heat stress-induced variations in mental performance. *Arch. Environ. Health* 43, 15–17. <http://www.ncbi.nlm.nih.gov/pubmed/3355239>

Abstract

Variation in mental performance under different levels of heat stress-induced dehydration was recorded in 11 subjects heat acclimatized to the tropics. Dehydration was induced by a combination of water restriction and exercise in heat. The psychological functions--arithmetic ability, short-term memory, and visuomotor tracking--were assessed in a thermoneutral room after the subjects recovered fully from the effects of exercise in heat, as reflected by their oral temperature and heart rate. The results indicated significant deterioration in mental functions at 2% or more body dehydration levels. PMID: 3355239 [PubMed - indexed for MEDLINE]

Hypertext_111

Wilson M, Morley E. Impaired cognitive function and mental performance in mild dehydration. *European Journal of Clinical Nutrition* (2003) 57, Suppl 2, S24–S29. doi:10.1038/sj.ejcn.1601898. <http://www.nature.com/ejcn/journal/v57/n2s/full/1601898a.html>

Abstract

Dehydration is a reliable predictor of impaired cognitive status. Objective data, using tests of cortical function, support the deterioration of mental performance in mildly dehydrated younger adults. Dehydration frequently results in delirium as a manifestation of cognitive dysfunction. Although, the occurrence of delirium suggests transient acute global cerebral dysfunction, cognitive impairment may not be completely reversible. Animal studies have identified neuronal mitochondrial damage and glutamate hypertransmission in dehydrated rats. Additional studies have identified an increase in cerebral nicotinamide adenine dinucleotide phosphate-diaphorase activity (nitric oxide synthase, NOS) with dehydration. Available evidence also implicates NOS as a neurotransmitter in long-term potentiation, rendering this a critical enzyme in facilitating learning and memory. With ageing, a reduction of NOS activity has been identified in the cortex and striatum of rats. The reduction of NOS synthase activity that occurs with ageing may blunt the rise that occurs with dehydration, and possibly interfere with memory processing and cognitive function. Dehydration has been shown to be a reliable predictor of increasing frailty, deteriorating mental performance and poor quality of life. Intervention models directed toward improving outcomes in dehydration must incorporate strategies to enhance prompt recognition of cognitive dysfunction.

Hypertext_112

Cian C, Barraud PA, Melin B, Raphel C. Effects of fluid ingestion on cognitive function after heat stress or exercise-induced dehydration. *Int J Psychophysiol.* 2001 Nov;42(3):243-51. <http://www.ncbi.nlm.nih.gov/pubmed/11812391>

Abstract

This study investigated the effects of heat exposure, exercise-induced dehydration and fluid ingestion on cognitive performance. Seven healthy men, unacclimatized to heat, were kept euhydrated or were dehydrated by controlled passive exposure to heat (H, two sessions) or by treadmill exercise (E, two sessions) up to a weight loss of 2.8%. On completion of a 1-h recovery period, the subjects drank a solution containing 50 g l(-1) glucose and 1.34 g l(-1) NaCl in a volume of water corresponding to 100% of his body weight loss induced by dehydration. (H1 and E1) or levels of fluid deficit were maintained (H0, E0). In the E0, H0 and control conditions, the subject drank a solution containing the same quantity of glucose diluted in 100 ml of water. Psychological tests were administered 30 min after the dehydration phase and 2 h after fluid ingestion. Both

dehydration conditions impaired cognitive abilities (i.e. perceptive discrimination, short-term memory), as well as subjective estimates of fatigue, without any relevant differences between the methods. By 3.5 h after fluid deficit, dehydration (H0 and E0) no longer had any adverse effect, although the subjects felt increasingly tired. Thus, there was no beneficial effect of fluid ingestion (H1 and E1) on the cognitive variables. However, long-term memory retrieval was impaired in both control and dehydration situations, whereas there was no decrement in performance in the fluid ingestion condition (H1, E1). PMID: 11812391 [PubMed - indexed for MEDLINE]

Hypertext_113

Grandjean A, Grandjean N. Dehydration and Cognitive Performance. *Journal of the American College of Nutrition*, Volume 26, Supplement 5, 2007. <http://www.ncbi.nlm.nih.gov/pubmed/17921464>

Abstract

Human neuropsychology investigates brain-behavior relationships, using objective tools (neurological tests) to tie the biological and behavior aspects together. The use of neuropsychological assessment tools in assessing potential effects of dehydration is a natural progression of the scientific pursuit to understand the physical and mental ramifications of dehydration. It has long been known that dehydration negatively affects physical performance. Examining the effects of hydration status on cognitive function is a relatively new area of research, resulting in part from our increased understanding of hydration's impact on physical performance and advances in the discipline of cognitive neuropsychology. The available research in this area, albeit sparse, indicates that decrements in physical, visuomotor, psychomotor, and cognitive performance can occur when 2% or more of body weight is lost due to water restriction, heat, and/or physical exertion. Additional research is needed, especially studies designed to reduce, if not remove, the limitations of studies conducted to date. PMID: 17921464 [PubMed - indexed for MEDLINE]

Hypertext_58

Kenefick RW, Sawka MN. *Hydration at the work site*. *J Am Coll Nutr*. 2007 Oct;26(5 Suppl):597S-603S. Review. *J Am Coll Nutr*. 2007 Oct;26(5 Suppl):597S-603S. [Hydration at the work site](#).

Abstract

When performing physical work, sweat output often exceeds water intake, producing a body water deficit or dehydration. Specific to the work place, dehydration can adversely affect worker productivity, safety, and morale. Legislative bodies in North America such as the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend replacing fluids frequently when exposed to heat stress, such as one cup (250 ml) every 20 minutes when working in warm environments. However, the majority of legislative guidelines provide vague guidance and none take into account the effects of work intensity, specific environments, or protective clothing. Improved occupational guidelines for fluid and electrolyte replacement during hot weather occupational activities should be developed to include recommendations for fluid consumption before, during, and after work. PMID: 17921472 [PubMed - indexed for MEDLINE].

09

References

- Ajzen I (2000), *Nature and operation of attitudes*, Annual Review of Psychology 52, pp. 27–58
- Beck U., 1986 *Risikogesellschaft*, Frankfurt am Main, Suhrkamp Verlag; trad. it. La società del rischio, Carocci, Roma 2000
- Bere E and Klepp KI (2005), *Changes in accessibility and preferences predict childrens future fruit and vegetable intake*, International Journal of Behavioral Nutrition and Physical Activity 2, pp.1-5
- Bianchi M., *Paracelso contro i falsi medici. Sette autodifese*, Laterza, Roma Bari 1995
- Borgna P., *Immagini pubbliche della scienza. Gli italiani e la ricerca scientifica e tecnologica*, Edizioni di Bott V., Médecine anthroposophique. *Un élargissement de l'art de guérir*, Triades, Paris 1972
- Cosmacini G., *Il mestiere del medico*, Cortina, Milano 2000
- Coulter A., *Evidence based patient information*, in «British Medical Journal», 1998, 317, pp. 225-6
- Cox D and Ajetunmbi O (2007), *Whit fettle?*, The Dumfries & Galloway Wellbeing and Lifestyle Survey
- De Martino E., *Morte e pianto rituale, dal lamento funebre antico al pianto di Maria*, Boringhieri, Torino 1958
- Dean M, Grunert KG, Raats MM, Nielsen NA and Lumbers M (in press), *The impact of personal resources and their goal relevance on satisfaction with food related life among the elderly Appetite*, Department of Health (2004)
- At Least Five A Week: Evidence On The Impact Of Physical Activity And Its Relationship To Health* (London: Department of Health)
- Domel-Baxter S & Thompson WO (2002), *Fourth-grade childrens consumption of fruit and vegetable items available as part of school lunches is closely related to preferences*, Journal of Nutrition Education and Behavior 34, pp.166-171
- Domenighetti G., *Il conflitto originale: attese versus realtà*, in «L'Arco di Giano», 2000, 23, pp. 31-40
- Dumont L., *Essais sur l'individualisme*, Seuil, Paris 1983, trad. it. *Saggi sull'individualismo*, Adelphi, Milano 1993
- Dunn AL, Trivedi MH, Kampert JB, Clark CG, and Chambliss HO (2005), *Exercise treatment for depression: efficacy and dose response*, American Journal of Preventive Medicine, 28, pp. 1-8
- Eastwood H., *Why are Australian GPs Using Alternative Medicine? Postmodernisation, Consumerism and the Shift towards Holistic Health*, in «Journal of Sociology», 2000, 36, pp. 133- 156
- Ernst E., *What's the Point of Rigorous Research on Complementary/Alternative Medicine?*, in «The Royal Society of Medicine», 2002, 95, pp. 211-213
- Evans M. - Rodgar I., *Medicina antroposofica. La cura del corpo, dell'anima e dello spirito secondo gli insegnamenti di Rudolf Steiner*, RED, Como 1995
- Faulkner G. and Taylor AH (2005), *Exercise, Health and Mental Health: Emerging Relationships*, (London, UK: Routledge)
- Ferrie JE, Shipley MJ, Marmot MG, et al *An uncertain future: the health effects of threats to employment security in white-collar men and women*, in «American Journal Public Health», 1998, 88, pp. 1030-6
- Filoramo F., *Il risveglio della gnosi, ovvero diventare Dio*, Laterza, Roma-Bari 1990
- Findlay R (2003), *Interventions to reduce social isolation amongst older people: where is the evidence?*, Aging and Society 23, pp. 647-658
- Giddens A., *The Consequences of Modernity*, Polity Press, Cambridge 1990; trad. it. *Le conseguenze della modernità*, Il Mulino, Bologna 1994
- Gilman S.L., *Disease and Representation. Images of Illness from Madness to AIDS*, Ithaca- Corneil University Press, London 1988; trad. it. *Immagini della malattia. Dalla follia all'AIDS*, Il Mulino, Bologna 1993
- Goffman E., *The Presentation of Self in Everyday Life*, Doubleday, New York 1959; trad. it. *La vita quotidiana come rappresentazione*, Il Mulino, Bologna 1969
- Gualtierotti Roberto; *Elementi di Idrologia Medica*; Libreria dello Studente 1974
- Heird, WC. *Nutritional Requirements*. Klieg-man RM, Jenson Behrman RE. Nelson Textbook of Pediatrics. Philadelphia: Saunders; 2004.
- Henry JD and Crawford JR (2005), *The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample*, British Journal of Clinical Psychology 44, pp. 227-239
- Iliffe S, Kharicha K, Harari D, Swift C, Gillmann G and Stuck AE (2007), *Health risk appraisal in older people*, 2 British Journal of General Practice, April 2007
- Keyes C (1998), *Social well-being*, Social psychology quarterly, pp. 121-140
- Keyes C (2004), *The nexus of cardiovascular disease and depression revisited: the complete mental health perspective and the moderating role of age and gender*, Aging and Mental Health 8, pp. 266-274
- Keyes C (2005), *Mental Illness and/or Mental Health? Investigating Axioms of the Complete State Model of Health*, Journal of Consulting and Clinical Psychology 73, pp. 539-548
- King F.X., *Rudolf Steiner and holistic medicine*, Nicolas-Hays, York Beach, MA 1987
- Klein R. - Day P. - Redmayne S., *Managing scarcity*, Open University Press, Buckingham 1996
- Kruger H., *Other healers, other cures. A guide to alternative medicine*, Bobbs-Merrill, New York 1974
- Kunst A.E., et al, *Occupational class and cause specific mortality in middle aged men in 11 European countries, comparison of population based studies*, in «British Medical Journal», 1998, 316, pp. 1636-42

- Larson NI, Neumark-Sztainer D, Hannan P and Story M (2007), *Family Meals during Adolescence Are Associated with Higher Diet Quality and Healthful Meal Patterns during Young Adulthood*, Journal of the American Dietetic Association 107, pp. 1502-1510
- Laurin D, Verreault R and Lindsay J (2005), *Physical activity and dementia*, In G Faulkner & AH Taylor (eds) *Exercise, Health and Mental Health: Emerging Relationships* pp. 11-26 (London, UK: Routledge)
- Lázero P. - Fitch K., *From universalism to selectivity: is "appropriateness" the answer?* in «Health Policy», 1996, 36, pp. 261-72
- Markenbach J.P., et al, *Socio-economic inequalities in morbidity and mortality in western Europe*, in «Lancet», 1997, 349, pp. 1655-9
- Marmot M.G., et al, *Contribution of job control and other risk factors to social variations in coronary heart disease incidence*, in «Lancet», 1997, 350, pp. 235-9
- Marmot M.G., *Improvement of social environment to improve health*, in «Lancet», 1988, 351, pp. 57-60
- Mc Kie R.M. - Hole D.J., *Incidence and thickness of primary tumours and survival of patients with cutaneous malignant melanoma in relation to socio-economic status*, in «British Medical Journal», 1996, 312, pp. 1125-8
- McKeown T., *The role of medicine: dream, mirage, or nemesis?*, Nuffield Provincial Hospitals Trust, London 1976
- Miller K., *The Evolution of Professional Identity: The Case of Osteopathic Medicine*, in «Social Science & Medicine», 1998, 47, pp. 1739-1748
- Minder E.C., *Socio-economic factors and mortality in Switzerland*, in «Soz Präventivmed», 1993, 38, pp. 313-28
- Mutrie N (2000), *The relationship between physical activity and clinically defined depression*, In SJH Biddle, KR Fox, & SH Boutcher (eds) *Physical Activity and Psychological Well-being* pp. 46-62 (London, UK: Routledge)
- Oltersdorf U, Schlettein-Gsell D & Winkler G (1999), *Assessing Eating Patterns – an Emerging Research Topic in Nutritional Sciences: Introduction to the Symposium*, Appetite 32, pp. 1-7
- Petraccia L., Mennuni G., Fontana Mr., Fraioli A., *Cheltenham Waters, Inauguration of the Central Spa Clin Ter.*, 2005 Sep-Oct; 156 (5): 231-3)
- Ratner P.A., et al *Setting the Stage for Health Impact Assessment*, in «Journal Public Health Policy», 1997, 18, pp. 67-79
- Saks M., *Professions and the Public Interest. Medical Power, Altruism and Alternative Medicine*, Routledge, London 1993
- Serrentino J., *How natural remedies work*, Harley & Marks, B.C. 1991
- Shilling C., *The Body and Social Theory*, Sage, London 1993
- Siahpush M., *A Critical Review of the Sociology of Alternative Medicine: Research on Users, Practitioners and the Orthodoxy*, in «Health», 1999, 4, pp. 159-178
- Tinetti Falls Efficacy Scale. Tinetti M, Richman D and Powell L (1990), *Falls efficacy as a measure of fear of falling*, Journal of Gerontology 45, pp. 239-
- Vahtera J. - Kivimaki M. - Pentti J., *Effect or organizational downsizing on health of employees*, in «Lancet», 1997, 350, pp. 1124-8
- Waliczek TM, Zajicek JM and Lineberger RD (2005), *The influence of gardening activities on perceptions of life satisfaction*, Horticultural Science. 40, pp. 1360-1365
- Warwick Edinburgh Mental Well-Being Scale (WEMWBS). See Tennant R, Fishwick R, Platt S, Joseph S and Stewart-Brown S (2006), *Monitoring positive mental health in Scotland: validating the Affectometer 2 scale and developing the Warwick-Edinburgh Mental Well-being Scale for the UK*, (Edinburgh: NHS Health Scotland). See also www.healthscotland.com/documents/1467.aspx
- Wolf A.M., *Impact of informed consent on patient interest in prostate-specific antigen screening*, Arch Intern Med 1996, 156, pp. 1333-6

10 On-line resources

Crudeli Aurelio; *Il settore termale nella riorganizzazione dell'assistenza primaria a 10 anni dalla legge 323; La salute come bene comune nel Welfare delle opportunità* a cura di Gianfranca Ranisio Valentina Mazzacane con saggio introduttivo di Crescenzo Simone Atti del V congresso nazionale della cooperazione di medicina generale Fiuggi 2010; (<http://www.aicanet.it/aica/ecdl-health/2b0%20VOLUME%20ANCoM.pdf>)

Ganong WF (2005). *Review of Medical Physiology*, 23rd edn, LANGE Science: New York. <https://emergencypedia.files.wordpress.com/2013/04/ganong-pdf.pdf>

Grandjean AC, Campbell SM (2004). *Hydration: Fluids for Life*. A monograph by the North American Branch of the International Life. Science Institute. ILSI North America: Washington DC (<http://www.ils.org/NorthAmerica/Publications/HYD%20-%20Hydration%20-%20Fluids%20for%20Life.pdf>)

Konturek SJ., Brzozowski T., Konturek PC., Schubert ML., Pawlik WW., Padol S., Bayner J., *Control of Gastric Secretion** J Physiol Pharmacol 2008 Aug; 59 Suppl 2: 7-31 (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2092355/>)

Markt W., Wien Klin Wochenschr. 2009; 121 (17-18): 544-50 (<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2526733/>)

Nadel ER, Wenger CB, Roberts MF, et al *Physiological defenses against hyperthermia of exercise*. AnnNYAcad Sci. 1977;301:98-109. (<http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1977.tb38190.x/abstract;jsessionid=39984036FDEC8A3DA3A3A51DEEC56F0A.f01t02>)

S.De Luca, G.Nappi, A.Merconi Orsini. *Progetto Naiade*; Med. Clin. Term. 47:197-206,2001 (http://www.worksafebc.com/health_care_providers/Assets/PDF/hydrotherapy_application_physiotherapy.pdf)

World Health Organization (WHO). *Guidelines for drinking-water quality*. 3rd ed. Geneva: WHO, 2008 (http://www.who.int/water_sanitation_health/dwq/fulltext.pdf)

In the light of the foregoing evidence we call upon all Countries to include adequate hydration as part of a healthy diet among the key priorities for health protection. And to make this an ongoing and long-lasting commitment we invite the leading international organizations, the United Nations and the World Health Organization, to soon adopt a World Hydration Day, to raise awareness of the importance for all people to take and keep the habit of drinking water which is key to ensure the health of future generations.