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**I International
and III National
Hydration
Congress**

RENC

Palacio Municipal de Congresos de Madrid
December 3-4, 2013



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Nutrición Comunitaria

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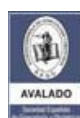
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Editorial

This special issue of the Spanish Journal of Community Nutrition (RENC) starts a new publishing stage under Aula Medical and is entirely focused on spreading the knowledge of the best ten oral and poster communications presented at the First International and Third National Congress of Hydration held on December 3rd & 4th 2013 at the Palacio Municipal de Congresos in Madrid, Spain.

In recent times the importance of obtaining and maintaining an adequate hydration status as a premise for health and physical and cognitive performance has been recognized by both the scientific community and the general public and health professionals, both on nutrition and physical activity and sport sciences. We have added the hydration variable, as an essential key for maintaining and promoting health, to nutrition, physical activity and emotional balance.

The above mentioned Congress gathered some of the most prestigious experts in our country together with international specialists in all subjects related to the importance of hydration and its latest scientific development.

More than a thousand attendees enjoyed interesting scientific sessions, and more than 90 oral and poster communications, previously reviewed and selected by a Scientific Committee with the following members: Ángel Gil, Andreu Palou, Arturo Anadón, Ascensión Marcos, Carmen Gómez-Candela, Carmen Pérez-Rodrigo, Claudio Maffei, Dr. Daniel Ramón, Emilio Martínez de Victoria, Gregorio Varela-Moreiras, Hans Braun, Isabel Polanco, Javier Aranceta, Lluís Serra-Majem, Manuel Díaz-Rubio, Marcela González-Gross, María Kapsokefalou, Nieves Palacios, Pilar Riobó, Ryszard Gellert, Ronald J. Maughan, and Rosa M^a Ortega, under the perfect coordination of Rafael Urrialde. Among those, the 10 communications with a highest score were selected to be included in this special issue. Poster presentation evaluation and the session on oral communication was chaired by Carmen Pérez-Rodrigo and Elena Alonso-Aperte.

The papers included in the present supplement are the best top ten rated communications. In addition, some conclusions of the Congress and a summary of the different sessions are presented.

The selected papers are:

1. URINARY OSMOLALITY OF PRESCHOOL CHILDREN WITH A LARGELY COMMON WEEKDAY MEAL OFFERING, FROM THE WESTERN HIGHLANDS OF GUATEMALA. *María José Soto-Méndez.*
2. ADEQUATE HYDRATION STATUS PROMOTES A LOWER CONCENTRATION OF PROINFLAMMATORY CYTOKINES IN HEALTHY ADULTS. *Bricia López Plaza.*
3. SUGAR-SWEETENED SOFT DRINK FREQUENCY AND ASSOCIATED FACTORS IN SPANISH SCHOOL-CHILDREN: STUDY. *Ana María López-Sobaler.*
4. CHARACTERIZATION OF BIOIMPEDANCE MEASURES IN OVERWEIGHT AND OBESE HEMODIALYZED PATIENTS. *Mar Ruperto.*
5. WATER INTAKE ADEQUACY AND DIETARY SOURCES IN SCHOOLCHILDREN FROM MADRID BY PHYSICAL ACTIVITY LEVEL. *Liliana Guadalupe González Rodríguez.*
6. HYDRATION PROTOCOL OF THE UNIVERSITY HOSPITAL LA PAZ: AN INITIATIVE TO PREVENT AND TREAT DEHYDRATION AND HYPERHYDRATION IN HOSPITALIZED PATIENTS. *Carmen Gómez-Candela.*
7. TOTAL BODY WATER AS A POSSIBLE MARKER OF THE ALTERED METABOLISM IN OBESE CHILDREN AND ADOLESCENTS. *Aurora Hernández.*
8. ASSOCIATION BETWEEN SODIUM INTAKE AND HYDRATION STATUS AMONGST COMMUNITY-DWELLING ELDERLY PEOPLE. *Joana Silva.*
9. BEVERAGES CONSUMPTION EVALUATION IN SPANISH HOUSEHOLDS ACCORDING TO THE FOOD CONSUMPTION SURVEY 2000-2012. *Emma Ruiz Moreno.*
10. CONSUMPTION OF NON ALCOHOLIC BEVERAGES AND PHYSICAL ACTIVITY IN CHILDHOOD AND ADOLESCENTS IN SPAIN. *Lourdes Ribas Barba.*

It represents an excellent sample of the research on human hydration currently undertaken in Spain and other countries. I hope you will enjoy reading the contents of this issue with our gratitude to the Coca-Cola Iberia company which has supported us in spreading this valuable contribution to the scientific knowledge on hydration and health.

Javier Aranceta MD, PhD
Director
Revista Española de Nutrición Comunitaria

Conclusions of the I International and III National Hydration Congress Madrid, Spain 3rd and 4th December, 2013

Lluís Serra-Majem¹ and Angel Gil²

¹Professor of Preventive Medicine at the University of Las Palmas de Gran Canaria. President of the Spanish Nutrition and Food Sciences Academy and President of the Nutrition Research Foundation. ²Professor of Biochemistry and Molecular Biology of University of Granada. President of the Spanish Nutrition Society and President of the Iberoamerican Nutrition Foundation, on behalf of the Scientific Committee, Scientific Secretary and Speakers (Ángel Gil, Andreu Palou, Ana Adan, Arturo Anadón, Ascensión Marcos, Bob Murray, Carmen Gómez-Candela, Carmen Pérez-Rodrigo, Claudio Maffei, Daniel Ramón, David Benton, Elena Alonso-Aperte, Emilio Martínez de Victoria, Eric O'Neal, Gregorio Varela-Moreiras, Hans Braun, Isabel Polanco, Javier Aranceta, José González-Alonso, Juan del Coso-Garrigós, Kathryn A. Kaiser, W. Larry Kenney, Lluís Serra-Majem, Luís B. Sardinha, Manuel Díaz-Rubio, Marcela González-Gross, María Kapsokéfaloú, Mariela Nissensohn, Mindy Millard-Stafford, Michael N. Sawka, Nieves Palacios, Pascale Hébel, Pilar Riobó, Rafael Urrialde, Rainer Wirth, Ricardo Mora-Rodríguez, Ronald J. Maughan, Rosa M^a Ortega, Ryszard Gellert, Susan Shirreffs and Teresa Partearroyo).

After two days of presentations and debates during the I International Congress of Hydration, held in Madrid on the 3rd and 4th December 2013, a set of conclusions have been established. More than 25 speakers from 10 countries participated in the Congress, with an audience of more than 1000 attendees and 93 poster presentations covering different aspects of hydration in human health.

Hydration is a relatively recent area of nutrition that has received very little research attention in the past. The high quality science reviewed during the two days of this First International Congress of Hydration allows us to conclude that:

- 1) Hydration is an important factor now recognized in nutrition and health science. It warrants further scientific attention and concern addressing the diverse aspects which constitute the field of hydration research.
- 2) Water is an essential nutrient obtained through the consumption of different foods and beverages as part of our diet.
- 3) There is increasing awareness at the population level about the importance of being properly hydrated throughout the day.
- 4) Water has important functions in our body: including transport of nutrients, elimination of waste products, temperature regulation, as well as structural and lubricant qualities.
- 5) The daily water requirements set by the European Food Safety Authority (EFSA) are 2 and 2.5 litres per day for adult women and men, respectively, and they depend on their physiological status, physical activity and environmental conditions. However, the available scientific evidence suggests that most European populations do not meet these recommendations for adequate intakes.
- 6) The most vulnerable population groups for hypo-hydration are children, pregnant and breast feeding women and the elderly.
- 7) All non-alcoholic beverages may hydrate if they contain over 80% water and less than 50 mEq/l of salt, characteristics especially needed when faced with specific hot environmental conditions and physiological strain.
- 8) The assessment of hydration status is complex and requires the combination of clinical, anthropometrical and biochemical indicators.
- 9) Dehydration of 2% body mass loss or more impacts physical performance capability. This level of dehydration may affect mood and some cognitive abilities, such as visual-motor coordination, attention, short-term memory...
- 10) Dehydration can alter brain activity and the functioning of certain neurotransmitter systems involved in the cognitive process, as well as hampering brain barrier permeability.
- 11) Dehydration also impairs aerobic exercise performance, particularly in warmer climate.
- 12) Dehydration is an avoidable cause of morbidity and mortality.
- 13) Increasing daily water and liquid intake in patients suffering from headaches, especially among those individuals whose liquid intake falls below recommended levels, may reduce the intensity and number of episodes.
- 14) Hydration assessment is an emerging research area including nutritional, exercise, behavioral and biochemical sciences. Both observational and experimental studies are needed to probe causality as well as effectiveness.

Summaries of the different sessions of the Congress:

Summary of the Inaugural Conference by Marcela González-Gross, PhD. Professor at the Department of Health and Human Performance. Technical University of Madrid. Madrid. Spain.

Opening Lecture: Fluid consumption in a sample of healthy French children, adolescents and adults.
Speaker: *Pascale Hébel, PhD. France.*

Dr. Hébel described fluid intake in a French population. Data were obtained on three occasions from 2002 until 2010, from October 2002 to July 2010. The methodology included a 7-day food and drink dietary record, the Suvimax booklet to make the definition of portion size and type of drink and food easier by the subjects, and the French food composition table from 1995. A novel approach of presenting the data was by generations. A generation was defined by the date of birth of the subjects and the time when they were 20 years old. This author also took into account the type of beverages are found at the market during that period of time, when people were 20. Apart from water, which was consumed by all subjects and the most consumed beverage, a generational effect could be observed in the type of beverage consumed. The older people drank more alcoholic drinks but less soft drinks and juices than the younger people at the same age. The introduction of a new beverage into the market has a higher effect on younger people than on the older ones. Regarding current intake, data are comparable to the data obtained in other studies. Children and adolescents have a different beverage pattern consuming (more milk drinks, fruit juices and soft drinks) than adults, who consume more coffee, tea and alcoholic drinks. Mean total fluid intake was quite low, between 1 and 1.3 litres per day depending on age groups. Most of the people did not reach the recommended intake level, which is also a common result in different studies.

Summary of the Session 1 by Pilar Riobó, MD, PhD. Head of Nutrition and Endocrinology Service. Hospital of Jimenez Díaz Foundation. Madrid. Spain.

- **Hydration in the healthy: challenges and opportunities**
Speaker: *Susan Shirreffs, PhD. Scientist. GSK Consumer Healthcare. London. United Kingdom.*
- **Beverage and water intake in European countries: measurement techniques**
Speaker: *Mariela Nissensohn, PhD. Doctor at the Department of Clinical Sciences, University of Las Palmas de Gran Canaria. Las Palmas de Gran Canaria. Spain.*
- **Hydration and aerobic exercise performance: impact**

of environment and physiological mechanisms

Speaker: *Michael N. Sawka, PhD. Professor at the School of Applied Physiology. Georgia Institute of Technology. Atlanta. United States of America.*

- **Dehydration, thirst mechanisms, and fluid intake in the elderly**

Speaker: *W. Larry Kenney, PhD. Professor of Physiology and Kinesiology Pennsylvania State University. Pennsylvania. United States of America.*

One of the topics was hydration in the healthy and exercise, covered by Susan Shirreffs and Michael Sawka. During exercise, the rate of sweat secretion onto the skin is increased, and sweat output often exceeds water intake, producing a water deficit or hypohydration; it also induces a loss of electrolytes and causes a hypertonic-hypovolemia. This triggers some cardiovascular adaptations, including an increased heart rate and peripheral resistance. Hypertonicity and hypovolemia both contribute to reduced heat loss and increased heat storage. In addition, hypovolemia and the displacement of blood to the skin make it difficult to maintain central venous pressure and thus cardiac output to simultaneously support metabolism and thermoregulation. Aerobic exercise is likely to be adversely affected by heat stress and hypohydration; the warmer the climate the greater the potential for performance decrements. The negative consequences of exercise in the heat are attenuated to some extent by a period of adaptation, and by the ingestion of appropriate fluids. Dehydration will impair aerobic exercise performance. Optimum fluid replacement strategies will depend on the exercise task, the environmental conditions and the individual physiological characteristics of the athlete.

Prof. Larry Kenney spoke about dehydration, and fluid intake in the healthy elderly. The aging process alters important physiological control systems associated with thirst and satiety. 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. Older men and women have a higher baseline osmolality and thus a higher osmotic operating point for thirst sensation (with little or no change in sensitivity), and exhibit diminished thirst and satiety in response to the unloading (hypovolemia) and loading (hypervolemia) of baroreceptors.

Another topic was about the available techniques to assess beverage and water intake, covered by Dr. Nissensohn. She explained two different questionnaires that have been designed to know the usual beverage intake. A final conclusion is that we need to develop rapid, non-invasive technologies to measure total body water and hydration status, with enough resolution to measure deficits as small as 5% of total body water. In addition, Dr. Nissensohn presented the range of fluid and water intake in some European countries.

Summary of the Session 2 by Ángel Gil, PhD. Professor of Biochemistry and Molecular Biology. University of Granada. Granada. Spain.

- **Hydration of body cell mass and fat free mass: functional effects in elite athlete.**

Speaker: *Luís B. Sardinha, PhD. Professor and Head of Exercise and Health Laboratory. Faculty of Human Kinetics, University of Lisbon. Lisbon. Portugal.*

- **Dehydration and team sports performance**

Speaker: *Juan del Coso Garrigós, PhD. Head of the Exercise Physiology Laboratory. Camilo José Cela University. Madrid. Spain.*

- **Dehydration and endurance performance in competitive athletes**

Speaker: *Bob Murray, PhD, FACSM. Founder and principal of Sports Science Insights, LLC. United States of America.*

- **Ingestion of salt and fluid: effects on blood volume and exercise performance**

Speaker: *Ricardo Mora Rodríguez, PhD. Professor and Head of the Exercise Physiology Lab. University of Castilla-La Mancha. Toledo. Spain.*

The first lecture concluded that isotope dilution techniques using stable isotopes such as deuterium or sodium bromide to estimate total body water (TBW) and extracellular water (ECW) in cross-sectional and prospective observational studies in elite athletes have shown that intracellular water (ICW) (TBW minus ECW) is more related to the functional tests of athletic performance than the pool ECW. New valid and non-biased bioelectrical impedance analysis-based models to predict TBW, ECW, and ICW, using dilution techniques as the criterion method in elite athletes were also presented. These new models provide practical monitoring with applications within the framework of health and sports performance hydration. The conclusions of the second lecture could be summarized as: 1) Before exercise players on sports teams must be well hydrated drinking adequate amounts of liquids two hours before starting of the activity. The consumption of drinks containing adequate concentration sodium help to maintain the feeling of thirst and the consumed water retention; (2) During exercise an individualized rehydration should be performed through the use of beverages that include moderate amounts of electrolytes, primarily sodium, in order to reduce deficits of these mineral elements and prevent muscle cramps; and (3) After exercise a quantity of water equivalent to 1.5 times the mass of liquid loss should be consumed during exercise with the inclusion of sodium from foods or drinks, which is essential to retain the water consumed. The third paper concluded that during physical activity,

it is always better to be well hydrated than dehydrated. This is particularly true during exercise in hot environments and any time performance is important. Even slight dehydration (e.g., <-1% body mass) can negatively affect a variety of cardiovascular and thermoregulatory functions and can impair performance in continuous and intermittent activities.

Finally, the fourth paper concludes that the intake of liquids and salt prior to exercise in a hot or environment of neutral temperature contributes to the cell volume expansion and increases performance during exercise. As a general conclusion there is enough scientific evidence that supports that a good hydration associated with an adequate intake of electrolytes, especially sodium, is important to increase athletic performance. However, the mechanisms of action at the molecular level of the liquid intake and sodium ergogenic effects, are unknown in a large part: therefore in the near future new studies will have to be designed and carried out in order to meet this need.

Summary of Conference 1 by Carmen Gómez-Candela, PhD. Head of Clinical Nutrition Department. La Paz University Hospital. Madrid. Spain.

- **Thirst and hydration status in daily life**

Speaker: *Mindy Millard-Stafford, PhD. Professor and Associate Chair of School of Applied Physiology. Georgia Institute of Technology. Atlanta. United States of America.*

Water is an essential nutrient. It is the principal constituent of human body (50-70% of body weight), distributed into intracellular fluid (65%) and extracellular compartment (35%) divided into the interstitial and plasma spaces. Approximately 5% to 10% of total body water is turned over daily via obligatory fluid losses (respiration, sweat, urine and faeces). Sweat losses depends on various sports and every degree above 37° C may increase losses by an additional 500 cc water/day consumption.

Net body water balance is regulated day to day as a result of thirst and hunger drives, coupled with ad libitum access to food and fluids to offset water losses via homeostatic responses (interplay between neuroendocrine and renal responses to body water volume and tonicity changes), and socio-behavioural factors that ensure that small changes of over/under hydration are readily compensated for in the short term.

Daily water needs determined from fluid balance, water turnover or consumption studies provide reference values for a given set of conditions. Normal water needs range widely due to numerous factors (diet, climate, exercise, age, clothing...); thus, normal hydration is compatible with a wide range of fluid intakes. About 80% of total daily water intake is obtained from beve-

rages and 20% from food. The recommendation "drink to thirst" is frequently given to healthy individuals during daily life. However, other factors and health conditions influence thirst.

Over the years several different total water intake recommendations have been put forward (1-1.5 mL/kcal consumed or 30 mL/kg body weight). The scientific basis for a common U.S. recommendation of drinking "8 glasses of 8 ounces of water per day" is lacking; consequently, limited evidence is available to assure drinking less will do no harm but neither does it validate that this dose (1.89 L) is optimal for health. The best way to refer human water requirements is "Adequate Intake or AI (level intake expected to meet nutritional adequacy for near all members of a healthy population). Dr. Millard-Stafford analyzed the scientific basis of different recommendations of water intake per day. Daily water requirements have been systematically evaluated through water balance, water turnover, and/or water consumption studies. A reference document for Adequate Intake (AI) published by the Institute of Medicine (2004) acknowledges a range of daily fluid intake values can maintain daily hydration status with a median AI for healthy adult men and women (age 19- 50 yr) as 3.7 and 2.7 L per day (for those not physically activity or exposed to hot weather). This AI is not different for older individuals (> 50 yr). The 2010 European Food Safety Authority AI for water are 2.5, 2.0 L for men and women, respectively. Published data available suggest that with the exception of some diseases and special circumstances (strenuous exercise, long airplane flights, and climate), most adults are probably drinking enough total fluid (when accounting for all sources of water from all types of beverages combined with food). Data indicate a variety of beverages contribute water for maintaining hydration.

The role of water in health is generally characterized in terms of deviations from an ideal hydration status. However, it is fundamental to know how to measure the hydration status. At present no single measure can adequately reflect this dynamic and complex mechanism. More research focused on elucidating the factors affecting accurate assessment of hydration status appears warranted and studies that identify risk factors for poor fluid intake and dehydration.

Summary of Conference 2 by Ryszard Gellert, MD, PhD. Professor of Nephrology and Department of Nephrology. Centre of Postgraduate Medical Education. Head of Nephrology Unit Bielariski. Varsaw. Poland.

- Hydration, morbidity and mortality in vulnerable populations
Speaker: Ronald J. Maughan, PhD. Professor of Sport and Exercise Nutrition. Loughborough University. Loughborough. United Kingdom.

At the Conference "Hydration, morbidity and mortality" held on the second day of the I International Congress on Hydration, Prof. Ronald J Maughan from the Loughborough University, presented the only lecture "Hydration, morbidity and mortality in vulnerable populations". Prof RJ Maughan stressed out that the everyday fluctuations in hydration status are normal, common, and usually corrected at intervals without being perceived. However, sometimes water losses cannot be only replaced by oral intake. This is especially true in vulnerable populations – elderly, children, and chronically disabled. Ageing diminishes the sensation of thirst, which can be further compromised by numerous medications (SSRI, ECEi., anti-Parkinson), increased renal water excretion (loss of kidney concentrating capacity, diuretics), and the voluntary reduction in urine excretion in order to decrease the incontinence, the effort to get and swallow fluids, or to visit the toilet. The chronic dehydration, the most common cause of death in the elderly apart from malnutrition, is linked to numerous diseases (e.g. urolithiasis, urinary tract infections, asthma, and renal failure). The level of hypohydration can further increase in hot weather conditions, with diarrhoea or vomits. The acute hypohydration, as well as the exacerbation of water deficit, proved to be linked to the increased rate of infections, hospitalisations, and mortality. It seems the dehydration is especially dangerous to those with poor survival prognosis, but it affects also children and, less so, the adults. Even a minor reduction in body fluid volume, as small as 1-2% of body weight, can decrease ones mood, alertness, cause headache, and further decrease the fluid intake. The resulting hypovolemia may result in hypotension, falls and bone fractures compromising ones mobility, quality of life and survival prognosis. This is why, to assure the proper fluid consumption all individuals susceptible to hypohydration should receive attention from their caregivers. Prof. RJ Maughan also stressed out, that more studies are urgently needed to prove the dehydration is an avoidable cause of morbidity and mortality, because the currently available data from epidemiological studies are suggestive, but lack the power to prove any causal relationship between hydration status and health. Prof. RJ Maguhan also stated that developing a hydration index could help diagnosing dehydration and prevent its complications.

Summary of the Session 3 by María Kapsokefalou, PhD. Associate Professor in Human Nutrition. Agricultural University of Athens. Athens. Greece.

- Dehydration in geriatric patients and bioimpedance analysis
Speaker: Rainer Wirth, MD, PhD. Doctor of the Department of Internal Medicine and Geriatrics. St. Marien-Hospital Borken. Borken. Germany.

- **Evolution of the assessment of hydration status: eliminating the problems and advancing the practice with bioimpedance**

Speaker: *Henry Lukaski, PhD. Adjunct Professor of Kinesiology and Public Health Education Department. University of North Dakota. Dakota. United States of America.*

Dehydration is a problem in older adults, prevalence estimated at 10% in the general older population and of about 30% in nursing home residents. Nevertheless diagnostic criteria are uncertain. Clinical signs of dehydration, such as dry mouth or persisting skin folds or dry axilla are not very specific or sensitive while laboratory measurements, such as plasma osmolality, may not be reliable in some cases in older adults. Bioelectric impedance analysis (BIA) may be a method of choice because, in healthy subjects, it agrees well with reference methods in the evaluation of total body water. However, while BIA is an elegant technique of body composition analysis in healthy subjects, its application has several limitations in evaluating hydration status in patients. For example, disturbances of electrolytes such in hyponatremia or changes in body composition (fat mass versus free fat mass) may lead to false measurements. Dr Rainer Wirth, suggested that future developments may overcome these limitations.

Bioimpedance vector analysis (BIVA) uses 50-kHz measurements of whole-body resistance (R) and reactance (Xc), normalized for standing height and plotted on the RXc graph to illustrate an impedance vector that has length, which is inversely related to TBW, and direction, that indicates tissue hydration status and cell mass. Vector position on the RXc graph is interpreted relative to the bivariate distribution R/H and Xc/H of vectors derived in healthy people and expressed as 50, 75 and 95% confidence intervals shown as ellipses. Individual vectors outside of the upper pole of the 50% ellipse are classified as dehydration whereas vectors outside of the lower pole of the 50% tolerance ellipse are described as fluid overload. Changes in tissue hydration status less than 200 mL can be detected with BIVA. The principal use of BIVA is the assessment of hydration status in patients with altered fluid hydration status as well as nutritional status assessment and muscle function among hospitalized and elderly patients.

Summary of the Session 4 by Claudio Maffeis, MD, PhD. Head of the Unit of Clinical Nutrition and Obesity, of the Regional Centre for Juvenile Diabetes. University of Verona. Verona. Italy.

- **Do minor changes in hydration status influence mood and cognition?**

Speaker: *David Benton, DSc. Department of Psychology. Swansea University, Wales, United Kingdom.*

- **Impact of mild or moderate dehydration on cognitive performance**

Speaker: *Ana Adan, PhD. Senior Lecturer in the Department of Psychiatry and Clinical Psychobiology. University of Barcelona. Barcelona. Spain. Institute for Brain, Cognition and Behaviour Research (IR3C), Barcelona, Spain.*

- **Headache and hydration: scientific evidence**

Speaker: *Lluís Serra-Majem, MD, PhD. Professor of Preventive Medicine and Public Health, Director of the Research Institute of Biomedical & Health Sciences. University of Las Palmas de Gran Canaria. Las Palmas de Gran Canaria Spain.*

The topic of this section was to report available evidence on the relationship between hydration status and brain activity. In particular, David Benton made an overview on the impact of mild dehydration on mood and cognitive performance. Data reported suggested an improvement of both memory and attention after the consumption of a drink in children who eat and drink as normally. These data are impressive due to the potential positive consequences of improved memory and attention in the delicate phase of mental growth and maturation typically occurring in childhood. In adults, a degree of dehydration of 2% body weight or more was found to be disruptive for some cognitive functions. In particular, avoiding a loss of fluid was associated with better cognitive function and mood. Several mechanisms are involved in causing changes in brain activity by mild dehydration. Ana Adan reported the results of studies showing that changes in electrolytes concentration in the body as well as changes in blood-brain barrier permeability may affect neurotransmitter system involved in brain function. Dehydration was also associated with a decrease of blood flow in some areas of the brain and to an inefficient use of brain metabolic activity: in fact, using functional magnetic resonance imaging techniques, dehydrated healthy adults demonstrated a higher neural activity for achieving the same performance in planning and visual-spatial processing than controls. Finally, some evidence is available on the relationship between mild dehydration and a very common clinical condition as headache. Lluís Serra-Majem reported the results of some observational and clinical studies showing a relationship between fluid restriction and feeling of headache, accompanied by a reduction of concentration ability and alertness. Moreover, in adults suffering from migraine, the increase of water intake by 1.5 l per day above the usual intake was able to improve perceived intervention effect versus controls although it did not reduce the number of days of at least one moderate headache. Further studies are necessary to increase the knowledge on the relationship between brain function and hydration and on the benefits of the maintenance of adequate hydration through the day different ages.

Summary of Session 5 by Andreu Palou, PhD. Professor of Biochemistry and Molecular Biology. University of Balears. Palma de Mallorca. Spain.

- **Fluid intake between and during exercise bouts: A consideration for perception of sweat loss**
Speaker: *Eric O'Neal, PhD, CSCS. Professor at the Department of Health. Physical Education and Recreation. University of North Alabama. Alabama. United States of America.*
- **Hydration and human physiological function during rest and exercise**
Speaker: *José González-Alonso, PhD. Professor of Exercise and Cardiovascular Physiology and Head of the Centre for Sports Medicine and Human Performance. Brunel University of London. London. United Kingdom.*

Much effort has been made to determine the optimal approach for athletes to rehydrate during and between training bouts. Previous views were described but, nowadays, the key tenet in developing and implementing fluid intake strategies to deter extreme hypo- or hyper-hydration is to base fluid consumption on volume of sweat losses incurred. However, recent findings from Prof. O'Neal's laboratory have revealed both endurance and intermittent sprint sport athletes consistently and greatly underestimate their training sweat losses. A conclusion is that increased efforts through popular media need to be used as avenues to further promote the proper procedures to determine sweat loss volume. Awareness of sweat loss volume could increase the efficacy of hydration strategies for athletes whose thirst drive fails to stimulate fluid intake that results in a return to euhydration between training bouts.

On another hand, it was the central question on how body water deficit or dehydration can pose a major challenge to the regulation of human physiological function and exercise capacity, particularly during prolonged and intense exercise in hot environments. The presentation by Prof. Gonzalez-Alonso discussed the more recent advances in our knowledge and understanding of the physiological consequences of dehydration and fluid replacement on human physiological function at rest and during exercise. Emphasis was placed on the evidence that dehydration indeed influences physiological function and the potential underlying mechanisms. These lectures were followed by extensive discussion with the participation of various congress delegates.

Summary of the Oral Communication Session by Carmen Pérez-Rodrigo, MD, PhD, President of the Spanish Society of Community Nutrition. Bilbao, Spain. and Elena Alonso-Aperte, PhD. Senior Lecturer Assistant in Nutrition and Food Science. CEU San Pablo University. Madrid. Spain.

- **O.C.1: Adequate hydration status promotes a minor concentration of proinflammatory cytokines in healthy people**
Speaker: *Bricia López. Institute for Health Research. La Paz University Hospital (Idipaz). Madrid. Spain.*
- **O.C. 2: Evaluation of water Intake and food sources in school children from Madrid with different physical activity level**
Speaker: *Liliana Guadalupe González. Department of Nutrition. Faculty of Pharmacy. Complutense University of Madrid. Madrid. Spain.*
- **O.C.3: Characterization of bioimpedance measures in overweight and obese hemodialysed patients**
Speaker: *Mar Ruperto. Alfonso X El Sabio University. Madrid. Spain.*
- **O.C.4: Frequency of consumption of sugar sweetened soft beverages and associated factors in Spanish children**
Speaker: *Ana María López-Sobaler. Department of Nutrition. Faculty of Pharmacy. Complutense University of Madrid. Madrid. Spain.*
- **O.C.5: Association of urinary biomarkers of cellular oxidation with urine volume and osmolality In Guatemalan preschoolers**
Speaker: *María José Soto. Department Of Biochemistry and Molecular Biology Ii. University of Granada. Granada. Spain and CESSIAM, Guatemala.*

The Oral Communication Session provided to the scientific community an important overview of the latest research projects on hydration. A total of 5 different communications were presented and all of them were outstanding as considering the scientific rigor, the relevance of the results, the concluding remarks and the capacity of the speakers to present their research projects. Presentations dealt with hydration as related to inflammation, obesity and overweight in hemodialysed patients, and oxidation, as well as hydration and community epidemiology. These different approaches give in conjunction an outstanding review of the role of hydration in relation to common diseases, as well as a hint of the importance of fluid intake and hydration status assessment in different community groups. The study on adequate hydration status and proinflammatory cytokines in healthy people showed a promising research on the identification of relevant biomarkers that could further explain the impact of hydration in chronic inflammation issues. A similar expectancy is generated by the study of urinary biomarkers in Guatemalan pre-schoolers, as related to cellular oxidation. Two of the oral communications dealt with the matter of assessing water intake and sugar sweetened soft beverages consumption in children, using the most precise methods and dealing with the

different factors that may modify intake, such as physical activity or family habits. The projects are relevant due to the broad lack of data on the matter and because they identify important public health issues and provide a solid basis for community recommendations. Finally, using bioimpedance in hemodialysed patients proves to be an interesting tool for nutritional assessment in these patients, particularly as related to obesity and overweight, as presented in the last oral communication.

All five presentations elicited a great interest in the audience, clearly demonstrated by the number of questions aroused and the need for further discussion, which was necessarily interrupted due to time schedule. It is also important to point out that the research projects presented are housed by the most relevant Spanish institutions in nutrition research. Furthermore, these presentations were selected from a significantly higher number of oral communications. This is another proof of the increasing interest in hydration research.

So, all together, in my consideration, the most outstanding commentaries on the oral communication session as a whole are:

- A broad picture of recent research on hydration
- An outstanding session from the scientific point of view
- High level of presentation and debate directed by young researchers

Summary of Closing Conference by Gregorio Varela-Moreiras, PhD. Professor of Nutrition and Food Sciences. Head of Pharmaceutical & Health Sciences Department. CEU San Pablo University. Madrid. Spain.

- Will reducing sugar-sweetened beverage consumption reduce obesity? Evidence supporting conjecture is strong, but evidence when testing effect is weak

Speaker: Kathryn A. Kaiser, PhD. Office of Energetics, Dean's Office, School of Public Health, University of Alabama at Birmingham. Alabama. United States of America.

Dr. KA Kaiser raised this very important, controversial topic. Her conference was mostly focused to provide arguments to this debate question through a very updated meta-analysis of available studies as of October 2012. Dr. Kaiser firstly explained the proposal of the question to be addressed and for which she evaluated the available evidence (e.g. the definition of *sufficient evidence* for what?... to draw a conclusion that decreasing sugar-sweetened beverages (SSBs) consumption may lead to a lower prevalence of obesity and obesity related diseases). Dr. Kaiser also clarified that the debate was not to address some ongoing issues such as whether obesity is a crisis, or if some sugars are worse than others, or the effect of food

marketing on this topic. Therefore, Dr. Kaiser's conference summarized data from randomized controlled trials for the following questions: does an increase in SSB intake increase body weight or body mass index (BMI) or the other way around, if a reduction of SSB intake lowers body weight and/or BMI. Dr. Kaiser and co-authors concluded that the currently available randomized evidence (scarce studies however) is very equivocal for weight gain in all groups analyzed. Moreover, the point estimates of effects on BMI reduction are small, roughly only 1.5% of the variance observed in those who were overweight at baseline. According to the evidence reported by Dr. Kaiser, the debate proposition cannot be supported. She also claimed that further and better controlled studies are needed to conclude that there are significant causal effects from sugar-sweetened beverages related modifying public health recommendations for a healthier diet and lifestyle in the overweight and obese population. Dr. Kaiser's conference also stressed the following question: if the data are as weak as shown, why do some members of the public, the media but also from the scientific community seem to perceive that the proposition has having been proven? To answer, three major reasons seem to be plausible: the emotion-raising language; the distortion of the scientific information, and finally the so-called the mere exposure effect.

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Urinary osmolality of preschool children with a largely common weekday meal offering, from the western highlands of Guatemala

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Abstract

Introduction: Urine volume and osmolality are within the most practical methods for measuring human hydration status.

Objectives: To describe the distribution and central tendency of urinary osmolality (Uosm) for preschool children, and to assess the reproducibility of Uosm measurements after frozen storage and when determined in two different osmometers.

Methods: We collected three samples of 24-hour urine over three consecutive weeks among children attending three day-care centres in different settings in Quetzaltenango, Guatemala. Volume was determined and samples were stored at different temperatures for different periods of time. Finally, Uosm was measured on two different osmometers in different countries. Data were analyzed using SPSS version 20.

Results: Twenty-four hour urine volumes ranged from 65 to 1,670 ml, with a median value of 485 ml; urine osmolality ranged from 158 to 1,088 mOsm/kg, with a median of 475 mOsm/kg (n = 234 urine collections), without differences by sex, centre, or collection order. Seventy-six subjects completed 3 collections; Coefficients of Variation ranged from 1 to 68%. When refrigerated urine samples were compared to split-sample aliquots frozen at -80°, the correlation was r = 0.89 and the difference in medians was 0.2%. Values from frozen samples between a Vogel-Löser 815 and Gonotec-Osmomat 030 had a correlation of r = 0.83, with an 11% difference in the median.

Conclusions: Guatemalan children show some of the lowest median Uosm values so far reported. A good reproducibility was found when measuring after different storage times and temperatures, but on the same equipment. However, reproducibility across different osmometer brand, was not within acceptable limits.

Key words: Hydration. Urine osmolality. Preschool children. Reproducibility. Guatemala.

OSMOLALIDAD URINARIA DE NIÑOS PREESCOLARES CON UN MISMO MENÚ OFRECIDO DURANTE DÍAS HÁBILES, EN EL ALTIPLANO OCCIDENTAL DE GUATEMALA

Resumen

Introducción: El volumen y la osmolalidad urinarios son dos de los métodos más prácticos para medir hidratación en humanos.

Objetivos: Describir la distribución y tendencia de osmolalidad urinaria (Uosm) en preescolares y determinar los efectos del almacenamiento en congelación y la medición en diferentes osmómetros sobre la reproducibilidad de resultados.

Métodos: Se recolectaron tres muestras de orina de 24-horas durante tres semanas, en niños que asistían a tres guarderías de diferentes lugares en Quetzaltenango, Guatemala; se determinó volumen y las muestras fueron conservadas durante diferentes tiempos y temperaturas. Finalmente, la Uosm fue medida en dos diferentes osmómetros y países. Los datos se analizaron usando SPSS versión 20.

Resultados: El volumen de orina varió entre 65 y 1.670 ml, con una mediana de 485 mL; la Uosm entre 158 y 1.088 mOsm/kg con 475 mOsm/kg de mediana, (234 muestras de orina), sin diferencias por sexo, centro ni semana de recolección. 76 sujetos completaron las 3 recolecciones y los CV oscilaron entre 1 y 68%. Al analizar las alícuotas refrigeradas y compararlas con las congeladas (-80°C), la correlación fue r = 0,89 y la diferencia de medianas fue de 0,2%. Las mediciones de las muestras congeladas entre el Vogel, Löser, y el Gonotec, Osmomat, tuvieron una correlación de r = 0,83 con un 11% de diferencia de medianas.

Conclusión: Guatemala tiene uno de los valores más bajos de Uosm observados hasta el momento. Se encontró una buena reproducibilidad en las mediciones en diferentes tiempos y temperaturas, pero en el mismo equipo. La reproducibilidad no fue aceptable entre diferentes marcas de osmómetros.

Palabras clave: Hidratación. Osmolalidad urinaria. Niños preescolares. Reproducibilidad. Guatemala.

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Abbreviations

Uosm: Urinary Osmolality.
SOSEP: Secretaría de Obras Sociales de la Esposa del Presidente.
mOsm: milliosmoles.
FINUT: Fundación Iberoamericana de Nutrición.
FUNDANIER: Fundación del Niño Enfermo Renal.
CeSSIAM: Centre for the Studies of Sensory Impairment, Aging, and Metabolism.

Introduction

Water has been called the primary and most important nutrient¹. Mild dehydration is defined as 1–2% loss of body weight secondary to fluid loss; this impairs exercise performance and increases the risk of urinary stone disease². Among the different techniques that can help in the assessment of hydration status are: isotope dilution, neutron activation analysis, bioelectrical impedance, body mass change, plasma osmolality, per cent plasma volume change, 24-hour urine volume, salivary flow rate or osmolality, urine color, urine specific gravity, urine conductivity, and urine osmolality. However, estimating the state of hydration within the *normal* (non-pathological) range is an elusive proposition³. Manz⁴ provides guidance toward an operational concept of normative hydration: "in a subject, minimum and maximum urine osmolality define the range of euhydration." Urine has the advantage over the other biological fluids mentioned in the non-invasive nature of collection, its sanitation and the availability of ample volumes⁵. Urinary osmolality (Uosm) alone has been reported widely in studies to approximate hydration state, including in children^{6–12}. However, obtaining quantitative 24-hour urine collections in young children is a notoriously significant challenge¹³.

Twenty-four-hour urine collections and osmolality measurements were two of the activities programmed in a field project called: "Study on the normative state and inter- and intra-individual variation in growth, hematology, hydration, and markers of oxidation, infection and inflammation in pre-school children with a similar dietary intake," conducted among day-care centre attendees in the Western Highlands of Guatemala. The centres were in different geographical locations, and of ethnic make-up and social-economic status. A common feature was the 4-meal menu offered in each daycare centre. In the present study, we describe Uosm distributions and central tendencies in the children of the sample. We also compare our findings with other pediatric studies. On the methodological side, we examine the effects of different storage periods and temperatures and compared osmometers of two different manufacturers.

Methods

Setting

Guatemala is the country of 108,889 km² located in the center of the American continent. Its name comes from the Náhuatl language expression "Quauhtlemallan" that means "woodland". Guatemala has great variety of microclimates and different cultures¹⁴. Guatemala also has the highest under-5 stunting index in Latin America, with nutritional anemia that affects 26% of children between 1–5 years and 26% of the women between 18 to 45 years. Infant mortality rate is the third highest in the world¹⁵. The study was conducted in the Western Highlands of Guatemala in the province of Quetzaltenango, which is located 220 Km from the capital and 2357 m above the sea level, with a land area of 1,943 km² and 24 municipalities¹⁶; SOSEP designated three centres to our study, one located in La Esperanza (Centre A), another in La Puerta del Llano (Centre B) and the last one—and most rural—in San Martín Sacatepéquez (Centre C).

Study Design and Subjects

The study is a descriptive, cross-sectional field survey and was conducted in three day-care centres (*Hogares Comunitarios*) of the SOSEP system. One site, Centre A, was located in La Esperanza, a semi-urban area 2 miles away from downtown Quetzaltenango, Guatemala. The second, Centre B, was located in the outskirts of the city of Quetzaltenango close to rural areas in La Puerta del Llano; for that reason it was classified as marginally urban. The rural area or Centre C was located 15 miles away from Quetzaltenango in La Estancia, San Martín Sacatepéquez. Almost all children attending the centres were indigenous; however, some habits, pastimes and physical characteristics varied between centres.

- *Exclusion Criteria:* Eligible children were required to attend the selected SOSEP centre and to be 2 to 7 years old. Also, subjects needed to attend at least 80% of the centre working days during the study. Eligible subjects were apparently healthy and with no restrictions to consume the foods offered by the SOSEP menu. Children who refused to adhere to the urine collection routine or to participate in the study, or whose parents refused to sign the consent form were excluded.
- *Ethical considerations:* The Centre for the Studies of Sensory Impairment, Aging, and Metabolism's Human Subjects Committee in Guatemala City granted ethical approval of the study protocol. A consent form was to be signed by a parent or guardian. Previous authorization was obtained from the Director of SOSEP for the Quetzaltenango area. Whenever the situation required, we complemented the diet offered to the children in order to provide all items prescribed on the menu. A local

physician took care of the results of the hemogram, stool and urine tests and delivered deworming treatment along with medical prescription or medical care (e.g. of urinary infection), if required.

Sample collection and Storage

- *Urine collection:* Three samples of 24-hour urine were collected, one each in the 3 collection weeks in order to measure urinary osmolality (Uosm). BD Vacutainer® No.364999 plastic 24-hour collection container (Becton, Dickinson and Company, New Jersey, United States) were used. Urine collection was started at the time when each child arrived in the day-care centre and was supervised by investigators and SOSEP personnel. Collection was continued at home with the parents' assistance, and was finished after 24 h.
- *Aliquoting and Storage:* All collected 24-hour urine samples were well mixed. Aliquots of each sample were stored at 0°C in Quetzaltenango for 16 to 25 weeks variously between August, 2012 and February, 2013. During the third round of urine collection, 2 additional 4-ml aliquots were stored at -80°C in an ultra-cold freezer in Guatemala City. One of those specimens was shipped to Granada, Spain, on dry ice and stored at -80°C until analyses (total storage time: 43 to 52 weeks). The final specimen remained in storage in Quetzaltenango until analysis after a total storage time of 50 to 59 weeks.

Laboratory Procedures

Analyses in Quetzaltenango, Guatemala, were performed using the Vogel-Löser 815 osmometer (Vogel, Giessen, Germany). For the determinations performed in Granada, Spain, we used the Gonotec-Osmomat 030 (Gonotec, Berlin, Germany), each according to manufacturers' specifications. Both instruments work on the principle of freezing-point depression of Peltier. Immediately before measurement, the aliquots were mixed for approximately 3 minutes and 100 µl or 50 µl were transferred to the measurement vessels for the Löser osmometer and the Osmomat model, respectively. Results are expressed in milliosmoles per kilogram of urine (mOsm/kg).

Urinary creatinine concentrations were measured in Guatemala City using the colorimetric Jaffe reaction method. This value was applied in a predictive formula developed in Dortmund Germany by Remer¹⁷ to screen for completeness of 24-hour urine collections in pediatric studies.

Statistical Analyses

Data were entered into a SPSS Version 20 database. Descriptive statistics were expressed as median, 95% Confidence interval (CI) and minimum and maximum. Central

tendencies were compared between two or among three sub-groups using a non-parametric statistical test (e.g. Independent Median, Mann-Whitney U, Wilcoxon, Friedman and Kruskal-Wallis tests), as the Uosm-values were not normally distributed. Association of values collected at different points in time was tested using Pearson product-moment correlation coefficient or Spearman rank-order coefficient, as appropriate. A probability level of < 0.05 was accepted as statistically significant.

Results

Distribution and Variation in Urinary volume and Osmolality

We collected a total of 234 urine specimens of supposedly 24-hour duration. The volumes ranged from 65 to 1670 ml with a median of 485 ml. Table I shows descriptive statistics (median, 95% CI, minimum and maximum). No significant differences were found, neither between the volumes collected in all patients of a subgroups as compared to those meeting the Remer criterion¹⁷ ($p = 0.120$), nor between sexes ($p = 0.807$), nor among sequences of collection ($p = 0.670$), nor among sites ($p = 0.194$).

Within Individual Stability of Urinary Osmolality

To test the intra-individual reproducibility of Uosm across the three collection days we performed Pearson correlations. Figure 1 shows the r values of the comparison between first collection vs second ($r = 0.222$ $p = 0.0025$), second vs third ($r = 0.368$ $p < 0.001$), and first vs third ($r = 0.155$ $p = 0.088$). Coefficients of variance (CV) of Uosm for all subjects who provided urine samples on the three occasions varied from 1% to a high extreme of 68%. The median CV for repeat collections was 22%.

Correspondence of Measurements after Cold Storage vs Frozen Storage

When samples were measured by two different operators in the Vogel Löser 815 osmometer in Quetzaltenango, Guatemala, the median value of the 0°C storage specimens was 484 mOsm/kg (464–538 mOsm/kg, 95% CI). After -80°C corresponding values were 486 mOsm/kg (456–529 mOsm/kg, 95% CI) ($p = 0.275$ by Wilcoxon test). A significant correlation, $r = 0.893$ ($p < 0.0001$), was found using Spearman test (fig. 2) when samples stored at either temperature.

Correspondence of Measurements with Frozen Storage in Two Different Osmometers

When samples were measured by two different observers, and by use of two different osmometers in

Table I
Median and variance of Urinary Osmolality by Whole-Group and Sub-Group tabulations

Subgroup	n	Uosm in mOsm/kg		
		Median	95% CI	Min-Max
All collections	234	475	478/521	158-1,088
All Remer complete*	134	495	490/541	263-1,088
p value		p = 0.120 (Independent median test)		
All Girls' collections	116	475	466/531	208-1,088
All Boys' collections	113	475	470/527	158-1,068
p value		p = 0.807 (Mann-Whitney U-test)		
First collection	77	474	462/539	245-1,088
Second collection	74	467	455/532	228-1,068
Third collection	78	484	464/538	158-1,080
p value		p = 0.670 (Friedman test)		
Centre A	57	489	469/545	274-1,088
Centre B	71	504	470/543	208-900
Centre C	101	446	451/524	158-1,080
p value		p = 0.194 (Kruskal-Wallis test)		

* Remer T, Neubert A, Maser-Gluth C. Anthropometry-based reference values for 24-h urinary creatinine excretion during growth and their use in endocrine and nutritional research. *Am J Clin Nutr* 2002 Mar;75 (3): 561-9.

Quetzaltenango (Löser 815) and Granada (Osmomat 030), respectively, the median value of Löser 815 osmometer specimens was 486 mOsm/kg (456-529 mOsm/kg, 95% CI) as compared to 430 mOsm/kg (407-491 mOsm/kg, 95% CI) for the Osmomat 030 osmometer ($p < 0.001$ by Wilcoxon test). A significant correlation, $r = 0.828$ ($p < 0.0001$), was found between groups using Spearman test (fig. 3).

Discussion

The non-invasive nature of urine collection is a major advantage of urinary biomarkers although urinary biomarkers cannot provide a full description of human hydration status. Many reports on Uosm in adults¹⁸⁻²¹ and children^{8,9} used spontaneous ambient urine sample for analyses. Other studies, even in children^{6,7,10-12}, aspired to make a complete 24-hour collection, which provides the advantage of leveling out changes in concentration during the course of a day. Completeness of urinary collection over 24 hours was called the "Remer criterion", developed in the DONALD study¹⁷ in Dortmund, Germany. The younger the child, the more challenging is the complete collection for the full 24-hour urines. Complete collection of urine over 24 hours was our goal in the community and institutional setting investigated here. However, in spite of intense efforts, only 57% of the samples collected in our preschoolers met the

"Remer criterion" for completeness. In our experience the adherence to that criterion did not influence the overall Uosm estimate. Still, all but two of our collected urine volumes were in excess of 100 ml in one setting. In our study staff and parents were trained how to collect urine and supervised intensely. As a result, correspondence of Uosm in the second and third collection period improved considerably, showing the impact of experience with the urinary collection procedure.

Table II shows arithmetic mean values for 8 reports from 6 countries, with the present study being the only one of non-European or Middle-Eastern origin. Comparing the mean of the distribution may not be ideal since, at least in our experience, the data are not normally distributed. With that caveat, Guatemala has the lowest median value. Belgium and Guatemala are the only two sites with mean Uosm below 600 mOsm/kg, and the only two presenting results obtained with instrumentation of the 21st century. The German values were highest and those from France and Denmark were in-between. The German study⁸ may have provided the highest values, possibly because the samples may have been collected early in the day when the urine is most concentrated. One may also speculate that the lower values could be due to the improved and possibly more valid technology of modern osmometers, or to differences in hydration, or both.

The first author was present at each study site at which the common menu was served. It offered 3 beverages of 200 mL volume per day plus a 240 g of a usually

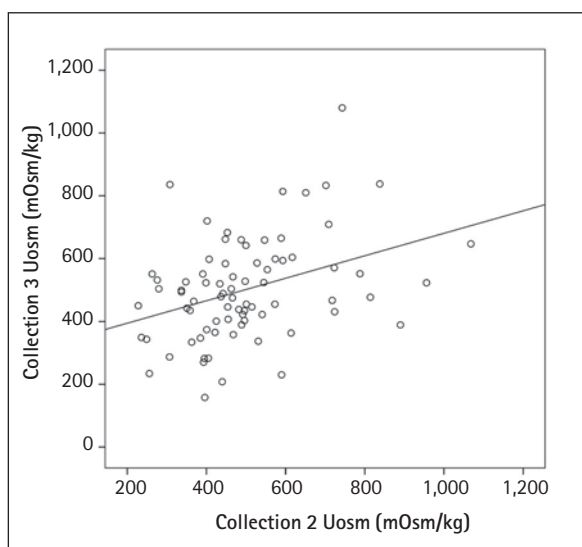
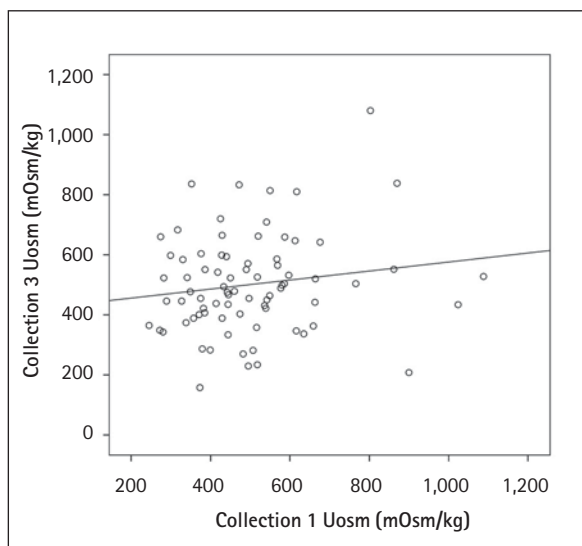
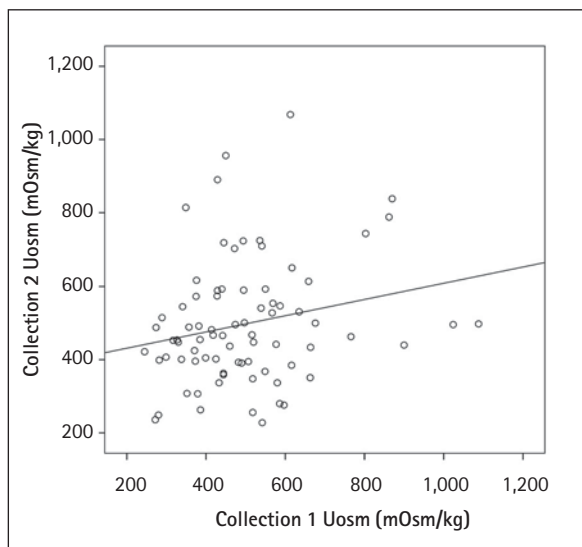


Fig. 1.—Association of Urinary Osmolality Measurement Between Collections.

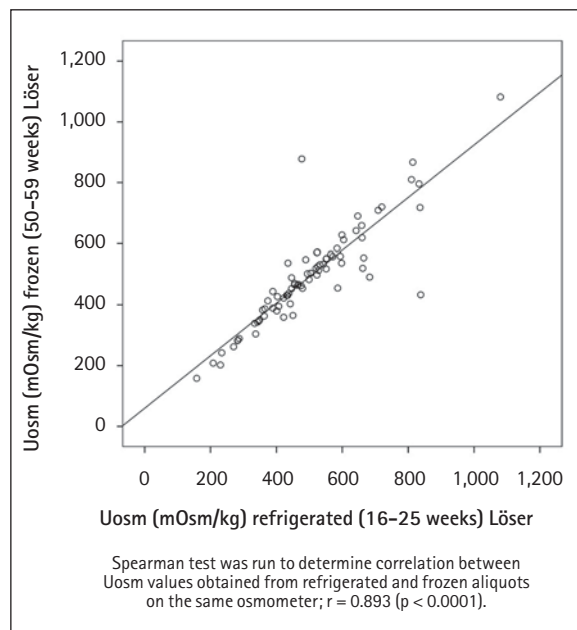


Fig. 2.—Comparison of Urinary Osmolality Measurements between Zero- and minus Eighty-degree Storage Temperatures, Third Collection Specimens.

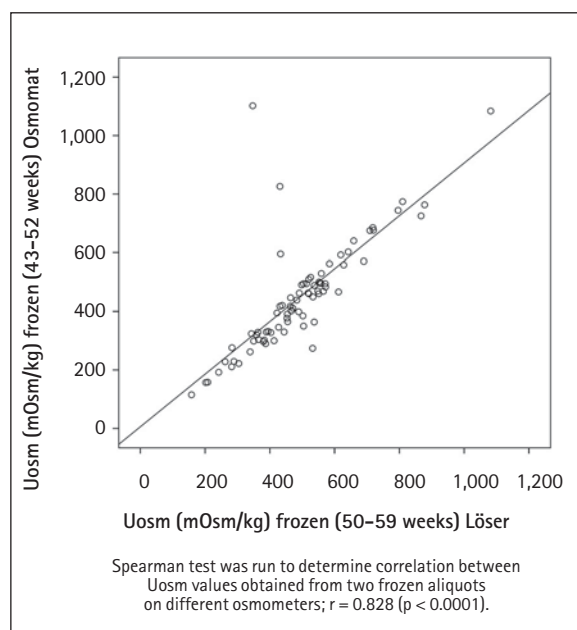


Fig. 3.—Comparison of Urinary Osmolality Measurements between Osmometers in Deep-Frozen, Third Collection Specimens.

succulent fruit which offer ~800 mL of water. Children could request additional servings of the beverages. Additional unknown amounts of liquids were probably consumed at home in the evenings. Between liquids and fruit, without considering the moisture in other plant and animal items of the diet, we have the basis of abundant water consumption.

Preschoolers are, by nature, physically active. However, in the rainy season at an altitude of 2,357 m, the ambient

Table II
Mean urinary osmolality values across pediatric studies of combined sexes in the literature review

Authors	Location	N	Age (y)	Mean Uosm (mOsm/kg)
Robers & Manz (1996) ⁶	Germany	231	3-18	801
Remer et al. (2006) ⁷	Germany	358	6-12	730
Stolley & Schlage (1977) ⁸	Germany	566	5	860*
Phillip et al. (1993) ⁹	Israel	200	2-6	791*
Chaptal et al. (1963) ¹⁰	France	46	3-14	755
Rittig et al. (1989) ¹¹	Denmark	22	Unspecified	676
Vande Walle et al. (2000) ¹²	Belgium	24	Unspecified	560
Soto-Méndez et al. (present)	Guatemala	78	2-6	531

*Data from spontaneous non-24-hour collection.

mean temperature of 15°C reduces perspiration and water losses by transpiration. Preschoolers in our study were in the narrow age range from 2-6 years. Other studies specified the ages ranges up to 12 to 18 years^{6,7,10}. This goes along with the relatively larger body surface and lung capacity and leads to greater absolute water losses in older children. We do not offer the values with the older children omitted in the Results Section, nor do we interpret these values. Although the Guatemalan values are the lowest in the international comparison, we feel that the values of 531 mOsm/kg (average) or 475 mOsm/kg (median) are plausible and consistent with the described conditions of collection, measurement, and the children's succulent diet, body-surface area and temperate environment.

The measurement reproducibility studies have important implications for the design and conduct of coordinated, multicentre urinary osmolality research. Here, we performed 2 comparisons, one related to the temperature of urine storage and another on the correspondence between two osmometers of different brands. In theory, on the one hand, the deep freezing of urine could cause precipitation of some of the less soluble constituents. These constituents might not be fully re-dissolved when the urine specimen is thawed and brought to room temperature. This would predict a decrease in Uosm value after freezing. On the other hand, any sublimation of water from the frozen urine would tend to reduce liquid volume and concentrate the constituents in solution. The results of our comparison of 0°C and -80°C storage showed no statistical significance ($p = 0.275$), the difference of the medians was as low as 0.4%, and the degree of association was almost 0.89 (fig. 2). For practical purposes, therefore, urine can be deep frozen for storage and later thawed and analyzed months afterwards without major distortion of Uosm results. A multicentre study, therefore, with urines shipped in frozen from the various participating centres to a common reference laboratory would run no risk of error.

Secondly, if Uosm in a multicentre trial were to be measured independently by use of osmometers in place at different study site, the degree of correspondence between the readings by different instruments become of interest. There was an 11% difference ($p < 0.001$) between the

Löser and Osmomat outputs, and the association was 0.82 (fig. 3). This is obviously unacceptable, if data were to be pooled. Perhaps, with a set of common test urines or standard solutions, the instruments in different laboratories could be calibrated to an acceptable range. However, our results caution that confiding in the identity of outputs of different instruments would be unwise.

Conclusions

Although they differ from Uosm/kg values in other pediatric series we believe our values to be plausible and valid for preschoolers of the Guatemalan Western Highlands. As in other series no differences between sexes were seen, and circumstantially, no Uosm differences were found from centre to centre. Most importantly, since the group data from each of the three collection periods was identical, only one round of collections will be needed to achieve the consensus estimate on a group basis. However, experience with collection process seems important to improve the quality and consistency of the data for the individual.

Our studies on reproducibility reveal that frozen storage has no effect on the consistency of measurement in a single osmometer. Samples collected at different moments and places can be combined in comparative analyses. However, it will not be prudent to measure Uosm on different equipment without having a rigorous crossed-standardization and common calibration of the instruments involved.

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Adequate hydration status promotes a lower concentration of proinflammatory cytokines in healthy adults

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Abstract

Background: Good hydration status (HS) is necessary for an adequate homeostasis of the organism. Cytokines are secreted mainly by inflammatory leukocytes and act as intercellular mediators.

Objective: Assessing pro and anti-inflammatory cytokines concentration in serum and in the aqueous phase of stools (APhS) from healthy adults in function of their HS.

Methods: HS data were obtained from 86 healthy adults of 45–65 years old and BMI ≥ 18.5 – <40 kg/m². HS was measured by bioelectrical impedance (BIA) with a standardized protocol. Cytokines serum concentrations were determined by multiple ELISAs. Stools were recollected by the participants, frozen, and carefully transported to the laboratory where they were stored at -80°C until their determination. Stools were ultra-centrifuged and cytokines were measured in APhS with an ultra-sensitive cytokines array. All samples were analyzed in duplicate.

Results: Mean age was 51.2 ± 4.9 years old and BMI was 28.2 ± 4.7 kg/m². The average intake of water from foods and beverages was not adequate enough ($1,411.6 \pm 427.4$ ml/day; 81% consumed less than two-thirds of the recommended intake) however only 89.5% showed an adequate HS and only 10.5% showed clearly dehydration measured by BIA. Volunteers who had good HS had lower values of IFN γ (2.7 ± 2.4 vs 6.4 ± 4.3 pg/ml; $p < 0.05$) and IL6 serum (5.5 ± 13.3 vs 6.4 ± 16.3 pg/ml; $p < 0.01$) than those who had a dehydration status. IL1 from APhS showed lower values in adults with good hydration than those dehydrated (648.3 ± 615 vs $1,194 \pm 561.2$ pg/ml; $p < 0.05$).

Conclusions: Adults with an appropriate HS have a minor concentration of pro-inflammatory cytokines in serum and in APhS than adults who showed a dehydration status. More studies are needed in order to corroborate these results.

Key words: Body water. Hydration. Dehydration. Cytokines and bioelectrical impedance analysis.

UNA ADECUADA HIDRATACIÓN PROMUEVE UNA MENOR CONCENTRACIÓN DE CITOQUINAS PROINFLAMATORIAS EN ADULTOS SANOS

Resumen

Introducción: Un adecuado estado de hidratación (EH) es necesario para mantener la homeostasis del organismo. Las citoquinas son mediadores intercelulares que son secretadas principalmente por leucocitos.

Objetivo: Valorar la concentración de citoquinas pro y antiinflamatorias en suero y la fase acuosa de las heces (FAH) de adultos sanos en función de su EH.

Métodos: Se obtuvo información sobre el EH de 86 adultos sanos de 45–65 años y un IMC de 18.5 – <40 kg/m². El EH fue medido por Impedancia Bioeléctrica (BIA) siguiendo el protocolo estándar. La concentración de citoquinas en suero fue determinada por múltiples ELISAs. Las heces fueron recolectadas por los participantes, congeladas y transportadas al laboratorio donde fueron almacenadas a -80°C hasta su determinación. Posteriormente las heces fueron ultracentrifugadas y las citoquinas fueron medidas en la FAH con un array ultrasensible.

Resultados: La edad media fue de $51,2 \pm 4,9$ años y el IMC fue de $28,2 \pm 4,7$ kg/m². El consumo medio de agua proveniente de los alimentos y las bebidas realizado por los participantes no fue suficiente ($1.411,6 \pm 427,4$ ml/día; el 81% consumió menos de dos tercios de la ingesta recomendada), sin embargo, el 89,5% presentó un adecuado EH y solo el 10,5% estuvo en rango de deshidratación. Los participantes con un adecuado EH tuvieron valores de IFN γ ($2,7 \pm 2,4$ vs $6,4 \pm 4,3$ pg/ml; $p < 0,05$) e IL6 séricos ($5,5 \pm 13,3$ vs $6,4 \pm 16,3$ pg/ml; $p < 0,01$) inferiores a las personas deshidratadas. La IL1 medida en la FAH mostró una concentración más baja en personas bien hidratadas que en aquellas deshidratadas ($648,3 \pm 615$ vs $1194,0 \pm 561,2$ pg/ml; $p < 0,05$).

Conclusiones: Los adultos de nuestro estudio con un adecuado EH presentan una concentración inferior de citoquinas proinflamatorias en suero y en la FAH que aquellos que estaban deshidratados. Se necesitan más estudios que confirmen estos resultados.

Palabras clave: Agua corporal. Hidratación. Deshidratación. Citoquinas y análisis de bioimpedancia.

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Abbreviations

HS: Hydration Status.
APhS: Aqueous Phase of Stools.
BMI: Body Mass Index.
BIA: Bioelectrical Impedance.
IFN: Interferon gamma.
IL6: Interleukin 6.
MCP1: Monocyte Chemotactic Protein-1.
VP: Neuropeptide hormone vasopressin.
TNF: Tumour necrosis factor-alpha.

Introduction

Good hydration status (HS) is necessary for an adequate cellular homeostasis of the organism and life. The cellular volume is a key signal for the metabolic orientation of cell metabolism¹. Under normal conditions the hydration of the fat free mass varies by only a few percentage points^{2,3} with the average of 73.2% water. Total body hydration and the balance between input and output of water are under homeostatic control by mechanisms which modify excretory pathways and stimulate intake. The role of water in health is generally characterized in terms of deviations from an ideal hydration status, generally in comparison to dehydration. It has generally been considered that decreases in performance responses and physiological impairment become apparent when dehydration exceeds 2% of body weight; that performance decrements become substantial when fluid losses exceed 5% of body weight; and that when fluid losses approach 6–10% of body weight, heat stroke and heat exhaustion become life-threatening⁴.

The concept of dehydration encompasses both the process of losing body water and also the state of dehydration. The mismatch of fluid intake and fluid losses may lead to a body water deficit⁵. Mild levels of dehydration can produce disruptions in mood and cognitive functioning⁶ however there is increasing evidence that mild dehydration may play a role in various others morbidities. In this sense, good hydration has been associated with a reduction in hypertension, fatal coronary heart disease, venous thromboembolism, and cerebral infarct⁷. Some of these diseases present a low-grade inflammation which plays a role in their evolution⁸. Inflammation is characterized by an increased concentration of pro-inflammatory cytokines. The main cytokine function is acting as intercellular mediators helping in cell signalling. In normal conditions cytokines are in a dynamic equilibrium, however in some stress circumstances, like dehydration, its concentrations can change. Some studies in experimental animals suggest that the central activation of interleukin-1 receptors by IL-1beta is able to impair the thirst-inducing mechanisms triggered by the physiological stimulus represented by dehydration, hyperosmolarity and hypovolemia⁹. It has been observed that some pro-inflammatory cytokines as TNF α induced weight loss in mice due, at least in part, to dehydration¹⁰. Even

thought there is some evidence that dehydration stimulus can increase pro-inflammatory cytokines in animals¹¹, there is a lack of evidence on human studies. For this reason, the present study assesses pro- and anti-inflammatory cytokines concentration in serum and in the aqueous phase of stools (APhS) from healthy people in function of their hydration status.

Methods

Study subjects

The study included 86 healthy adults (69 women and 17 men) of 45 to 60 years old who were recruited by staff of the Nutrition Department, La Paz University Hospital. The inclusion requirements were to have a BMI ≥ 18.5 but < 40 kg/m² and not to be adhered to any calorie restriction diet or be taking any weight control medication. The exclusion criteria were to be suffering of serious concomitant diseases such as diabetes mellitus type II, metabolic syndrome (according to the criteria of the Adult Treatment Panel III), cancer, kidney disease, HIV, tuberculosis, cardiovascular disease, chronic obstructive pulmonary disease, eating disorders, having undergone bariatric surgery and/or intestinal resection, and pregnancy. All subjects gave their signed, informed consent to be included in the study, as required by the latest version of the Helsinki declaration¹². The study was approved by the Scientific Research and Ethics Committee of the La Paz University Hospital (SREC Code 3824).

Hydration Status Determination

Hydration status data were obtained using bioelectrical impedance (BIA) (Electro Fluid Graph, Akern SRL, FI, USA) from the whole body. BIA was carried out after a 12-hour-overnight fast, with no stimulant drink or food consumption, no strenuous exercise 24 hours before and 30 minutes after urination and without any metallic objects during the measurement. From BIA were taken reactance and resistance data and using a standardized biovectornormogram (Body Gram Pro 3.0 Software Interface for Akern Body Composition Analysers[®]) it was possible obtain the HS. Thus, a person who is in the area 1 and 2 presents a dehydration status, between 2 and 4 a good hydration status, and in the area 4 and 5 a hyperhydrated status (Figure 1). This technique takes into account the participants age, weight and gender.

Serum cytokines determination

Blood samples were taken early in the morning at the La Paz University Hospital Extraction Unit after an 8 to 12-hour-overnight fast. Samples were stored at 4 to 6°C until analysis which was always performed within 48 h. These samples were prepared according to the standar-

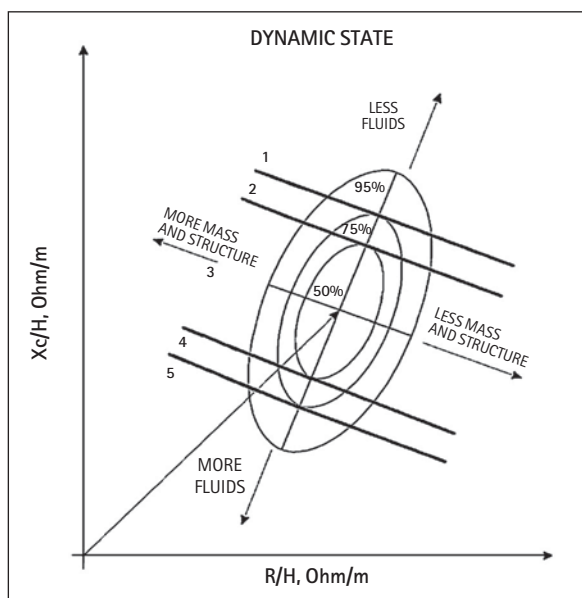


Fig. 1.—Classification of hydration status by Standardized Biovector normogram.

dized protocol and IFN γ , IL10, IL1 β , IL6, MCP1 and TNF α cytokines serum were quantified using a Luminex®-LX200 Analyzer (Millipore Corp, Billerica, Massachusetts, USA) and a MILLIPLEX MAP Human Cytokine/Chemokine Panel I (HCVD3-67CK-06) and a single plex Multi-species TGF β (TGF β -64K-01) (Millipore, St. Charles, Missouri, USA). All samples were analyzed in duplicate. Data were analyzed using 3.1 xPONENT Software (Millipore). The intra- and interassay coefficients of variation for the cytokine assays all fell in the 5–10% range. All analyses were performed in the Laboratory of Molecular Biology at the La Paz University Hospital.

Aqueous phase of stools cytokines determination

Stools were collected by the participants and immediately frozen at home. The stool sample must not be contaminated with water or urine and it had to be the closest sample to the consultation day. The samples were carefully cold transported to the laboratory where they were stored at -80°C until their determination. When all samples were collected the stools were homogenized with 2 ml of PBS buffer (pH of 7). Later, they were ultra-centrifuged at 13,000 rpm for 7 minutes in order to isolate the aqueous phase of stools. Cytokines were measured in this phase with an ultra sensible-cytokine array (Cytokine Array I High Sensivity from Randox®). All samples were analyzed in duplicate. Data were analyzed using an Evidence Investigator™ Analyzer (Randox®). The intra- and interassay coefficients of variation for the cytokine assays all fell in the 5.6–12.8% range. All analyses were performed in the Laboratory of Gastroenterology at the La Paz University Hospital.

Total water intake

Food and beverage intake was monitored using a food frequency questionnaire and a 3-day Food and Drink Record (including a Sunday) which were filled in the same week of the study. Subjects were instructed to record the weights of foods consumed if possible and to use household measurements (cups, spoons, etc) if not. All the information was processed in the DIAL software (Alce Ingeniería, 2004) from where it was obtained the total water consumed by the participants. Values obtained were compared to the water recommended intake (RI) which was 35 ml per kg body weight per day. With these data it was possible to calculate the percentage of RI contribution. The energy and nutrients contents of these foods were also obtained. The percentage of discrepancy in reporting was established in accordance with Johnson et al (1994) by using the following formula: Discrepancy (%) = (energy expenditure - energy intake) \times 100/energy expenditure¹³. When this method is used, a negative value indicates a reported energy intake greater than predicted total energy expenditure (over reporting) and a positive value denotes a reported energy intake less than predicted total energy expenditure (underreporting).

Statistical analysis

Data are presented as means \pm standard deviation (SD). The Kolmogorov-Smirnov test was used to check the normal distribution of the data. Atypical data (i.e., lying more than two SD from the mean) in asymmetric distributions were deemed to reflect true results; they were, therefore, not eliminated from the analysis. The Levene test was used to determine whether the variance presented by the measured variables was homogeneous. When the distribution of the results was normal, the Student t test was used to compare the mean values of the studied variables recorded for the two treatment groups. The Mann-Whitney U test was used when the distribution was not normal.

Results

From the 86 volunteers enrolled in the study, seventy five (89.5%) presented a good hydration status while nine out of eighty six (10.5%) were classified as dehydrated people (table I).

The main BMI classified the population as overweight in both groups and, even when there was a higher percentage of normal BMI in the dehydrated group, there was not a significant difference between them.

Average of total water from food and beverages was not adequate enough ($1,411.6 \pm 427.4$ ml/day), only one participant has a consumption higher than recommended intake and 77.9% of the population consumed less than two-thirds of the recommended intake which was $2,662.2 \pm 539.1$ ml/day. In this sense the underreporting of the diet was $8.2 \pm 11.2\%$ without significant differences between groups.

Table I
General characteristics of the sample. Differences in function of the hydration status ($X \pm SD$)

Variable	Hydrated	Well hydrated
n (%)	77 (89.9)	9 (10.5)
Age (years)	51.4 \pm 5.1	50.1 \pm 2.3
Weight (kg)	76.9 \pm 15.3	68.9 \pm 14.6
BMI (kg/m ²)	28.4 \pm 4.5	26.3 \pm 5.7
Normal (%)	27.3	44.5
Overweight (%)	39	33.3
Obesity (%)	33.7	22.2
Water Consumption (ml)	1,412 \pm 442	1,406 \pm 287
Recommended intake (RI) (ml)	2,691 \pm 537	2,411 \pm 513
RI Contribution (%)	60.2 \pm 15	54 \pm 19
Less than 2/3 RI (%)	79.2	66.6

Without significant difference between groups.

Table II
Cytokines concentration in serum. Differences in function of the hydration status ($X \pm SD$)

Variable	Well Hydrated	Dehydrated
TGF β (pg/ml)	34,037.83 \pm 8,368.69	31,096.67 \pm 11,408.49
IL10 (pg/ml)	3.79 \pm 9.87	4.72 \pm 4.72
IFN γ (pg/ml)	2.75 \pm 2.5	6.48 \pm 4.37*
IL1 β (pg/ml)	2.85 \pm 5.51	1.85 \pm 1.21
IL6 (pg/ml)	3.94 \pm 2.27	15.86 \pm 33.95**
MCP1 (pg/ml)	257.48 \pm 827.5	700.44 \pm 357.52°
TNF α (pg/ml)	24.12 \pm 38.96	26.1 \pm 32.48

Significant differences between groups: °p < 0.1; *p < 0.05; **p < 0.01.

Table III
Cytokines concentration in aqueous phase of stools. Differences in function of the hydration status ($X \pm SD$)

Variable	Well Hydrated	Dehydrated
IL10 (pg/ml)	1.99 \pm 1.63	2.51 \pm 1.03
IL4 (pg/ml)	8.2 \pm 8.26	6.56 \pm 4.45
IL2 (pg/ml)	13.57 \pm 24.94	9.83 \pm 6.31
IL6 (pg/ml)	6.45 \pm 16.35	5.57 \pm 13.38
IL8 (pg/ml)	3.44 \pm 14.56	2.78 \pm 2.89
VEGF (pg/ml)	167.47 \pm 261.99	238.3 \pm 184.96
IFN γ (pg/ml)	2.57 \pm 3.99	1.93 \pm 1.81
TNF α (pg/ml)	9.34 \pm 6.96	12.71 \pm 5.06
IL1 α (pg/ml)	648.34 \pm 615.88	1,194.01 \pm 561.25*
IL1 β (pg/ml)	11.66 \pm 36.16	11.91 \pm 16.29
MCP1 (pg/ml)	9.36 \pm 21.62	8.12 \pm 8.03
EGF (pg/ml)	30.27 \pm 89.67	20.36 \pm 41.28

Significant differences between groups: *p < 0.05.

Otherwise, volunteers who had a good hydration status showed lower values of IFN γ (2.7 \pm 2.4 vs 6.4 \pm 4.3 pg/ml; p < 0.05) and IL6 serum (5.5 \pm 13.3 vs 6.4 \pm 16.3

pg/ml; p < 0.01) than those who had a poor hydration status (table II). Serum monocyte chemotactic protein-1 (MCP1) presented the same tendency (257.4 \pm 827.7 vs 700 \pm 357.2 pg/ml) but the difference was not significant (p = 0.062). Other pro-inflammatory cytokines did not show significant differences between well hydrated or dehydrated adults. Anti-inflammatory cytokines as TGF β and IL10 serum did not presented significant differences between groups either.

In regard to aqueous phase of stools cytokines, it was possible to observe that adults with good hydration status had lower values of IL1 α than those dehydrated (648.3 \pm 615 vs 1,194.0 \pm 561.2 pg/ml; p < 0.05). The rest of the cytokines evaluated in this phase however, did not show significant differences in function of the hydration status.

Discussion

In this study, adults with an appropriate hydration status have lower concentration of pro-inflammatory cytokines in serum and in aqueous phase of stools than those who presented a dehydrated status.

However, it is fundamental to know how to measure the hydration status. Water is found in various compartments: intracellular fluid accounts for about 55% of total body water, interstitial fluid for about 20% and intravascular fluid for about 7.5%. For these reasons it is inevitable that no single measure can adequately reflect a dynamic and complex mechanism¹⁴. Even though there is not a one hundred per cent effective method to determine the hydration status, the use of bioelectrical impedance (BIA) analysis is widespread both in healthy subjects and patients. BIA allows the determination of the fat-free mass and total body water (TBW) in subjects without significant fluid and electrolyte abnormalities when using appropriate population, as used in these study, age BIA equations and established procedures¹⁵. BIA is easy, non-invasive, and relatively inexpensive and can be performed in almost any subject because it is portable. Using a standardized bioelectrical impedance vectornormogram it was possible find the adults who were dehydrated and the ones who were not. The ultimate attractiveness of BIA lies in its potential as a stand-alone procedure that permits patient evaluation from the direct measurement of the impedance vector and does not depend on equations or models¹⁶. In vector BIA, resistance (R) and reactance (Xc), standardized for height, are plotted as point vectors in the R-Xc plane (Figure 1). An individual vector can then be compared with the reference 50%, 75%, and 95% tolerance ellipses calculated in the healthy population of the same gender and race (R-Xc graph method). The ellipse varies with age and body size. It has been followed a strict procedure to carry out BIA and it is possible trust in the results obtained.

Taking into account this technique, 89.5% of the population had a good hydration status while 10.5% presented a dehydration status. This information contrasts with the total water intake observed by the participants enrolled in the study. Total water consump-

tion from foods and beverages was very low when it is compared to the recommended intake calculated from the participants' weight. A very high percentage of the population presented water intakes classified as at risk even when they were well hydrated. Two reasons are possible to explain this result. The whole diet underreporting average was high, that means people reported less energy from foods and beverages than predicted total energy expenditure (underreporting). Underreporting affects directly the total water intake as well. Additionally the adults enrolled in the study could be reported fewer liquids consumed than they really consumed. Another point to consider is that in this study has not been implemented a specific total water intake questionnaire. In light of the results it is recommendable used a specific questionnaire in order to complete the information. Even more, dietary intake of water is a highly variable event, which experiences significant differences day to day on the week, body size, physical activity and climatic exposure¹⁷ on a basic underlying pattern of consumption. Although the total water consumption was below the recommendation used, which was made according to actual body weight, and this was higher than showed in another studies in Spain¹⁸ and in Europe^{19,20}.

Cytokines are host's regulators which responses to infection, immune responses, inflammation, and trauma. All of them have an important role as intercellular mediators helping in cell signaling. Some cytokines act promoting inflammation (pro-inflammatory cytokines), whereas others serve to reduce inflammation and promote healing (anti-inflammatory effect). In this study adults with a good hydration status had lower values of some pro-inflammatory cytokines in serum (IFN γ and IL6) than those poor hydrated. It has well known that inflammation is a potential mechanism linking obesity²¹. In fact, growing body of evidence recently linked the pathogenesis of this disorder with a systemic low-grade inflammatory state characterized by an increase in the circulating levels of several pro-inflammatory mediators²². In our study there are 28% of people with obesity and it is likely that levels of pro-inflammatory cytokines are altered not by hydration status but by this physiological state. However, when it has been compared both hydration groups there were not any significant difference and even after excluding obesity adults the difference between groups were conserved ($p < 0.05$). Clinical use of BIA in subjects at extremes of BMI ranges cannot be recommended for routine assessment of patients, however longitudinal follow-up of body composition by BIA is possible in subjects with BMI from 16 until 34 kg/m² without abnormal hydration²³. In this study, obesity did not promote large changes in cytokines concentration but dehydration status did.

In this study, higher pro-inflammatory cytokines in serum were found in dehydrated adults. A possible explanation for these results is that, in dehydrated people, the pro-inflammatory cytokines can be working

as a signal to trigger other mechanisms to regulate the hydration status. In this sense, it is known that some cytokines such as the IL6, the IL1 or the TNF can transmit information to the hypothalamus, place where the vasopressin (VP) is synthesized, and it plays a key role in water homeostasis. The VP has a crucial role in osmoregulation and, consequently, in hydration regulation. Following the onset of dehydration (fluid deprivation), mammals respond to plasma hyper-osmolality by reducing the renal excretion of water. VP increases the permeability of the collecting ducts to water, promoting water conservation by decreasing the amount of water lost in urine. Physiological activation by dehydration results in a massive release of the stored hormone. Some studies revealed that IL6 up-regulation is followed to dehydration in experimental animals¹¹. The dehydration stimulus resulted in an increase in IL6 immune-reactivity and the authors suggest that IL6 takes the same secretory pathway as vasopressin.

But also the vasopressin acts in conjunction with corticotrophin-releasing hormone to modulate the release of corticosteroids from the adrenal gland. Corticosteroid as cortisol is related to the hydration status regulation. Cortisol acts as an antidiuretic hormone²⁴. In this study, IL1 α from APhS showed higher values in dehydrated adults. In this sense, intestinal level of pro-inflammatory cytokines could be working as a signal to trigger regulation of the hydration status. It is known that a decrease in water excretion following a decline in cortisol is due to inverse stimulation of vasopressin which, as it has been indicated before, takes part in the hydration status.

All these mechanisms could be working in dehydrated people explaining the results; however, more research is needed to verify the mechanisms of action and consequences of an inadequate hydration status in healthy people.

Conclusions

Adults with an appropriate hydration status have lower concentration of pro-inflammatory cytokines in serum and in aqueous phase of stools cytokines than people who showed a dehydrated status. Results from this study illustrate how an inadequate hydration status can favor an increase in concentration of pro-inflammatory cytokines. Having a good hydration status through food and beverages is essential for the adequate homeostasis of the organism.

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Sugar-sweetened soft drink frequency and associated factors in Spanish schoolchildren

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Abstract

Introduction: Childhood obesity is increasing alarmingly, and the consumption of sugared soft drinks (SSD) has been reported as a risk factor for weight gain and obesity in some systematic reviews. Nevertheless, the factors associated with the consumption of SSD, including activity patterns and some family factors, have not been investigated in deep in Spanish children.

Objective: to analyze SSD consumption habits in Spanish children and their relationship with physical activity habits and family factors.

Methods: 7,659 6–9-years-old Spanish children (3,841 boys and 3,818 girls) were selected to participate in ALADINO study. Children's weight and height were measured, and BMI calculated. Parents answered a questionnaire about the frequency of consumption of some beverages and activity patterns of their child, parent's weight and height, and other family aspects. Data were analyzed regarding the frequency of consumption of SSD using SPSS (v.19.0).

Results: 53.5% of children never consumed SSD (Non-drinkers, ND), 36.8% consumed them 1–3 times/week and 9.6% drunk SSD more than 3 times/week (frequent drinkers, FD). Children's BMI were similar in all groups. Nevertheless both father's and mother's BMI were higher in FD groups vs ND. Comparing with ND group, in FD group there were more children who skipped breakfast, spent >2 h/day watching TV or >1 h/day playing with computer games, and lived in families with a higher percentage of smoker parents, less educated mothers and fathers, and lower income.

Conclusion: In this group of Spanish children the frequency of consumption of SSD is not related to their BMI, but is associated with a more sedentary pattern of activity and unhealthy habits in their families.

Study founded by AESAN

Key words: Child. Carbonated beverages. Life style. Socioeconomic factors. Family.

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FRECUENCIA DE CONSUMO DE REFRESCOS AZUCARADOS Y FACTORES ASOCIADOS EN ESCOLARES ESPAÑOLES

Resumen

Introducción: Las cifras de obesidad infantil están aumentando de forma alarmante. Algunas revisiones sistemáticas sugieren que el consumo de bebidas azucaradas es uno de los factores relacionados con el aumento de peso y riesgo de obesidad. Sin embargo, no se han estudiado suficientemente los factores relacionados con este consumo de bebidas azucaradas, como pueden ser los hábitos de actividad física y características del entorno familiar, especialmente en niños españoles.

Objetivo: Analizar la frecuencia de consumo de refrescos azucarados (RA) en población escolar española y su relación con los hábitos de actividad física y características familiares.

Métodos: Se han estudiado 7.659 escolares españoles de 6 a 9 años (3.841 niños y 3.818 niñas) participantes en el estudio ALADINO, a los que se midió el peso y altura y se calculó su IMC. Los padres cumplimentaron un cuestionario con preguntas sobre la frecuencia de consumo de diferentes bebidas, las actividades realizadas habitualmente por su hijo, el peso y altura de los padres y características del entorno familiar. Se analizaron los datos en función de la frecuencia de consumo de refrescos azucarados empleando el programa SPSS (v.19.0).

Resultados: El 53,5% de los escolares no consume nunca RA (No consumidores, NC), el 36,8% los consume entre 1 y 3 veces por semana y el 9,6% los toma con más frecuencia (consumo frecuente, CF). El IMC de los escolares fue similar en todos los grupos. Sin embargo, el IMC de los padres y madres de niños del grupo CF fue significativamente mayor que para los del NC. En comparación con el grupo NC, en el grupo CF hay un mayor porcentaje de escolares que se saltan habitualmente el desayuno, ven más de 2 horas al día la TV o juegan más de 1 hora diaria con ordenadores o consolas, viven en familias con menores ingresos y tienen padres con menor nivel educativo o que son fumadores.

Conclusión: En este grupo de escolares españoles, la frecuencia de consumo de RA no está relacionada con su IMC, pero sí con un estilo de vida más sedentario y un entorno familiar menos saludable.

Palabras clave: Escolares. Refrescos. Estilo de vida. Factores socioeconómicos. Familia.

Abbreviations

ALADINO: "Diet, Physical Activity, and Obesity Child Development" Study.

FD: Frequent drinkers.

ND: Non drinkers.

OD: Occasionally drinkers.

SSB: Sugar-sweetened beverages.

SSD: Sugar-sweetened soft drinks.

WHO: World Health Organization.

Introduction

Childhood obesity is increasing alarmingly over the world¹. In Spain 18.3% of the schoolchildren between 6 and 9 years of age are obese². Obesity is a multifactorial disease, which involves genetic, metabolic and psychological factors, as well as eating habits and physical activity. One of this associated factors with increased odds of obesity are sugar sweetened beverages (SSB). These beverages have a high energy content, low glycemic index and also low satiety index, which can cause increased food intake after their ingestion^{3,4}. SSB consumption has been linked to weight status in children, and the consumption of these beverages has been reported as a risk factor for weight gain and obesity in some systematic reviews⁵⁻⁷. However, not all studies have observed this association or conclude that the results are still inconsistent⁷⁻⁹.

SSBs include sugared soft drinks (SSD), also carbonated drinks, sugared fruit juices and sugared sport drinks^{10,11}. SSB are consumed by about half of European adolescents and accounted for the largest amount of per capita energy intake from beverages¹².

Only few studies have analyzed the determinants of soft drink consumption in schoolchildren¹³, and the factors associated with the consumption of SSD, including activity patterns and some family factors, have not been investigated in deep in Spanish children.

Because of that, the aim of the present work is to analyze the SSD consumption habits of Spanish children and their relationship with physical activity habits and some family factors.

Methods

Sample

We have analyzed data from ALADINO study. "ALADINO" is the acronym that stands for "Diet, Physical Activity, and Obesity Child Development". The aim of the ALADINO study was to determine the prevalence of overweight and obesity in children in Spain. A detailed description of ALADINO study has been previously described². Briefly, this study is a cross-sectional study of Spanish children of primary school age (6-9 years), conducted from October 2010 to May 2011. The

sample was selected using a multistage method to ensure it was representative of Spanish boys and girls aged 6, 7, 8 and 9 years. The sample was stratified by political region, and was further stratified by the size of its population centres. Schools were then selected within each population stratum, again by simple random sampling, taking into account the region and the size of the population, and the kind of school (public or private). This study is affiliated with the World Health Organization European Childhood Obesity Surveillance Initiative (COSI), which was jointly developed by the WHO Regional Office for Europe and the participating Member States, which involved 17 member states using a common methodology to allow comparisons between countries¹⁴.

Data

The ALADINO study involved the original COSI questionnaires, translated and adapted for the Spanish population. A personal questionnaire for the children was completed during personal interviews at school. Also a family questionnaire was completed by parents of participating children, in which the social, economic and cultural characteristics of each family were recorded, as it also included information on food habits and the practice of physical activity of the children. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Ethics Committee of the Faculty of Pharmacy (Complutense University of Madrid, Spain). Written informed consent was obtained from the parents/guardians of participating children.

Frequency of consumption of SSD

The information about the frequency of consumption of SSD was extracted from the questions about food habits. Parents should complete a qualitative food and beverage frequency questionnaire, answering the question: "Over a typical or usual week, how often does your child eat or drink the following kinds of foods or beverages?". Possible answers were: "Never", "Some days (1-3 days)", "Most days (4-6 days)", "Once per day", and "2 or more per day". Children were classified as Non-drinkers (ND) if they never consumed SSD, "Occasionally drinkers" (OD), if they only consume some days, and "Frequent drinkers" (FD) if they consumed SSD 4 or more days per week.

Anthropometric data

During a personal interview at the schools, each child's anthropometric data were recorded by trained researchers. Body weight was recorded using a digital balance (model Tanita UM 076; range 0.1-150 kg, preci-

sion 100 g). Subject height (without shoes) was determined using a Tanita Leicester Portable Height Measure (range 0–207 cm, precision 1 mm). For these measurements, children were dressed in light clothing and did not wear shoes. Waist and hip circumferences were recorded using a Seca measuring tape (Seca 201; range 0–205 cm, precision 1 mm). The waist circumference was taken midway between the inferior margin of the last rib and the crest of the ilium, in a horizontal plane. The hip circumference was measured at the horizontal plane of maximum circumference encircling the buttocks. An assistant helped to hold the tape on the side of the subject's body opposite to the measurer. Standard techniques were employed throughout and WHO guidelines followed¹⁵. Body mass index (BMI) was calculated thus: $BMI = \text{Weight (kg)} / \text{height}^2 \text{ (m}^2\text{)}$. The prevalence of overweight and obesity was determined to using WHO growth standards¹⁶.

Other variables

Data about sex and age of each child (calculated from date of birth) was collected. Parents reported their weight and height and then mother's and father's BMI were calculated. They were classified as overweight or obese using WHO criteria¹⁷. Smoking habits of parents were described as "None of parents are smokers", "One parent is smoker", and "Both parents are smokers". Breakfast habits were recorded using two different questions: one for the children during the examination day ("Did you have breakfast this morning?") and other for parents ("Over a typical or usual week, how often does your child have breakfast?"). Parents reported the usual time the child spent watching TV (including videos) or using a computer for playing games on both weekdays and weekends. Highest educational level reached by mothers and fathers and family income in last year were also described.

Statistical analysis

Quantitative data are expressed as mean and standard deviation (SD), and qualitative ones as percentages. Preliminary analysis was carried out to test normality of the data using Kolmogorov-Smirnov test. The differences by sex were assessed using Student's t-test with quantitative data where the data was normally distributed, or using the Mann-Whitney test otherwise. Differences by SSD frequency of consumption were analyzed using ANOVA or Jonckheere-Terpstra test for ordered alternatives for quantitative variables, or Chi² analysis for qualitative ones. Comparisons between proportions were made using a normal approximation to the binomial distribution, using a continuity correction. The statistical significance was set at $p < 0.05$. All calculations were made using SPSS software (version 19.0 for windows; SPSS Inc., Chicago, IL).

Results

7,659 6–9-years-old Spanish children (3,841 boys and 3,818 girls) participated in ALADINO study. From these 7,079 (3,539 boys and 3,540 girls) answered the question regarding SSD frequency of consumption (92.4% of whole population) and were considered for this work.

Anthropometric and other data about the habits of consumption of SSD are shown in table I. Girls had lower weight, height and waist circumference, and lower prevalence of obesity than boys. Also, the frequency of consumption of SSD differs between sexes. There were more girls who never consume SSD and fewer who drank occasionally SSD (1–3 days/week) than boys. There were more boys who spent more than 1 hour per day playing with PC games or consoles, or who watch 2 or more hours per day watching television on weekends, comparing with girls. Regarding family characteristics, BMI of mothers and fathers were similar for boys and girls. Twenty-two point eight percent of mothers and 51.7% of fathers were overweight, and 7.5% of mothers and 14.6% of fathers were obese. 54.7% of children lived in families with no smoker parents, without differences between boys and girls. Nineteen point six percent of mothers and 25.7% of parents reached only primary studies, and 39.4% and 32.1% of mothers and fathers, respectively, had an university degree. Forty-three point three percent of parents declared a family income lower than 18.000 €/year, and 31.5% higher than 30.00 €/year. There were no differences regarding the sex of children in these familiar data.

Table II shows anthropometric, dietary and screen time data regarding the frequency of consumption of SSD. Children in OD and FD groups were older and taller than ND children. Nevertheless, when the sample was split taking into account the sex, we only found differences in boys regarding the age and height. OD and FD boys were slightly older (7.62 ± 1.1 years in both groups) than ND boys (7.45 ± 1.1 years, $p < 0.05$), and OD boys were taller (130.5 ± 8.5 cm) than ND ones (129.4 ± 8.5 cm, $p < 0.05$); there were no differences in anthropometric data of girls regarding SSD frequency of consumption. BMI was similar in all groups, even if we considered sex. More children in OD and FD groups skipped their breakfast, either punctually the day of the examination or routinely some or many days in the week. There were also more children in OD and FD groups with higher screen activity, both watching TV or playing with PC games and consoles.

Considering the familiar characteristics (table III), we found that the higher frequency of consumption of SSD, the higher parental BMI and the more prevalence of obesity in both mothers and fathers. There were also more smoking parents in OD and FD groups, and their educational level and family income were also lower in FD groups comparing with both ND and OD.

Discussion

Data from the present study indicate that in Spanish children between 6 and 9 years, the frequency of

Table I
Anthropometric data, dietary habits and screen time of studied children depending on the sex

	Total (n = 7,079)	Boys (n = 3,539)	Girls (n = 3,540)
Anthropometric data			
Age (y), mean ± SD	7.53 ± 1.12	7.55 ± 1.12	7.54 ± 1.12
Weight (kg), mean ± SD	30.34 ± 7.53	30.67 ± 7.51	30.06 ± 7.51***
Height (cm), mean ± SD	129.44 ± 8.55	129.92 ± 8.4	129.0 ± 8.62***
Waist (cm), mean ± SD	60.61 ± 7.64	61.08 ± 7.65	60.21 ± 7.65***
Hip (cm), mean ± SD	71.05 ± 8.03	71.1 ± 8.1	71.04 ± 7.98
BMI (kg/m ²), mean ± SD	17.89 ± 2.91	17.9 ± 2.9	17.8 ± 2.9
Overweight (%)	26.5	27.2	25.8
Obese (%)	18.3	20.9	15.5 *
Frequency of consumption of SSB (%)			
Never	53.5	51.8	55.3 *
Some days (1–3 days)	36.8	38.0	35.6 *
Most days (4–6 days)	4.9	5.3	4.6
Once/day	3.5	3.6	3.5
≥ 2 times/day	1.2	1.3	1.0
Breakfast habits (%)			
Skipped breakfast the day of the interview (#)	3.1	3.3	3.0
Habitual breakfast frequency (##):			
Always	93.8	94.4	93.1
4–6 days/week	3.6	3.3	4.0
1–3 days/week	2.1	1.8	2.4
Never	0.5	0.5	0.5
Screen time (%)			
Weekdays			
TV > 2 h/day	26.3	26.4	26.2
PC games > 1 h/day	13.6	16.5	10.5 *
Weekend days			
TV > 2 h/day	72.1	73.2	71.1 *
PC games > 1 h/day	52.1	62.1	41.6 *

Declared by the child; ## Declared by parents; * p < 0.05, *** p < 0.001

consumption of SSB is unrelated to their BMI or the condition of being overweight or obese. However, those children who consume these drinks more frequently also skip breakfast more often and spend more time on sedentary screen activities, like watching TV or playing with PC or consoles. Their parents declared a higher BMI and were more obese, more likely to be smokers, reached a lower education level and these children lived in families with lower household income.

We found that 38.8% of children occasionally (1–3 days/week) drink SSD and 9.6% do it more frequently. A comparison with other studies is difficult because there is no unanimity regarding which beverages are considered SSB or SSD, neither on how to define the consumption of these drinks. But the declared frequency of consumption in our study seems lower than that observed in other studied groups. For example, in USA, DeBoer et al.¹⁸ found 9.3%, 13.0% and 11.6% of children 2-, 4- and 5-years old who drink more than one soft drink per day, Striegel-Moore et al.¹⁹ found that 39% of children between 2 and 5 years of age drink SSD and Grimm et al.²⁰ found that 30% of children between 8–13

years drank soft drinks daily and that only 18% consume them less than once a week. Jensen et al.²¹ found that more than 70% of children and adolescents in Australia consumed sweet drinks, defined as soft drink and fruit juice and 32.5% of European adolescents between 12 and 17 years in HELENA study consumed SSB (including in this case calorically sweetened soda, fruit drinks and sports drinks). Among consumers the average intake was 430 ± 10.5 mL/day that provided 922 ± 22.2 kJ/day¹².

In our study boys consumed SSD more frequently than girls. This was also observed in other studies in adults²² and both in children and adolescents^{20,23–26} that found that gender is a strong determinant of soft drink consumption. Our results also showed that children, especially boys, are slightly older in the group with higher frequency of consumption of SSD, as other studies have also found in adolescents^{19,26–28}. This may be perhaps because parents have more control over what their children are consuming when they are younger. As the child grows, he/she is more independent in their food choices and may have free access to food and beverages.

Table II
Anthropometric data, dietary habits and screen time of studied children. Differences regarding frequency of consumption of SSD

	<i>Never drinkers</i> (n = 3,781)	<i>Occasionally drinkers</i> (n = 2,603)	<i>Frequent drinkers</i> (n = 685)	<i>p*</i>
Children data				
Age (y), mean \pm SD	7.48 \pm 1.11 ^a	7.58 \pm 1.13 ^b	7.61 \pm 1.12 ^b	< 0.001
Weight (kg), mean \pm SD	30.14 \pm 7.4	30.66 \pm 7.66	30.26 \pm 7.72	0.520
Height (cm), mean \pm SD	129.19 \pm 8.53 ^a	129.75 \pm 8.59 ^b	129.66 \pm 8.45 ^{a,b}	0.003
Waist (cm), mean \pm SD	60.43 \pm 7.55	60.88 \pm 7.77	60.63 \pm 7.67	0.097
Hip (cm), mean \pm SD	70.92 \pm 7.94	71.33 \pm 8.16	70.63 \pm 8.01	0.513
BMI (kg/m ²), mean \pm SD	17.85 \pm 2.88	17.99 \pm 2.93	17.77 \pm 2.97	0.427
Overweight (%)	26.7 ^a	27.5 ^a	21.8 ^b	0.039
Obese (%)	17.8	18.7	19.5	
Breakfast habits (%)				
Skipped breakfast the day of the interview (#)	2.5 ^a	3.5 ^b	5.2 ^c	< 0.001
Habitual breakfast frequency (##):				< 0.001
Always	95.0 ^a	93.3 ^b	88.4 ^c	
4–6 days/week	2.9 ^a	4.2 ^b	5.9 ^b	
1–3 days/week	1.7 ^a	1.9 ^a	4.7 ^b	
Never	0.4 ^a	0.5 ^{a,b}	1.0 ^b	
Screen time (%)				
Weekdays				
TV > 2 h/day	22.4 ^a	28.4 ^b	39.9 ^c	< 0.001
PC games > 1 h/day	10.7 ^a	15.6 ^b	21.8 ^c	< 0.001
Weekend days				
TV > 2 h/day	70.2 ^a	73.2 ^b	78.9 ^c	< 0.001
PC games > 1 h/day	48.9 ^a	55.3 ^b	58.1 ^b	< 0.001

Declared by the child; ## Declared by parents; a, b, c: Different letters mean significant differences between groups ($p < 0.05$); * ANOVA or Jonckheere-Terpstra test for ordered alternatives for quantitative variables or Chi² were used.

We have not found a relationship between SSD consumption and the BMI of children or the prevalence of overweight or obesity. The results of other studies in children are not unanimous. For example, our results agree with that observed in children aged 2 to 5 years in USA¹⁹, but disagree with other performed in a group of similar age¹⁸. Jensen et al.²⁹ in a longitudinal study in Danish children aged 6 years didn't find significant association between SSD intake and changes in BMI or skin-fold thickness at 9 or 13 years of age, nor in Australian children and adolescents³⁰. But, on the other hand, some systematic reviews and meta-analysis suggest that SSB consumption promotes weight gain in children and adults^{5,6} and also the development of metabolic syndrome and diabetes³¹.

Some of the reasons given to justify the relationship between SSB consumption and weight gain are their sugar and caloric content, and their low satiety capacity⁶. Some authors suggest that children drinking SSB on a regular basis intake a 17% to 20% more calories⁹, and Cullen et al.³² found that children between 9 and 12 years of age in the third tertile of SSD consumption followed diets with more calories than those in lower tertiles. We have no quantitative information in our study about the diet, so we can not analyze whether the caloric intake of the children was different in each SSD group. However, we also have to consider that the

lack of association between BMI and SSD frequency of consumption in our population could be due to a restriction in the consumption of SSB and SSD in some children with weight problems (or even the underestimation of the consumption), while children with healthy weight perhaps drink SSD more frequently because they are not concerned about the caloric content.

Breakfast consumption and quality are associated with healthier macro- and micronutrient intakes, body mass index and lifestyle^{33,34}. In our children the breakfast habits of frequent SSD consumers seem poorer. As far as we know, very few studies have examined the relationship between breakfast habits and the consumption of soft drinks, and results are not concluding. In Swedish adolescents it was found that eating breakfast less than five times per week was independently associated with high soft drink consumption in both girls and boys³⁵. But, on the other hand, in a study in Italian and Belgian adolescents this association was found only in Belgian girls and not in other groups³⁶.

As we did, other authors have found an association between the consumption of SSB and watching TV^{9,18,23,37-39}. The reasons given to explain this association are several. Watching TV is associated with increased exposure to advertising of SSB, which can increase the percentage of potential consumers of SSB among chil-

Table III
Familiar data of the studied children. Differences regarding the frequency of consumption of SSD

	<i>Never drinkers</i> (<i>n</i> = 3,781)	<i>Occasionally drinkers</i> (<i>n</i> = 2,603)	<i>Frequent drinkers</i> (<i>n</i> = 685)	<i>p</i> *
Anthropometric data				
Mother				
Weight (kg), mean±SD	62.90 ± 10.21 ^a	63.80 ± 11.26 ^b	64.64 ± 11.1 ^b	< 0.001
Height (cm), mean±SD	163.12 ± 6.03	162.88 ± 6.3	162.85 ± 6.09	0.140
BMI (kg/m ²), mean±SD	23.64 ± 3.66 ^a	24.02 ± 3.98 ^b	24.35 ± 3.95 ^b	< 0.001
Overweight (%)	22.9 ^a	23.2 ^{a,b}	27.7 ^b	< 0.001
Obese (%)	6.5 ^a	8.7 ^b	10.6 ^b	
Father				
Weight (kg), mean±SD	82.17 ± 11.9	82.28 ± 11.8	83.02 ± 12.36	0.415
Height (cm), mean±SD	175.81 ± 6.95 ^a	175.37 ± 6.98 ^b	174.85 ± 7.09 ^b	< 0.001
BMI (kg/m ²), mean±SD	26.57 ± 3.36 ^a	26.74 ± 3.36 ^a	27.15 ± 3.72 ^b	< 0.001
Overweight (%)	51.9	51.6	52.3	0.038
Obese (%)	13.9 ^a	14.9 ^{a,b}	18.4 ^b	
Smoking habits (%)				
Non smokers	57.2 ^a	52.5 ^b	48.7 ^b	< 0.001
One Smoker	28.7	30.7	31.0	
Both smokers	14.1 ^a	16.8 ^b	20.3 ^b	
Educational level (%)				
Mother				
Primary studies	16.9 ^a	21.2 ^b	28.1 ^c	< 0.001
Secondary studies	39.3 ^a	42.3 ^{a,b}	45.7 ^b	
University degree	43.7 ^a	36.5 ^b	26.2 ^c	
Father				
Primary studies	23.1 ^a	27.5 ^b	34.3 ^c	< 0.001
Secondary studies	41.0	43.1	44.9	
University degree	35.9 ^a	29.4 ^b	20.9 ^c	
Family income (%)				
< 18,000 €/year	36.7 ^a	47.2 ^b	63.1 ^c	< 0.001
18,000–30,000 €/year	26.5 ^a	24.5 ^{a,b}	20.9 ^b	
>30,000 €/year	36.7 ^a	28.3 ^b	16.1 ^c	

a, b, c: Different letters mean significant differences between groups (*p* < 0.05); * ANOVA or Jonckheere-Terpstra test for ordered alternatives for quantitative variables or Chi² were used.

dren who spend more time watching TV. In addition, children with greater exposure to TV are also more exposed to advertisements of high-calorie foods, different from the SSB. On the other hand, television is associated with increased inactivity and sedentary lifestyle. All these factors may explain why some studies have found an association between SSB consumption and a higher prevalence of overweight and obesity⁹, and suggest that a higher control of the exposure of children to television can be an effective measure to improve the drinking habits in children²⁰.

The BMI of mothers and fathers was related to the frequency of consumption of SSD of their children. De Boer et al.¹⁸ observed that the percentage of children who drink 1 or more SSD per day is higher when the mother is overweight or obese. Fiorito et al.⁴⁰, in a 10 year follow-up study of a group of 5-years old girls, found that both mother's and father's BMI was higher in the group of girls consuming SSD at 5 years of age ("consumers") than in girls who did not consume ("not

consumers"). During the follow-up study there were no differences in energy intake or weight status between both groups at 5 years of age, but the consumption of SSD increased until 15 years of age only in consumers group. The authors suggested that parents differing in parental BMI may be modelling different consumption patterns for their children⁴⁰.

Smokers and passive smokers tend to follow more unbalanced diets^{41–43}. Smoking habits of parents have shown to be related to the food habits of their children in other studies and also with more prevalence of overweight/obesity in the offspring³⁴. For example, children aged 18 months with smoker mothers are more likely to drink SSD⁴⁴. Children of mothers and fathers who smoke followed less healthy diets⁴⁵. An explanation for this association is that the children of smoking parents follow unbalanced diets as their parents do, and also that smoker parents are less concerned about health and nutrition and are negatively influencing the eating habits of their children.

In our study the children with higher consumption of SSD live in families with lower socioeconomic status and educational level of parents. This has been found in other studies in preschool children^{23,46,47} and in adolescents²⁷. It has been suggested that the level of education of the parents is likely to influence literacy, knowledge on nutrition, and health-related behaviour⁴⁸. Energy-dense and nutrient-poor diets have also low energy cost^{49,50}. A lower socio-economic status was associated with more frequent and higher availability of soft drinks in the household⁵¹, while soft drink availability at home and parental soft drink consumption seem the strongest factors associated with soft drink consumption in children⁵².

Our study has some limitations. The frequency of consumption of SSD is based on the statement made by the parents and not on a direct measure of consumption by children. We have no data about caloric intake or energy expenditure of children to explain deeper the lack of relationship between SSD consumption and BMI of children. But among the strengths of this study, it is noteworthy that this is a large and representative sample of Spanish schoolchildren from 6 to 9 years, using a common methodology and questionnaires to other countries participating in the COSI strategy so that our results can be analyzed and compared to those of other groups.

In conclusion, Spanish schoolchildren who consume SSD more often have similar anthropometric data than those who never drink them, but skip more often their breakfast, are more sedentary in their free time, and live in families with also unhealthier habits and lower socioeconomic status. SSB consumption has been linked to the increased prevalence of obesity and weight gain in children. But increased consumption of SSB is also associated with other risk factors for obesity and at a more obesogenic environment. Further studies are needed to delve into the factors that influence the drinking habits of SSB of Spanish children.

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Conflicts of interest

None.

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Characterization of bioimpedance measures in overweight and obese hemodialyzed patients¹⁻³

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Abstract

Introduction: Bioelectrical impedance analysis (BIA) is a non-invasive, safe method used for body composition and hydration status assessment in hemodialysis patients (HD).

Objective: To evaluate the influence of body size by measuring BMI and BIA-derived variables [fat mass (FM), phase angle (PA), and hydration status] in HD.

Patients and methods: Cross-sectional study in 73 HD patients (68 ± 14.4 years; males, 65%; diabetes mellitus, 15.8%). Participants underwent nutritional assessment [malnutrition-inflammation score (MIS)], including anthropomorphic parameters, and laboratory tests. Body composition analysis was determined by BIA. Patients were classified into normal-weight, overweight and obese categories. Additional nutritional-inflammatory biomarkers and their interactions were compared in the three BMI groups.

Results: Overweight/obesity was 43.8%. Lower prevalence of protein-energy wasting (PEW) was found in overweight/obese than normal-weight (38% vs 60%; $p < 0.05$). Overweight/obese HD-patients showed significant higher values of PA, FM and s-prealbumin ($p < 0.01$) but C-reactive protein (CRP) tended to be lower (~30%) but non-significant than normal-weight patients. Significant interactions between BMI and BIA-measurements (exchange Na/K, total body water, PA), s-albumin, s-prealbumin, and MIS ($p < 0.01$) by multivariate analysis were identified.

Conclusion: BIA appears useful identifying the nutritional-inflammatory-hydration status in HD-patients. The single use of BMI has limitations to assess PEW or sarcopenia in dialysis population.

Key words: Bioelectrical impedance analysis. BMI. Overweight/obesity. Protein-energy wasting. Hydration status.

CARACTERIZACIÓN DE LAS MEDICIONES DE BIOIMPEDANCIA EN PACIENTES CON SOBREPESO Y OBESIDAD SOMETIDOS A HEMODIÁLISIS

Resumen

Introducción: El análisis por impedancia bioeléctrica (BIA) es un método seguro, no invasivo utilizado para la valoración de la composición corporal y el patrón de hidratación en pacientes en hemodiálisis (HD).

Objetivo: Evaluar la influencia del tamaño corporal medido por IMC y variables derivadas de la BIA [masa grasa (FM), ángulo de fase (PA) y el patrón de hidratación] en pacientes en HD.

Pacientes y métodos: Estudio transversal en 73 pacientes en HD (68 ± 14.4 años; hombres, 65%; diabetes mellitus, 15.8%). Los participantes recibieron valoración nutricional [escala de malnutrición-inflamación (MIS)], que también incluía parámetros antropomórficos y pruebas de laboratorio. El análisis de composición corporal fue estimado por BIA. Los pacientes fueron clasificados en normopeso, sobrepeso y obesidad. Biomarcadores nutricionales e inflamatorios adicionales así como sus interacciones entre ellos fueron comparados en los 3 grupos según el IMC.

Resultados: Sobrepeso/obesidad era 43.8%. Menor prevalencia del síndrome de desgaste proteico-energético (PEW) fue encontrada en sobrepeso/obesidad que en normopeso (38% vs. 60%; $p < 0.05$). Pacientes en HD con sobrepeso/obesidad tenían valores significativos más altos de PA, FM y prealbúmina sérica ($p < 0.01$), pero la proteína C-reactiva tendía a ser menor (~30%) que en los pacientes con normopeso aunque no era significativa. El análisis multivariante identificó interacciones significativas entre IMC y parámetros de BIA (Na/K intercambiable, agua corporal total, PA), albúmina y prealbúmina séricas y MIS ($p < 0.01$).

Conclusiones: BIA aparece útil para identificar el estatus nutricional-inflamatorio-hidratación en pacientes en HD. El uso aislado del IMC tiene limitaciones para evaluar PEW o sarcopenia en población de diálisis.

Palabras clave: Análisis de impedancia bioeléctrica. BMI. Sobrepeso/obesidad. Síndrome de desgaste proteico-energético. Patrón de hidratación.

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Non-standards abbreviations

BIA: Bioelectrical impedance analysis.
BMI: Body mass index.
CKD: Chronic kidney disease.
CRP: C-reactive protein.
CVD: Cardiovascular disease.
ECW: Extracellular water.
HD: Hemodialysis.
ICW: Intracellular body water.
ICW/ECW ratio: Intracellular water/extracellular water ratio.
FM: Fat body mass.
Kt/V *urea* (*sp*): Single pool urea kinetic model.
LBM: Lean body mass.
MAMC: Mid-arm muscle circumference.
MIS: Malnutrition-inflammation score.
MM: Muscle mass.
PA: Phase angle.
PEW: Protein-energy wasting.
SBW(%): Percent of standard body weight.
S-albumin: Serum albumin.
S-prealbumin: Serum prealbumin.
TBW: Total body water.
TSF: Triceps skinfold thickness.
WC: Waist circumference.

Introduction

Overweight and obesity are relevant cardiovascular disease (CVD) risk factors of all-mortality causes in the general population¹. However, among patients undergoing maintenance hemodialysis (HD), higher body mass index (BMI) values have consistently been associated with reduced mortality risk^{2,3}. The Diaphane Collaborative Study⁴ was first to suggest the lack of association between obesity and increased mortality risk in a dialysis population. Leavey et al.⁵ reported an increased mortality risk for subjects with a BMI < 23.9 kg/m², but no increase in mortality risk in those with a BMI higher than 25 kg/m². The mechanism(s) by which overweight and obesity in HD patients may confer a survival advantage remain elusive.

Bioelectrical impedance analysis (BIA) is a non-invasive, safe method which has been used for analyzing body composition and hydration status in HD patients⁶. Current clinical nutrition guidelines in chronic kidney disease (CKD)^{7,8} recommend routine BMI measurement, but do not the assessment of hydration status. Some authors^{9,10} have studied the role of BIA-derived measurements as prognostic indicators of nutritional-hydration status. A comparison of different body composition compartments measured by BIA, including phase angle (PA), fat mass (FM) and hydration status has been shown to correlate with greater survival in overweight/obese HD patients¹¹⁻¹³. The reduction of PA was considered to reflect an increase the extra-to intracellular water ratio and/or a decrease in body cell mass (BCM)¹⁴.

Fluid overload has emerged as a parameter that strongly correlates with inflammatory and CV markers¹⁵. Adequate fluid status assessment is a pivotal issue in the accurate prescription of HD dose and a substantial amount of research in body composition analysis measured by BIA.

Protein-energy wasting (PEW) is a prevalence condition which was associated with inflammation and over-hydration markers as a risk factors of morbidity and mortality in HD population¹⁶. Consequently, practical and reliable indicators of body composition and hydration status are needed for clinical purposes. This paper hypothesized that the body size is related with nutrition-hydration status in HD patients. The aim of this study was to evaluate in HD patients classified according to BMI, the influence of body composition assessed by BIA-derived variables [fat mass (FM), phase angle (PA) on the nutritional – hydration status] and to analyze whether these factors were related.

Subjects and method

Study design

This cross-sectional study was carried out at Hospital Universitario de La Princesa, Madrid (Spain) in 73 HD patients. Eligible participants were HD adults (>18 years) stabilized for at minimum of 3 months before enrolment. Patients with amputation of limbs, clinically evident active infection, liver disease, autoimmune diseases, or malignancies were excluded to avoid the possible effects of these comorbid conditions on inflammatory markers and hydration status. Informed consent was obtained from every patient. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Medical Ethic Committee.

Patients underwent regular HD, at least 4 hours three times per week. Dialysis adequacy was assessed with regard to the delivered dialysis dose (Kt/V *urea*) using a *single pool* (*sp*) urea kinetic model. Patients were classified into BMI categories (normal weight, 20–24.9 kg/m²; overweight, 25–29.9 kg/m² and obese, ≥ 30 kg/m²).

Assessment of Nutritional status

Nutritional-inflammatory status was assessed by the malnutrition-inflammation score (MIS) questionnaire¹⁷ including eight different components: five subjective assessments (concerning the patient's medical history and physical examination) and three objective assessments (s-albumin, total binding iron capacity and BMI). In agreement with other studies^{18,19}, PEW was defined as a MIS score ≥ 5.

Anthropomorphic measurements

BMI, percent of standard body weight (SBW, %), triceps skinfold thickness (TSF), mid-arm muscle

circumference (MAMC) and waist circumference (WC) were recorded as anthropometric variables. The BMI was calculated as dry weight in kilograms divided by the square of height in meters. Percent of standard body weight (SBW, %) was calculated as follows: $SBW (\%) = (\text{actual weight} / SBW) \times 100$, where the patient's weight was the postdialysis weight and the SBW was the weight of Spanish people of the same, sex, height and age range²⁰. TSF was measured with a Lange Skin Calipers (Cambridge Instruments) using standard techniques. MAMC was estimated as follows: $MAMC (cm) = \text{Mid-arm circumference (cm)} - 0.314 \times TSF (mm)$. Waist circumference (WC) was measured according to WHO guidelines²¹ at the mid-point between the lower border of the rib cage and the iliac crest using a rubber measuring tape. All measurements were done in duplicate by the same investigator, and the mean value was taken for the analysis.

Body composition analysis

Single-frequency BIA was determined on the non-dominant side of the body, in the post-absorptive state, injecting 800 μA and 50 kHz alternating sinusoidal current with a standard tetrapolar technique (BIA 101 Impedance Analyzer; Akern, Firenze, Italy). BIA was performed after being 20 min at rest in the supine position^{22,23} with disposable electrodes (BiatrodesTM 100 S. Akern) as previously reference method validated in HD patients⁶. The BIA variables measured were resistance (R), and reactance (Xc). R and Xc were considered as such or indexed to height (R/H and Xc/H) for bioelectrical impedance vector analysis. The BIA-derived variables [(exchange Na/K, total body water (TBW), extracellular body water (ECW), intracellular body water (ICW), fat body mass (FM), muscle mass (MM), lean body mass (LBM) and PA] were estimated by BIA® software. The (ICW)/(ECW) ratio, (measured in liters), was calculated. Mean values of the ICW/ECW ratio $< 1 \pm SD$, and $PA < 4$ were indicators of volume overload in dialysis patients²⁴.

Biochemical parameters

Venous blood samples were drawn from all subjects in fasting conditions. Blood was obtained from HD patients directly through an arteriovenous fistula or central catheter immediately before their scheduled midweek HD session. Serum albumin (s-albumin) using bromocresol green method and serum prealbumin (s-prealbumin) were measured using an automated analyzer (Abbot, Aeroset®, Diamond Diagnosis, Holliston, MA)²⁵. Variation coefficients were lower than 2%. CRP (no-hs) was measured by immunoturbidimetry (Roche/Hitachi 904®/Model P: ACN 218, Roche Diagnostics, Basel, Switzerland).

Statistical analysis

Data are given as mean \pm SD. All data were first analyzed for normality of distribution using the Kolmogorov-Smirnov test. Student t-test was used to compare mean values of continuous variables while Chi-square test for categorical variables. Correlations between variables were calculated with the use of Spearman's test. ANOVA was used to analyze differences between the mean of BMI groups. Multivariate analysis of variance (MANOVA) was applied to identify significant interactions between variables. Simple linear regression model was constructed to explore the univariate associations between the percentage of TBW (TBW%) and nutritional-inflammatory variables as independent predictors. Durbin-Watson test was applied. All analyses were performed by using statistical software SPSS version 15.0 for Windows (SPSS®, Inc. Chicago, IL). Results were significant at p -values ≤ 0.05 .

Results

Demographic characteristics, nutritional status, and body composition

Demographic and clinical characteristics data of 73 HD patients are showed in table I. Primary etiology of CKD was diabetes mellitus (23.3%). Mean body weight ($p < 0.002$) and WC ($p = 0.03$) were significantly higher in men but non-gender significant differences were found for BMI. Significant differences between both sexes in FM, LBM and TBW ($p < 0.001$) but not in MIS score, visceral protein profile and inflammatory markers were noted. Fifty seven patients (57.5%) were identified as PEW (MIS > 5).

Correlations

According to Spearman rank correlations, BMI was positively and significantly associated with FM ($r = 0.40$; $p < 0.001$) and PA ($r = 0.29$; $p < 0.01$) while inversely correlated with additional nutritional-hydration parameters such as TBW ($r = -0.47$; $p < 0.001$) and MIS ($r = -0.47$; $p < 0.001$). S-albumin ($r = 0.27$) and s-prealbumin ($r = 0.26$) correlated significantly (both, $p < 0.05$) with BMI.

MIS was significantly correlated with PA ($r = -0.52$; $p < 0.001$), s-prealbumin ($r = -0.57$; $p < 0.001$) and CRP ($r = 0.43$; $p < 0.001$), whereas direct correlations between MIS and ECW ($r = 0.47$; $p < 0.001$) were found. PA was directly correlated with MM ($r = 0.57$; $p < 0.001$) and s-albumin ($r = 0.41$; $p < 0.001$), and inversely with ECW ($r = -0.91$; $p < 0.001$).

Relationship between nutritional-hydration data and BMI categories

Table II shows anthropometric characteristics and the clinical parameters of HD-patients classified according

Table I
Demographics and clinical characteristics of 73 hemodialysis patients^a

	Overall	Men	Women	p-value*
Subjects n, %	73	47 (64.4)	26 (35.6)	0.01
Age, years	68.5 ± 14.1	68.7 ± 13.9	67.9 ± 14.7	0.84
DM n, (%)	17 (23.3)	12 (25.5)	5 (19.2)	0.8
Time on HD, months	40.1 ± 36.9	38.5 ± 35.8	43 ± 39.4	0.62
Body weight, kg	67.7 ± 13.6	71.3 ± 13	61.2 ± 12.5	0.002
SBW, %	100.7 ± 18.3	97.3 ± 15	106.8 ± 22	0.03
BMI, kg/m ²	25.5 ± 4.6	25.2 ± 4.1	26.1 ± 5.3	0.41
Waist circumference, cm	96.2 ± 12.3	98.2 ± 11.2	91.3 ± 12.9	0.01
TSF, %	124.6 ± 54.6	123.4 ± 59.6	126.8 ± 44.7	0.8
MAMC, %	95.4 ± 10.2	94.8 ± 10.2	96.7 ± 10.3	0.45
Exchange Na/K	1.3 ± 0.3	1.4 ± 0.3	1.2 ± 0.3	0.11
Total body water, %	54.1 ± 6.9	57.1 ± 6	48.8 ± 4.9	< 0.001
Extracellular body water, %	53.5 ± 8	52.7 ± 8.7	55.1 ± 6.4	0.22
ICW/ECW ratio	0.91 ± 0.3	0.95 ± 0.4	0.83 ± 0.2	0.13
Fat mass, %	30.4 ± 10.1	26.4 ± 8.8	37.7 ± 8.2	< 0.001
Lean body mass, %	69.5 ± 10.1	73.6 ± 8.8	62.2 ± 8.3	< 0.001
Muscle mass, %	35.5 ± 8.4	37 ± 9.3	32.7 ± 5.6	0.03
Phase angle, (°)	4.5 ± 1.2	4.6 ± 1.3	4.2 ± 0.9	0.15
S-albumin, g/dL	3.8 ± 0.4	3.7 ± 0.5	3.8 ± 0.4	0.55
S-prealbumin, mg/dL	27.2 ± 8.9	27.1 ± 9.8	27.2 ± 6.8	0.98
CRP, mg/dL	1.7 ± 2.6	2 ± 2.9	1.3 ± 1.9	0.28
Charlson index (score)	8.2 ± 3	8.3 ± 3.1	7.9 ± 2.7	0.59
Kt/V urea (sp)	1.3 ± 0.1	1.3 ± 0.1	1.4 ± 0.2	0.08
MIS score	7.7 ± 4.7	8.1 ± 5.1	6.8 ± 3.8	0.27
PEW [†] n, (%)	42 (57.5)	27 (57.4)	15 (57.7)	0.72

*p-values are based on Chi-square test or Student's *t*-test. BMI, body mass index; DM, diabetes mellitus; HD, haemodialysis; Kt/V urea (sp), urea kinetic model; CRP, C-reactive protein; MIS, malnutrition-inflammation score; PEW, protein energy wasting; SBW%, percentage of standard body weight; TSF%, percentage of triceps skinfold thickness. [†]PEW was defined by MIS score ≥ 5.

to BMI. Body weight, SBW and TSF were significantly higher in obese patients than in the other groups (at least, $p < 0.01$). MAMC was significantly lower in normal-weight patients compared with overweight and obese patients ($p = 0.01$). As regards the BIA-derived variables FM% and PA, were higher in obese people in comparison to overweight and normal-weight patients ($p < 0.01$), whereas, TBW ($p < 0.01$), exchange Na/K ($p < 0.01$) and LBM ($p < 0.05$) were lower in obese patients. Serum levels of albumin and prealbumin were significantly lower ($p < 0.05$ and $p = 0.01$, respectively) in normal-weight and obese patients. CRP tended in a non-significant manner to be higher levels in normal-weight than in obese/overweight patients. Prevalence of PEW, measured by MIS ≥ 5, was 38% in overweight/obese HD patients.

Hydration status (Total body water) as a predictor in overweight and obese hemodialysis patients

To evaluate the influence between hydration status (measured by TBW%, as dependent variable) and nutritional-inflammatory potential indicators in overweight-obese HD patients a forward linear regression model was constructed (table III). Durbin-Watson test was 1.95.

FM%, ICW/ECW ratio, PA, and CRP as an inflammatory biomarker appear linearly associated ($R=0.99$; $R^2=0.98$; R^2 adjusted: 0.98; $p < 0.001$) as predictors of change in the TBW%.

Discussion

In the current study, the body size classified by BMI and the body composition assessed by BIA, shows higher values of FM and PA in overweight/obese patients, whereas an inverse relation with TBW and ICW/ECW ratio on the hydration status was noted. These results are suggesting that BIA measures appear to be adequate for monitoring body composition and hydration status in HD patients.

BMI is often used as indicator of body composition but does not discriminate between LBM and fat depots. This potential limitation pushed us to study HD population according to their BMI for assessing nutritional-hydration status measured by BIA.

In this study, women had more FM and a lower proportion of LBM than do men demonstrating gender influences on those parameters. According to BMI classification a high proportion of overweight/obesity was identified. The inverse correlation between TBW% and BMI suggests

Table II
Demographic and clinical characteristics of 73 hemodialysis patients stratified according to Body Mass Index (BMI)

	Normal-Weight <i>n</i> = 38	Overweight <i>n</i> = 23	Obesity <i>n</i> = 12	<i>p</i> -value*
BMI, kg/m ²	21.7 ± 1.7	26.7 ± 1.5	33.5 ± 4.2	<0.001
Age, years	69.1 ± 14.1	66.1 ± 15.6	70.9 ± 11.5	0.58
Time on HD, months	40.2 ± 37.2	41.6 ± 36.4	37.2 ± 34.2	0.94
Body weight, kg	59.7 ± 7.3	71.5 ± 10.8	85.7 ± 14.1	<0.001
SBW, %	89.2 ± 6.7	103.8 ± 10.1	131.2 ± 18.6	<0.001
Waist circumference, cm	89.4 ± 8	99.5 ± 8.6	111.5 ± 12.4	<0.001
TSF, %	94.9 ± 31.8	139.3 ± 47.2	196.5 ± 54.8	0.01 ^b
MAMC, %	89.2 ± 5.6	100.6 ± 10.5	105.2 ± 7.6	0.01 ^b
Exchange Na/K	1.5 ± 0.4	1.2 ± 0.3	1.1 ± 0.3	0.01 ^b
Total body water, %	55.9 ± 6.9	53.5 ± 5.8	49.6 ± 6.9	0.01 ^b
Extracellular body water, %	54.5 ± 5.9	52.2 ± 9.9	53.3 ± 9.9	0.57
ICW/ECW ratio	0.85 ± 0.2	0.98 ± 0.4	0.95 ± 0.45	0.28
Fat body mass, %	27.3 ± 10.2	29.9 ± 9.9	36.8 ± 10.5	0.01 ^b
Lean body mass, %	71.3 ± 9.6	70.1 ± 9.9	63.1 ± 10.5	<0.05
Muscle mass, %	35.5 ± 7.8	36.2 ± 8.7	32.7 ± 9.9	0.46
Phase angle (°)	4.2 ± 0.9	4.7 ± 1.4	4.9 ± 1.9	<0.05 ^c
S-albumin, g/dL	3.6 ± 0.4	3.9 ± 0.5	3.8 ± 0.4	<0.05 ^c
S-prealbumin, mg/dL	24.4 ± 7.3	29.7 ± 10.5	28.5 ± 7.8	0.01 ^b
CRP, mg/dL	2.1 ± 3.1	1 ± 1.4	1.5 ± 1.8	0.28
Charlson index score	8.6 ± 2.9	7.2 ± 3.3	8.4 ± 2.2	0.2
Kt/V urea (<i>sp</i>)	1.3 ± 0.1	1.3 ± 0.1	1.4 ± 0.2	0.59
MIS score	9.5 ± 5	5.9 ± 3.8	5.5 ± 3	0.01 ^b
PEW† <i>n</i> ,(%)	26 (68.4)	10 (43.5)	6 (50)	<0.05 ^c

**p*-values are based on Chi-square test or ANOVA test according body mass index (BMI); Classification into BMI categories were defined as follow: normal weight (BMI: 20–24.9 kg/m²), overweight (BMI: 25–29.9 kg/m²) and obese (BMI: ≥ 30 kg/m²). ^{a,b,c}*p*-values within the means of BMI categories bearing different letters were significantly different; ^a(*p* < 0.05), ^b(*p* < 0.01), ^c(*p* < 0.001) (MANOVA). DM, diabetes mellitus; HD, haemodialysis; Kt/V urea (*sp*), urea kinetic model; CRP, C-reactive protein; MIS, malnutrition-inflammation score; PEW, protein energy wasting; SBW%, percentage of standard body weight; TSF%, percentage of triceps skinfold thickness. †PEW was defined by MIS score ≥ 5.

Table III
Hydration status assessed by total body water as a potential predictor of the nutritional-inflammatory status in 35 selected overweight and obese hemodialysis patients

Variable	Total body water (%)			
	Coefficient	SEM	<i>p</i> -value	95% CI
Fat mass,%	- 0.79	0.02	< 0.001	- 0.83 to - 0.72
ICW/ECW ratio	- 24.15	2.06	< 0.001	- 28.8 to - 19.9
Phase angle (°)	4.7	0.54	< 0.001	2.76 to 5.1
CRP, mg/dL	- 0.46	0.13	0.017	- 0.82 to - 0.26
Constant	79.13	1.02	< 0.001	77 to 81.24

CRP, C-reactive protein (*non-hs*); ICW/ECW ratio, intracellular water/extracellular water ratio; SEM, standard error of the mean; 95% CI, 95% confidence interval. Total body water (%) appears as a dependent variable (*R* = 0.99; *R*² = 0.98; *R*² adjusted: 0.98) in the linear regression analysis. For more details see text.

that higher BMI values were associated with lower amount of TBW in HD patients. This supports the fact that patients with high values of FM and PA were those with overweight/obesity. This unusual phenomenon between high BMI and increased survival in overweight/obese HD patients has been termed "reverse epidemiology" who overweight/obese HD patients had lower mortality risk than normal-weight-HD patients^{26,27}. FM is highly increased in overweight/obese, whereas LBM

is lower than in normal-weight patients. It is not known how FM and LBM may be protective factors in HD patients. Higher FM in men and women and higher LBM in women were associated with greater survival in HD patients²⁸.

BMI appears to misclassify alterations of body composition in our study. LBM%, and exchange Na/K were lower in overweight/obese HD patients. These findings are somewhat similar to some previous study¹⁵ in

patients in whom body composition and hydration imbalances in fluid homeostasis are commonly observed.

One of the findings of this study is lower PEW in overweight/obese HD patients than normal-weight. Several studies^{17,29} reported a negative correlation between MIS, s-albumin and CRP which suggests that lower s-albumin levels that are mostly observed in patients with PEW may be secondary to inflammatory processes. As expected, MIS was inversely and significantly correlated with s-albumin, PA, ECW, and CRP, which have been used in several studies as nutritional-inflammatory markers³⁰⁻³². In accordance with these studies, significant interactions between BMI and BIA-measurements (exchange Na/K, total body water, PA), s-albumin, s-prealbumin, and MIS ($p < 0.01$) by multivariate analysis were identified. BIA seems to appear as a useful tool for the assessment of nutritional-hydration status, since a worse hydration status is significantly associated with oedema, inflammation, hypertension and adverse clinical prognosis in HD patients. Moreover, it should be pointed out that PEW was identified in the three BMI categories, but not underweight patients were included. A high proportion of overweight/obese patients were wasted, but PEW was also a concomitant factor in normal-weight patients. Thus, a higher FM may, in fact, be one of the characteristics of PEW in overweight/obese patients, a condition that has been called obese sarcopenia^{33,34}. These results show that the use of BMI alone has limitations to assess the nutritional status in HD patients, because PEW or obese sarcopenia might not be properly identified.

Linear regression analysis demonstrates an inverse relation between TBW% as a dependent variable and CRP, suggesting a lower amount of adipocytokines and inflammatory markers production when FM decreases in overweight/obese HD patients. Recent studies have shown that adipose tissue in overweight/obesity is characterized by macrophage infiltration³⁵ and that weight loss is associated with a reduction in circulating concentrations of inflammatory biomarkers³⁶ such as IL-6 and CRP³⁷. Body fat mass, in particular abdominal fat depots should be considered when interpreting the significance of an elevated CRP level in HD patients.

BIA is a validated method which has been used to assess dry weight^{6,38} but it is also useful for assessing body composition, nutritional status and overhydration^{10,39}. Moreover, it has been shown that BIA, through measuring hydration status, may be suitable for assessing the prognosis of HD patients^{40,41}. BIA-derived measures, as PA was higher in overweight/obese than in normal-weight patients. It has defined that a decline in PA indicates that a change in body composition, specifically the loss of body cell mass, may occur even in the absence of a change in body weight or LBM⁴². The regression analysis identifies a threshold value of PA (4.7 degrees) below which the risk of PEW seems to be increased. A likely explanation for such a finding in the present HD population is that there is an increase in extracellular fluid proportional to a decrease in body cell

mass and PA. Nevertheless, the hydration status and the presence of inflammation and comorbid conditions make the analysis of body composition relatively complex.

Several limitations of the current study must be highlighted. First, the cross-sectional design of our study limits the ability to detect more subtle changes over time or the influence of inflammatory markers on changes in other measures of body composition. However, such as those between hydration status and nutritional status^{41,43} and the abnormalities of BIA measures in overweight/obese HD patients⁴⁴, suggests that the findings described here support the confirmation of previous known associations. Second, only one single BIA measurement was used in the present study, even though hydration status may vary with time. Third, although BMI is often used for practical reasons, as a predictor of nutritional status, it is not a reliable indicator as does not differentiate between muscle and fat mass as body compartments. Furthermore, BMI has poor specificity for assessing central adipose tissue excess; as a body composition parameter is a poor nutritional status indicator in patients with gross fluid homeostasis imbalances or in patients with sarcopenia and well-preserved fat mass. Taking into account those potential biases, BMI was not selected as sole criteria diagnosis for assessing nutritional-hydration status in the present study.

In summary, BIA appears useful for identifying alterations of the nutritional-inflammatory-hydration status in overweight/obese as well as normal-weight HD patients. The single use of BMI has limitations to assess the nutritional status in HD patients, because PEW or obese sarcopenia might not be identified. Further studies are required to evaluate the importance of these findings in overweight/obese HD patients.

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Water intake adequacy and dietary sources in schoolchildren from Madrid by physical activity level

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Abstract

Introduction: Inadequate fluid intake may contribute to lower cognitive and exercise performance in children.

Objective: To evaluate the adequacy of water intake and dietary sources in schoolchildren from the Community of Madrid by physical activity level.

Methods: 564 schoolchildren (258 boys and 306 girls) aged between 9 and 12 were studied. Dietary data was obtained by applying a food intake record (3 days) and the weighing method. Water intake was compared with the adequate intake established by the EFSA. Physical activity level was obtained by applying a questionnaire and criteria established by IOM. All calculations were made using SPSS (v19.0) and statistical significance was set at $p < 0.05$.

Results: Three point five percent of schoolchildren had a sedentary level (S), 77.7% had a low active level (LA) and 18.8% had an active level (A). Mean total water intake was $1,504.6 \pm 329.35$ mL/day (S: $1,526.3 \pm 386.05$ mL/day, LA: $1,504.8 \pm 326.17$ s and A: $1,499.3 \pm 334.27$ mL/day; $p > 0.05$). Ninety-one percent of the studied children did not meet the adequate intake for total water intake (S: 90%, LA: 91.1% and A: 90.6%; $p > 0.05$). The major dietary sources were beverages (S: 48.92%, LA: 40.05%, A: 38.63%), dairy products (S: 22.45%, LA: 27.06%, A: 28.268%), fruits (S: 7.98%, LA: 10.69%, A: 10.93%) and vegetables (S: 8.74%, LA: 9.38%, A: 9.34%).

Conclusions: Most of the studied children had an inadequate water intake, independently of physical activity level. Main water food sources were beverages (not including milk or dairy drinks), dairy products, fruits and vegetables. It would be advisable to increase the intake of water through beverages and water-rich foods.

Key words: Water intake. Adequate intake. Food. School age population.

ADECUACIÓN DE LA INGESTA DE AGUA Y FUENTES DIETÉTICAS EN ESCOLARES DE MADRID EN FUNCIÓN DEL NIVEL DE ACTIVIDAD FÍSICA

Resumen

Introducción: El consumo inadecuado de líquidos puede provocar un menor rendimiento cognitivo y deportivo en los niños.

Objetivo: Evaluar la adecuación de la ingesta de agua y determinar sus fuentes dietéticas en escolares de la Comunidad de Madrid en función del nivel de actividad física.

Material y Métodos: Se estudiaron 564 escolares (258 varones y 306 niñas) de 9 a 12 años. La ingesta de agua y las fuentes dietéticas se obtuvieron aplicando el registro de consumo de alimentos durante 3 días y por pesada precisa. La ingesta de agua se comparó con la ingesta adecuada propuesta por la EFSA. El nivel de actividad física se obtuvo aplicando un cuestionario y los criterios establecidos por el IOM. El análisis estadístico se realizó mediante el SPSS (versión 19.0). Se consideran significativas las diferencias con $p < 0,05$.

Resultados: El 3,5% de los escolares estudiados fueron sedentarios (S), 77,7% poco activos (PA) y el 18,8% activos (A). La ingesta media de agua total de los escolares estudiados fue de $1.504,6 \pm 329,35$ mL/día (S: $1.526,3 \pm 386,05$ mL/día, PA: $1.504,8 \pm 326,17$ mL/día y A: $1.499,3 \pm 334,27$ mL/día; $p > 0,05$). El 91% de los escolares estudiados no alcanzaron a cubrir la ingesta adecuada para la ingesta total de agua (S: 90%, PA: 91,1% y A: 90,6%; $p > 0,05$). Las principales fuentes dietéticas fueron bebidas (S: 48,92%, PA: 40,05%, A: 38,63%), lácteos (S: 22,45%, PA: 27,06%, A: 28,26%), frutas (S: 7,98%, PA: 10,69%, A: 10,93%) y verduras (S: 8,74%, PA: 9,38%, A: 9,34%).

Conclusiones: La ingesta de agua fue inadecuada en la mayoría de los escolares estudiados, independientemente del nivel de actividad física. Las principales fuentes de agua fueron las bebidas (sin incluir leche o bebidas lácteas), lácteos, frutas y verduras. Sería recomendable aumentar el consumo de agua a través de alimentos con alto contenido de agua.

Palabras clave: Ingesta de agua. Ingesta adecuada. Alimentos. Población de edad escolar.

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Abbreviations

AI: Adequate intake.
BMI: Body mass index.
EER: Estimated energy requirement.
EAR: Estimated Average Requirements.
EFSA: European Food Safety Authority.
IOM: Institute of Medicine.
NHANES: National Health and Nutrition Examination Survey.
HELENA: Healthy Lifestyle in Europe by Nutrition in Adolescence.
PAL: Physical activity level.
WHO: World Health Organization.

Introduction

Water is the major component of the human body since it represents about 60% of the adult body's volume and approximately 60% in boys and 50% in girls by puberty^{1,2}. An adequate water balance is essential to carry out practically all functions of the body (cellular homeostasis, physiological and metabolic processes)¹. Moreover, hydration may play a role in the prevention of urolithiasis, urinary tract infections, bladder and breast cancer, constipation, pulmonary disorders, heart disease, hypertension, venous thrombosis and other conditions¹.

A number of conditions have been described corresponding to various degrees of dehydration. Studies in children and young adults have shown that mild dehydration corresponding to only 1% to 2% of body weight loss can lead to significant impairment in cognitive function affecting concentration, alertness and short-term memory²⁻⁴. Decrements in physical performance in children athletes have been observed under conditions of as little as 2% dehydration, measured acutely as percent body weight loss³⁻⁵. Even mild to moderate dehydration can therefore persist for some hours after the conclusion of physical activity². Moreover, more severe dehydration induces important impairment of survival capacity and ultimately can lead to death^{4,5}.

Children are at greater risk for dehydration than adults since they have a higher surface-to-mass ratio allowing increased water loss through the skin and higher metabolism^{2,6}. They have different thirst sensitivities and body cooling mechanisms than adults. Other important aspect to consider is that while adults are free to consume all kinds of food and beverages, the intake of food and fluids in children depends in most of the cases of their caregivers, especially in young children². In addition, during exercise, children may not hydrate adequately since they may not recognize the need to replace lost water and may require longer acclimation to increases in environmental temperature than adults⁶.

There are only a few studies about the intake water in different collectives and especially data in healthy schoolchildren is very scarce. Therefore the aim of the

present study was to evaluate the adequacy of water intake and determine the dietary sources in schoolchildren from the Community of Madrid by different physical activity level.

Methods

Subjects

A total of 564 schoolchildren aged between 9 and 12 years from 14 public and private schools of the Community of Madrid (Spain) were recruited to take part in the study. The head of each school was contacted by phone to arrange an interview wherein the characteristics and the importance of the study were explained. An interview with the parents of the children in the age group 9–12 years was then requested. Once permission was given, the details of the study were explained to the parents and all questions about the study were answered. Signed permission was then sought to include their children in the study. All subjects took part voluntarily.

The exclusion criteria were the following:

- A lack of authorization or the nonacceptance of one or more of the conditions required to take part in the study.
- Nonattendance on days when tests or interviews were performed.
- Having a pathology that might modify the results, alter food habits (and therefore nutrient intake), or where participation was not recommended.

This work was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Ethics Committee of the Faculty of Pharmacy (Universidad Complutense de Madrid, Madrid, Spain).

Anthropometric data

All anthropometric measurements were carried out in the morning in the facilities assigned by the school for the study, following the norms set out by the World Health Organization (WHO)⁷. Body weight and height were determined using a digital electronic balance (Seca Alpha, GMBH & Co., Igni, France) (range 0.1–150 kg, precision 100 g) and a Harpenden stadiometer (Pfifter, Carlstadt, NJ, USA) (range 70–205 cm, precision 1 mm), respectively. For these measurements, the subjects were barefoot and wore underwear only. The subjects' body mass index (BMI) was calculated as weight (kg) divided by height² (m²). Normal weight, overweight and obesity were defined according to BMI specific percentiles for age and sex in the reference population⁸. The cut-off for overweight was the 85th percentile and for obesity the 97th percentile⁹.

Dietary data

Participants recorded their dietary intake using a "3-day food intake record" from Sunday to Tuesday¹⁰. Parents were asked to weigh all the foods ingested if possible or to use household measures (spoonfuls, cups, etc.) to evaluate the dietary intake. Trained personnel visited the school canteen on Monday and Tuesday to apply the precise weight method during the meal time. For this, foods served in the menu, the amount of food served to each child, and the amount of food left on the plate were recorded.

DIAL software (v.2.3, Alce Ingeniería, Madrid, Spain) was used to process all dietary data¹¹. Energy and water intake were calculated using food composition tables¹². Estimated energy requirement (EER) was calculated by taking into account the body weight, height, age and physical activity of each children using the equations proposed by the IOM¹³. Also, energy intake adequacy expressed as percentage was calculated (energy intake/estimated energy requirement).

To evaluate the adequacy of water (expressed as percentage), total intake of water (defined as water intake from beverages and foods) and water intake from beverages (not included milk or dairy drinks) were compared to the adequate intake (AI) for children of 9–13 years proposed by the European Food Safety Authority (EFSA)¹⁴ which as shown below:

AI of total water intake (9–13 y):
boys (2,100 mL/day) and girls (1,900 mL/day)

AI of water intake from beverages (9–13 y):
boys (1,470 mL/day) and girls (1,330 mL/day)

The contribution of each food group to the total intake of water was calculated as percentage, by dividing the amount of water provided by each food group for all persons by the total intake of water from all foods for all persons¹⁵.

To validate the results of the dietary study, energy intake was compared to the theoretical energy expenditure. The percentage discrepancy between the energy intake and the sum of the measured and declared intakes was determined using the following formula:

$$\frac{(\text{Theoretical energy expenditure} - \text{energy intake}) \times 100}{\text{theoretical energy expenditure}}$$

A negative value indicated that the declared energy intake was to be greater than the theoretical energy expenditure (probable overestimation), while a positive value indicated it to be lower than the theoretical energy expenditure (probable underestimation)^{16–18}.

Physical activity level

The subjects' physical activity level (PAL) was examined by a questionnaire¹⁹, registering the length of time

spent on different daily activities, such as sleeping, eating, walking, resting, playing sports, etc. A physical activity coefficient was established for each participant by multiplying the time spent in each activity by coefficients related with the activity type: a coefficient of 1 for sleeping and resting; 1.5 for very light activities (those that can be done sitting or standing up such as typing, or painting); 2.5 for light activities (e. g., walking); 5 for moderate activities (e. g., playing tennis, skiing, and dancing); and 7 for intensive activities (e. g., playing basketball), then the sum of these values was then divided by 24²⁰. The physical activity coefficient was used to classify schoolchildren by PAL using the criteria of the IOM (sedentary: $\geq 1.0 - < 1.4$, low active: $\geq 1.4 - < 1.6$, active: $\geq 1.6 - < 1.9$ and very active: $\geq 1.9 - < 2.5$)¹³.

Statistical analysis

Mean and standard deviation (SD) were calculated for quantitative variables and percentages for qualitative variables. Preliminary analysis was carried out to test homoscedasticity of variances and normality of the data using Levene's test and the Kolmogorov–Smirnov test, respectively. The significant differences by sex were assessed using Student's t test with quantitative data where the data was normally distributed, or using the Mann–Whitney test otherwise. Differences by PAL were analyzed using ANOVA or Kruskal–Wallis test for quantitative variables. Qualitative variables were examined with the z test for two proportions and for three proportions the Bonferroni's method. All calculations were made using SPSS software (version 19.0 for windows; SPSS Inc., Chicago, IL). The level of significance was set at $p < 0.05$.

Due to the inter-correlation of energy intake with nutrients, an adjustment of total water intake and water intake from beverages for total energy intake using the residual method was performed^{21,22}.

Results

A total of 564 schoolchildren (258 boys and 306 girls) aged between 9 and 12 years from 14 schools of the Community of Madrid (Spain) took part in the present study. The results were analyzed by sex and PAL.

Age, anthropometric, physical activity and energy and water intake data of the studied participants by sex are shown in table I. Age, weight, height and BMI were similar in boys and girls. The percentage of children with normal weight was higher in girls while the percentage of obesity was higher in boys.

Regarding physical activity, the percentage of children who had a low active level was higher in girls in comparison with boys while the percentage of children with active level was higher in boys than in girls. There was a significant correlation between the physical activity coefficient and the age of the schoolchildren ($r = -0.124$, $p < 0.01$).

Table I
Age, anthropometric, physical activity and energy and water intake data of the studied schoolchildren. Differences by sex

	Total (n = 564)	Boys (n = 258)	Girls (n = 306)
Age (years)	10.67 ± 0.88	10.65 ± 0.88	10.68 ± 0.88
Weight (kg)	39.34 ± 9.53	39.25 ± 9.73	39.41 ± 9.38
Height (m)	1.43 ± 0.08	1.42 ± 0.07	1.43 ± 0.08
Body mass index (kg/m ²)	18.94 ± 3.27	19.00 ± 3.43	18.89 ± 3.13
Normal weight (%)	69.6	64.3	73.9*
Overweight (%)	15.2	15.9	14.7
Obesity (%)	15.2	19.8	11.4*
Physical activity level	1.53 ± 0.07	1.54 ± 0.08	1.53 ± 0.07
Sedentary (%)	3.5	3.5	3.6
Low active (%)	77.7	72.5	82.0*
Active (%)	18.8	24.0	14.4*
Very active (%)	0.0	0.0	0.0
Energy intake (kcal/day)	2,143.1 ± 351.77	2,207.2 ± 350.11	2,089.1 ± 344.57***
Estimated energy requirement (kcal/day)	2,124.1 ± 362.68	2,388.6 ± 314.21	1,901.1 ± 224.80***
Energy intake adequacy (%)	103.19 ± 21.65	93.79 ± 18.34	111.10 ± 21.08***
Discrepancy intake/requirement (kcal/day)	-19.01 ± 458.44	181.40 ± 455.74	-187.99 ± 387.71***
Discrepancy intake/requirement (%)	-3.19 ± 21.65	6.20 ± 18.34	-11.10 ± 21.08***
Total water intake (mL/day)†	1,504.6 ± 329.35	1,532.1 ± 353.84	1,481.4 ± 305.85***
Total water intake adequacy (%) [‡]	75.59 ± 19.28	74.77 ± 19.85	76.28 ± 18.8
% total water intake < AI [‡]	91%	90.7%	91.2%
Water intake from beverages (mL/day)††	603.11 ± 295.08	627.46 ± 323.45	582.58 ± 267.67*
Water intake from beverages adequacy (%) [‡]	43.24 ± 21.72	43.71 ± 22.64	42.85 ± 20.94
% water intake from beverages < AI [‡]	97.9%	97.3%	98.4%

Values are expressed as mean and SD or %. Differences by sex *p < 0.05, **p < 0.01, ***p < 0.001.

†Beverages not include milk or dairy drinks.

‡Data adjusted for total energy intake.

[‡] Adequate intake (AI) for children by EFSA¹⁴.

Total energy intake was higher in boys than in girls and the adequacy to the estimated energy requirement was higher in girls in comparison with boys. Furthermore, probable overestimation evaluated by the discrepancy between the total intake and the energy requirement expressed as kcal/day and as percentage was higher in girls than in boys (table I).

Mean total water intake was 1,504.6 ± 329.35 mL/day. There was no significant correlation between the total water intake and the age of the studied schoolchildren ($r = 0.011$, $p > 0.05$) nor between the water intake from beverages and age ($r = 0.036$, $p > 0.05$). There were significant differences between sexes in relation to water intake (table I). Boys had higher total water intake and water intake from beverages than girls.

Table II shows data about energy and water intake of the studied schoolchildren by PAL. There were no significant differences respect to the total energy intake between the different PALs, but energy intake adequacy was higher in children who had a sedentary and low active level than active level. The intake of total water, water from beverages, the contribution to the adequate intake, and the percentages of children who did not meet the adequate intake were similar among the different PALs.

Water dietary sources of the studied participants and by PAL (expressed as percentage of total water intake) are shown in table III. Dietary sources of water for all the participant were beverages (40.08%), followed by dairy

products (27.13%), fruits (10.64%), vegetables (9.35%), meat (6.01%), cereals (2.59%), fish (1.79%), eggs (1.41%), precooked food (0.49%), pulses (0.18%), condiments and sauces (0.17%), appetizers (0.07%), sugar, sweets and pastries (0.07%) and oils (0.01%).

Discussion

This study addresses water intake in a sample of Spanish healthy schoolchildren, focusing mainly on the water intake adequacy assessment and on the analysis of the intake of water in children with different PAL. Data on water intake is scarce especially in healthy schoolchildren^{23,24}. This study adds updated information concerning the situation about water intake and also shows the main dietary sources. The results of this study may be useful for our country and for other developed and developing countries and are essential from the standpoint of nutrition and health.

The results of the anthropometric data (weight, height and BMI) of the studied schoolchildren are in accordance with other studies performed in Spain and in Europe in children of similar age^{25,26}. The percentage of obesity was higher in boys than in girls that has also been described in other studies performed in Spain^{27,28}.

When comparing the physical activity coefficient of the studied children with the criteria proposed by the

Table II
Energy and water intake data of the studied schoolchildren. Differences by physical activity level

	<i>Sedentary (n = 20)</i>	<i>Low active (n = 438)</i>	<i>Active (n = 106)</i>
Energy intake (kcal/day)	2,057.5 ± 394.27	2,132.6 ± 349.09	2202.6 ± 350.41
Estimated energy requirement (kcal/day)	1,854.5 ± 274.6	2,063.4 ± 315.32	2426.0 ± 395.78 ^{a*} ^{b***c***}
Energy intake adequacy (%)	113.23 ± 27.33	105.31 ± 21.31	92.54 ± 18.36 ^{b***c***}
Total water intake (mL/day)†	1,526.3 ± 386.05	1,504.8 ± 326.17	1499.3 ± 334.27
Total water intake adequacy (%) [‡]	74.03 ± 25.94	75.53 ± 19.28	76.11 ± 17.99
% total water intake < AI [‡]	90.0	91.1	90.6
Water intake from beverages (mL/day)††	741.99 ± 371.79	602.66 ± 292.84	578.80 ± 284.06
Water intake from beverages adequacy (%) [‡]	51.80 ± 30.21	43.16 ± 21.50	41.96 ± 20.59
% water intake from beverages < AI [‡]	95.0	97.9	98.1

Values are expressed as mean and SD or %. Differences by physical activity level: ^asedentary vs low active, ^bsedentary vs active, ^clow active vs active. *p < 0.05, **p < 0.01, *** p < 0.001.

† Beverages not include milk or dairy drinks.

†† Data adjusted for total energy intake.

[‡] Adequate intake (AI) for children by EFSA¹⁴.

Table III
Water dietary sources of the studied schoolchildren with different physical activity level (%)

	<i>Total</i>	<i>Sedentary (n = 20)</i>	<i>Low active (n = 438)</i>	<i>Active (n = 106)</i>
Cereals	2.59	2.69	2.58	2.61
Pulses	0.18	0.16	0.15	0.32
Vegetables	9.35	8.74	9.38	9.34
Fruits	10.64	7.98	10.69	10.93
Dairy products	27.13	22.45	27.06	28.26
Meat	6.01	5.42	5.96	6.31
Fish	1.79	1.84	1.88	1.42
Eggs	1.41	0.97	1.43	1.39
Sugars, sweets and pastries	0.07	0.05	0.07	0.05
Oils	0.01	0.01	0.02	0.01
Beverages	38.63	48.92	40.05	38.63
Precooked food	0.49	0.32	0.49	0.49
Appetizers	0.07	0.18	0.08	0.07
Condiments and sauces	0.17	0.26	0.17	0.17

Values are expressed as percentages.

IOM for determine the PAL, it was observed that both boys and girls had a "low active" level of physical activity¹³. Additionally, it was noteworthy that none of the participants had a "very active" level. Furthermore a tendency of decreasing physical activity with increasing age of the children was also observed in our study, which is consistent with a study carried out in Australian schoolchildren²⁹. Moreover, the percentage of girls who had a low active level was higher than boys and the percentage of boys with active level was higher than in girls, showing that girls were less active than boys. This also has been described in a study performed in Danish children where girls were less active than boys³⁰.

Energy intake was higher in boys than in girls; this situation has also been found in other studies^{31,32}, and is consistent with higher energy requirement in boys¹³. Energy intake adequacy was higher in girls in comparison with boys, but both around the 100% of energy

requirement. Moreover, energy intake was no different among PALs, but the energy intake adequacy was higher in those children who were classified in "sedentary" or "low active" level than children who were more active. Either way, the percentage of energy intake adequacy also was found around the 100% of energy requirement in the three levels of physical activity.

Furthermore, the discrepancy between the total energy intake and estimated energy requirement was $-3.19 \pm 21.65\%$, indicating on average that declared dietary data probably was overestimated. However, mean value of discrepancy was found quite low, so that it can be considered that the dietary intake collection was performed adequately^{17,18}. Comparing the discrepancy between sexes, this one was higher in girls than in boys. On average diet of girls overestimated ($-11.10 \pm 21.08\%$), while boys underestimated ($6.20 \pm 18.34\%$) ($p < 0.001$), indicating that boys were more likely to declare

a lower intake in relation to they actually do in comparison with girls. This fact has also been found in the literature²⁷ and probably, as has occurred in that study, may be due to the higher percentage of boys with obesity (comparing with girls). This situation is consistent with other studies conducted, where it has been found that individuals with overweight tend to underestimate their intake more than subjects with normal weight or low^{17,33}.

In European countries data on water intake are mostly not comparable due to several aspects, such as differences in the methods to dietary data collection and in the categorization of foods and beverages, the lack of clear definitions of beverage items, errors due to semi-quantitative measures and due to measuring total weight (including nutrients instead of water intake only) and besides that, underreporting appears to be a problem^{14,23}. Keeping in mind the above, we compared our results with those from other studies performed in children of similar age^{3,34,35}. Comparing with the results of the National Health and Nutrition Examination Survey (NHANES) conducted in children of 4–13 years old in the United States (2005–2010)³⁴, we found that the intake of total water seems to be higher than in our study ($1,711 \pm 29.6$ mL/day vs. $1,504.6 \pm 329.35$ mL/day, respectively). Moreover, a study carried out in a sample of healthy French children of 6–11 years old showed that the intake of water from beverages (excluding milk or dairy drinks) was of 799.2 mL/day³, which seems to be slightly higher than the intake found in our study (603.11 mL/day). After the total energy intake adjustment, relative to boys, girls reported lower total water intake and water intake from beverages, which is consistent with the lower needs in girls and agree with the results of the NHANES³⁵.

Some studies have found that total liquid intake and water from some beverages, as carbonated drinks, increases with age^{35,36}. However, in our study, the total water intake ($r = 0.011$, $p > 0.05$) or the water intake from beverages ($r = 0.036$, $p > 0.05$) and the age of the studied schoolchildren were not associated. Probably because the age range in our study was smaller (9–12 y) in comparison with population of those studies, where also participated younger children and adolescents.

It would be advisable and expected that children with higher physical activity were also those who have a higher intake of water. However, total intake of water and from beverages adjusted by energy intake and adequacy in both cases were similar among the different PALs. In relation to this we only found one study performed in adolescents, the HELENA study (Healthy Lifestyle in Europe by Nutrition in Adolescence), which was performed in individuals of 12.5–17.5 years old indicating that the intake of water and other beverages analyzed in the study were similar between the tertiles of PAL for both males and females³⁷.

The need to attain a daily balance between total water intake and water losses is well recognized^{14,38}. There have been set different dietary recommendations to guide population about the intake of water in

different countries¹⁴. However, difficulties in the establishing of specific intake of water that ensures an adequate hydration and promotes optimal health for a variety of conditions and populations have been described in the literature¹. The report of the IOM published in 2004 highlighted the impossibility to determine the Estimated Average Requirements (EAR) for water, due to the impact of temperature and activity level on needs of water³⁸. Also, the report pointed out that although low water intake has been associated with some chronic diseases, evidence was insufficient³⁸. Therefore, an adequate intake was set up to prevent deleterious, primarily acute, effects of dehydration, which include metabolic and functional abnormalities³⁸. Likewise, in 2010, EFSA established the water adequate intake having into account 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 (PALs: 1.6)¹⁴.

In order to assess the adequacy of the water intake in this study group, we considered apply the dietary reference values for water established by the EFSA¹⁴, since they are recent and set for European population. In this regard, mean adequacy percentage of total water intake ($75.59 \pm 19.28\%$) and of water from beverages ($43.24 \pm 21.72\%$) were below the adequate intake. It is stressed that water intake from beverages did not meet even half of the recommendation. In addition, we found that the situation of water intake is of concern, since most of schoolchildren (91%) had a total water intake below the AI and in relation to water intake from beverages this percentage was higher (97.9%). Respect to the above, no significant differences were observed between boys and girls, nor in the PALs. It is necessary to take measures since if these water intake habits persist, the risk of dehydration is higher, especially in those children who play some sport and the water losses are not adequately replaced.

Foods that were the major contributors to water intake in the studied schoolchildren were determined. As expected, the major water dietary source were beverages that representing the 40.08% of the total water intake, while dairy products were the second major source (27.13%), followed by fruits with a 10.64% and vegetables with 9.35%. Considering the above, it seems necessary to promote the intake of these food items that besides providing water may also contribute to meet the needs of macro and micronutrients.

One limitation of the present work is that the study sample was not selected to be representative and thus, these results cannot be extrapolated to all the population of schoolchildren from the Community of Madrid. Nonetheless, we consider that given that not much information is available on water intake in this age group, our results are relevant and useful and give a good picture of the current situation.

In conclusion, most of the studied children had an inadequate water intake, independently of physical activity level. Main water food sources were beverages (not including milk or dairy drinks), followed by dairy products, fruits and vegetables. It would be advisable to increase the intake of water through beverages and water-rich foods as fruits and vegetables to attain adequate hydration status, especially in those who practice exercise regularly to ensure an optimal physical performance. Finally, on the basis of children spend a considerable time at school, educational centers and in particular school food services, play an essential role in promoting healthy drinking patterns, also is recommendable ensure availability of water sources in their facilities and provide healthy choices to increase the intake of water in children.

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Conflict of interest statement

None of the authors had any personal or financial conflict of interest.

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Hydration protocol of the university hospital La Paz: an initiative to prevent and treat dehydration and hyperhydration in hospitalized patients

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Abstract

Introduction: There is a high prevalence of hydration disorders in the hospitalized population.

Objectives: In addition to promoting the prevention of dehydration and its early diagnosis, we intend to standardize fluid therapy practices with the aim of reducing complications and improving the prognosis of our patients.

Material and methods: A multidisciplinary workgroup consisting of members from the Nutrition Quality Committee was formed, all interested in the subject, and whose area of expertise was relevant to the group. The issues were distributed amongst the team members based on their knowledge area, and a literature review was conducted. They held monthly meetings throughout 2013, and they developed this protocol upon the clinical experience accumulated.

Results: A Hydration Protocol was developed that starts with the identification of patients and clinical situations at risk of dehydration and subsequently identifies the clinical signs and symptoms of risk. Other laboratory tests are subsequently performed, such as hematocrit, serum and urinary electrolytes, renal function and acid-base balance tests. All of these parameters allow us to make the diagnosis of the hydration state, classifying patients as hyper-hydrated, well-hydrated or dehydrated and defining the severity of the process. The protocol establishes the most appropriate way to calculate, individually, the daily water, sodium, potassium and chloride requirements; it tries to ensure a supply of at least 125 grams per day of glucose. We reviewed different oral and intravenous rehydration patterns, depending on the plasma sodium level and its follow-up. Finally, we proposed a new guideline of standard fluid therapy.

Conclusions: We consider that this protocol is very important for our hospital clinical practice, and once implemented, the results will be evaluated and new modifications or other corrective measures will be established.

Key words: Hydration. Dehydration. Fluid therapy. Protocol.

PROTOCOLO DE HIDRATACIÓN EN EL HOSPITAL UNIVERSITARIO LA PAZ: UNA INICIATIVA PARA PREVENIR Y TRATAR LA DESHIDRATACIÓN E HIPERHIDRATACIÓN EN LOS PACIENTES HOSPITALIZADOS

Resumen

Introducción: Existe una alta prevalencia de desórdenes de la hidratación en la población hospitalizada.

Objetivos: Además de promover la prevención de la deshidratación y su diagnóstico precoz, se pretende estandarizar las prácticas de fluidoterapia con la intención de disminuir complicaciones y mejorar el pronóstico de nuestros pacientes.

Materiales y métodos: Se formó un grupo de trabajo multidisciplinar constituido por miembros de la Comisión de Calidad de Nutrición, interesados en el tema y cuya área de especialización era relevante para el grupo. Se distribuyeron los temas entre todos en función del área del conocimiento y se realizó una revisión bibliográfica. Se mantuvieron reuniones mensuales durante todo el año 2013, e igualmente basados en la experiencia clínica acumulada, se elaboró el presente protocolo.

Resultados: Se elaboró un protocolo de Hidratación que se inicia con la identificación de los pacientes y las situaciones clínicas de riesgo de deshidratación y posteriormente se identifican los signos y síntomas clínicos de riesgo. Se revisan posteriormente otras pruebas a realizar, incluyendo las de laboratorio como hematocrito, electrolitos séricos y urinarios, pruebas de función renal y del equilibrio ácido-base. Con todos estos parámetros podemos ya hacer el diagnóstico del estado de hidratación clasificando a los pacientes como hiperhidratados, normohidratados o deshidratados y definiendo la severidad del proceso. Se establece la forma más adecuada para calcular de forma individualizada los requerimientos diarios de agua, sodio, potasio, cloro e intentar garantizar un aporte de al menos 125 gramos de glucosa al día. Finalmente se revisan diferentes pautas de rehidratación oral e intravenosa, en función de los niveles de sodio plasmático y su seguimiento. Y para acabar se propone una nueva pauta de sueroterapia estándar.

Conclusiones: Consideramos que la elaboración de este protocolo es muy importante para la práctica clínica de nuestro hospital y una vez implementado, valoraremos los resultados obtenidos por si se deben establecer modificaciones u otras nuevas medidas correctoras.

Palabras clave: Hidratación. Deshidratación. Fluidoterapia. Protocolo.

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Abbreviations

PSS: Physiological Saline Solution.
NaCl: Sodium Chloride.
Cl⁻: Chloride.
Na⁺: Sodium.
K⁺: Potassium.
LR: Lactated Ringer.
PL: Plasma-lyte.
mEq: Milliequivalent.
L: Liter.

Introduction

A previous study conducted with 50 elderly patients in our hospital, using the Bioelectrical Impedance technique, demonstrated the existence of a high percentage of abnormal states of hydration. 18% were dehydrated and 24% were hyper-hydrated. In turn, the achievement of adequate fluid and electrolyte states in hospitalized patients is often performed in accordance with standardized practices and rarely meets the real needs of each patient.

One of the most frequently used solutions is sodium chloride (NaCl) at 0.9%, also called physiological saline solution (PSS), although its characteristics are far to resemble the physiological properties of plasma¹. In fact, the very high concentration of chloride (Cl⁻) in this solution can produce hyperchloremia, which attached to dilutional acidosis type generated by the PSS can ultimately induce a hyperchloremic metabolic acidosis^{2,3}. Hyperchloremia is also the cause of renal vasoconstriction and decreased glomerular filtration rate⁴; it was observed in surgical patients that, after changing the routine use of PSS to a Lactated Ringer (LR) or Plasma-lyte (PL), rise in creatinine blood levels and incidence of acute renal failure was less than with PSS⁵. The LR solution does not produce hyperchloremia or acidosis, since it contains less chloride loading. Likewise, in the metabolism of the lactate to pyruvate and eventually to glucose, 1 mol of bicarbonate (HCO₃⁻) per mole of administered lactate is generated,³ producing a relatively slower alkalization start, although with a risk of rebound alkalosis⁶. Some studies suggest the superiority of LR as a resuscitation therapy in hypovolemic hemorrhagic shock, producing less pulmonary edema than PSS⁷. Also to be taken into account is the fact that LR, being a hypo-osmolar solution, it raises intracranial pressure, a critical event in patients with head injuries and mass space-occupying lesions at cranial level⁸. As mentioned above, lactate metabolism generates glucose and it is not surprising that the intraoperative administration of LR doubles concentrations of glucose in diabetic patients⁹. The use of Plasma-lyte (a mixed solution of organic and electrolytic anions) suggests a lower incidence of major complications, and mortality, and a reduced need for dialysis when compared with the PSS.¹⁰

Since there are multiple solutions available, each one with different concentrations of solutes and different physiological properties, and taking into account that adequate fluid may be a determinant in the management and prognosis, as well as having influence on morbidity and consequently on the hospital stay,^{5,10,11,12} it is essential to standardize patterns of fluid therapy in our hospital. To this aim, we propose the development of a protocol for the prevention and treatment of dehydration and hyper-hydration states. This begins with the identification of patients at risk, identifying the signs and symptoms of dehydration, reaching the diagnosis of the hydration state, and finally stating the most appropriate rehydration formula for each case.

Objectives

In addition to promoting the prevention of dehydration and its early diagnosis, we intend to standardize fluid therapy practices with the aim of reducing complications and improving the prognosis of our patients.

Materials and methods

A multidisciplinary workgroup consisting of members from the Nutrition Quality Committee was formed, all interested in the subject, and whose area of expertise was relevant to the group. The issues were distributed amongst the team members based on their knowledge area, and a literature review was conducted. They held monthly meetings throughout 2013, and they developed this protocol upon the clinical experience accumulated.

Results

A Hydration Protocol was developed, including an operation flowchart based on the findings; this flowchart is shown below (fig. 1).

First of all, the water served in the hospital was analyzed to check it met all the criteria for composition and microbiology safety enforceable by law and certified by the Department of Preventive Medicine. Also, we have confirmed that patients were receiving fluids from the Food Service on their own trays (water, tea, juices, milk, soups...) in the service of breakfast, lunch and dinner, and before going to bed. However, strategies of support must be established so that invalid patients also receive the necessary fluids. This must promote the use of thickeners in cases where dysphagia exists and greater attention in certain areas like Geriatrics where it is already implemented.

However, the inconvenience of using jars to distribute water and ice to cool it, has lead us to request the installation of fresh water sources for every floor (currently in installation phase). Also, vending machines have already been installed in almost all the floors and they offer a wide range of drinks that can be adjusted to the tastes

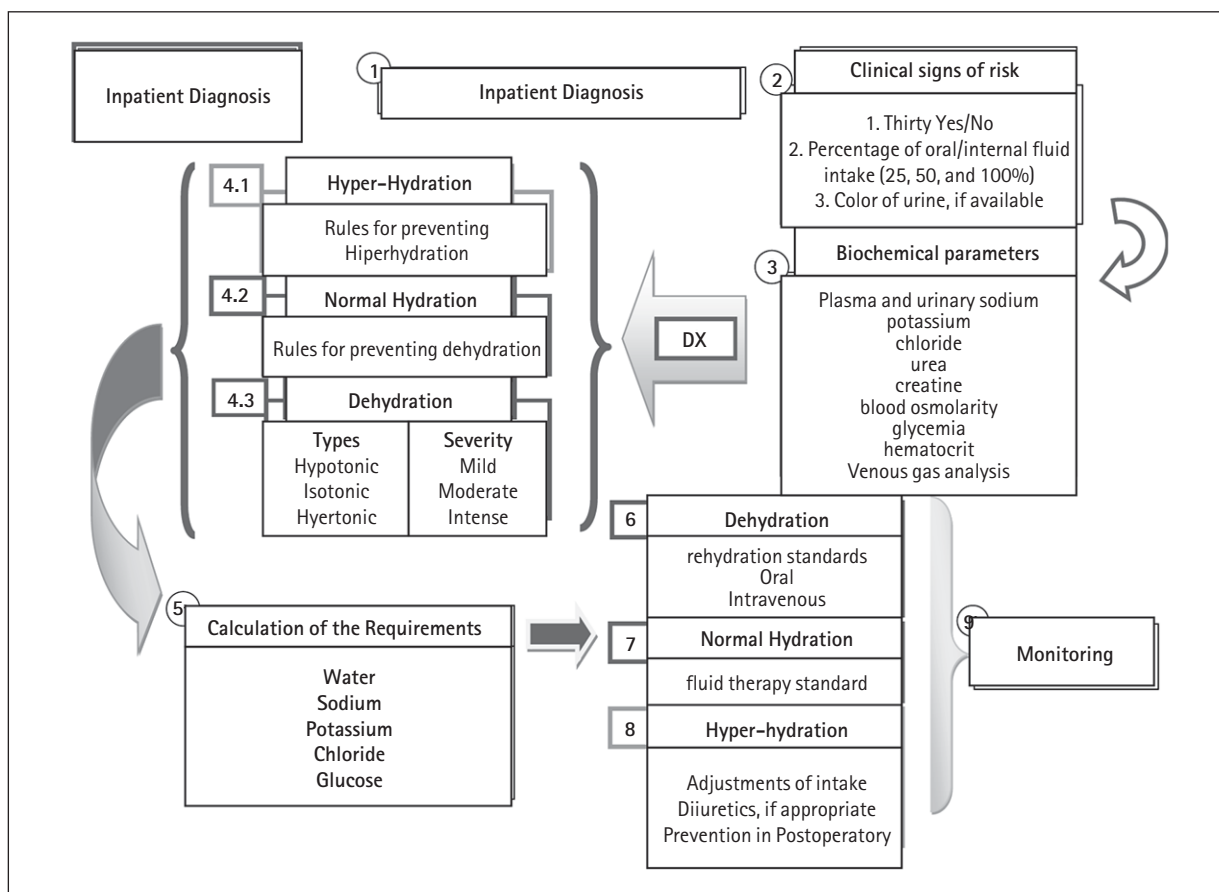


Fig. 1.—Algorithm for Hospital Hydration.

and needs of all potential consumers (in this case, patients, families and professionals).

Identification of risk groups and situations

Elderly people (especially over 85), children, pregnant women, critically ill patients, those who present abnormal mobility, and prolonged bed rest, patients with stroke, dementia, acute confusional state, delirium, or depression, are a group with a high risk of dehydration or hyper-hydration¹³.

In addition, we must take into account situations that may alter the hydro-electrolyte balance and others that require quantification of the hydro-electrolyte loss whether through the digestive tract (diarrhea, vomiting, drainage, fistulas, bleeding, ostomy), skin loss (by fever, pressure ulcers, burns, wounds, pemphigus), renal losses (diabetes insipidus, hyper-protein diets, diuretics), lung loss (fever, hyperventilation) or various losses (by dialysis, pleural drainage, peritoneal, non-gastrointestinal bleeding). In turn, it is estimated that fever increases water loss to 100–150 ml per degree from 37 °C¹⁴.

Other variables to take into account: *the ambient temperature* (the combination of high heat and humidity is more harmful), *the quality of the diet* (an estimated

20% of the water requirements are obtained from foods if they contain enough fruit and vegetables and a good variety in general) and *the quantity* (if patients eat poorly they will also get less water from food), as well as the *direct consumption of fluids* and the administration of *drugs and serum or parenteral or enteral feeding*.

Identification of clinical signs of risk

It is often difficult to assess the hydration state of the hospitalized patient. Color-concentrated urine, as well as thirst (symptom indicating intracellular fluid deficiency), are good predictors of dehydration. The daily weight of the patient is the best parameter to evaluate the gain or loss of water during hospitalization, but we know it is not a very common practice and it is difficult to carry out in inpatients. There is no formula to estimate the volume of fluid lost, although it could be approximated as a function of blood pressure (BP), heart rate (HR), diuresis, jugular venous pressure, skin turgor (or skin pinch) and the state of consciousness¹⁵. However, it is also true that fluids administered based on clinical signs of intravascular volume changes (BP, HR, peripheral temperature or diuresis) diffuse into the interstitial space, having peripheral and pulmonary edema¹⁶ as a result.

Biochemical parameters

Plasma sodium is a good indicator of the water balance in relation to a solute; however, it does not convey information about the total body water volume. Other determinations of use are the plasma levels of potassium, chloride, urea, creatinine, blood osmolarity, glucose, and hematocrit. The concentration of Na^+ in urine, with a value less than 15 meq/L indicates a state of salt retention as a compensatory mechanism to a loss of volume. An increased hematocrit, if there is no history of bleeding, is also indicative of a state of dehydration. Nevertheless, in some of the hospital wards such as Nutrition and Nephrology, we use a technique of Bioimpedance for the diagnosis of dehydration. This method, although useful, is not incorporated in this protocol because it is not a common practice and cannot be carried out in all hospital services.

Diagnosis of the state of hydration

Taking into account the symptoms, clinical signs, and results from the tests requested, three clinical situations can be differentiated.

Hyperhydration

An excess volume is evident especially at interstitial level (as in Cirrhosis, Heart failure, or in Nephrotic syndrome), represented clinically by the presence of

edema in extremities or ascites and causing lung edema at pulmonary level. This state of hyperhydration can coexist with a volume deficiency at intravascular level.

Normal Hydration

The patient is in a proper water balance. As a precaution, ensure free access to glasses and bottles of water as well as making available sources of moisturizers in the hospital ward. Patients who do not have access to them must be provided with water frequently.⁹ If you need to administer intravenous fluid therapy, this will be as a Maintenance Therapy, taking into account the daily and individualized needs of water and of each of the solutes.

Dehydration

Hydro-electrolyte losses have exceeded intake and compensatory mechanisms have not been sufficient to maintain balance. Depending on the level of Na^+ in plasma, it can be classified, in turn, in **Hypotonic, Isotonic and Hypertonic dehydration** (table I).

Calculate the daily requirements: Maintenance therapy

The recommended daily intake for normal hydrated patients is^{17, 18} as follows:

Table I Types of dehydration according to the plasma levels of sodium, etiology, and clinical signs depending on the current severity		
Types	Causes	Severity
ISOTONIC – Balanced loss of water and salts (Na^+) from the extracellular compartment – There is no displacement of intracellular water to the extracellular	<ul style="list-style-type: none"> • Ascites • Diuretics • Gastrointestinal losses (diarrhea,...) • Pleural aspiration • Inadequate intake of water and minerals • Burns • Fistulas • Bleeding 	<ul style="list-style-type: none"> • Mild: Fatigue, weakness, muscle spasms, thirst, vertigo • Moderate: Oliguria, cyanosis, abdominal pain and/or chest pain, confusion, dullness • Severe: Hypovolemic Shock (hypotension and tachycardia), cyanosis, oliguria, mental disturbances
HIPOTONIC or HYONATREMIC – Loss of Na^+ higher than H_2O – Entry of H_2O inside the cell Profuse sweating	<ul style="list-style-type: none"> • Profuse sweating • Loss of gastrointestinal fluid • Use of thiazides • Replacement of H_2O without supplying Na^+ and K^+ 	<ul style="list-style-type: none"> • Mild: Nausea, upset stomach • Moderate: Headache, lethargy, confusion, and dullness • Severe($\text{Na}^+ < 120 \text{ mEq/L}$ or decreasing rapidly): Stupor, seizures, coma
HIYPERTONIC or HYPERNATREMIC – Increased loss of H_2O than Na^+ – Exit of H_2O from the intracellular compartment	<ul style="list-style-type: none"> • Vomiting • Sweating • Osmotic Diuresis • Osmotic Diarrhea • Inadequate water intake 	<ul style="list-style-type: none"> • Mild: Thirst and oliguria • Moderate: Weakness, neuromuscular irritability, neurological focal deficiencies • Severe ($\text{Na}^+ > 180 \text{ mEq/L}$ or increasing rapidly): Coma, seizures

Water

The recommended daily intake is 1 ml per Kcal. In adults, it is estimated a minimum intake of 35 ml/kg/day, except in people over the age of 70, who are advised not to exceed 30 ml/kg/day. When executing the water balance it must be remembered that enteral nutrition formulas provide different percentages of water depending on whether they are isocaloric (1 Kcal/ml) or energetic (1.5 Kcal/ml), and (2 Kcal/ml) that they respectively provide 80, 50, and 30 % of free water.

Sodium

The needs range from 1-2 mEq/kg/day (1 mEq = 23 mg). It is recommended to provide around 100 mEq/day.

Potassium

The intake of K⁺ in our environment ranges from 40 to 120 mEq/day (1 mEq = 39 mg). The needs are 1-2 mEq/kg/day. It is recommended to provide around 50-60 mEq/day. In case of hypokalemia, 80-100 mEq of intravenous support is needed to elevate figures of K⁺ plasma in 1 mEq/L. The maximum infusion rate is 20 mEq/hour¹⁹.

Chloride

The needs range from 1-2 mEq/kg/day. It is recommended to provide 60-100 mEq/day.

Glucose

A minimum daily intake of about 125 grams of glucose, equivalent to 500 kcal, must be ensured to prevent protein catabolism and ketosis. This premise is important in fluid-therapy and especially in diabetic patients.

Replacement therapy: Rehydration

Oral rehydration

It is done by oral rehydration solutions (ORS), which are valid for any type of dehydration at any age. These solutions are indicated for the prevention and treatment of acute dehydration, although contraindicated in cases of hypovolemic shock, sepsis, decrease or loss of awareness and severe dehydration (loss of more than 10% of weight). Paralytic ileus and intense and sustained fecal losses (more than 10 ml/kg/h) also contraindicate its administration; mild vomiting, kidney failure, and worsening during the rehydration phase would be considered as some relative contraindications. (table II).

In children with mild isotonic and/or hypotonic dehydration, we must provide 50 ml/kg of ORS every 4 hours, being necessary to give 100 ml/kg every 4 hours if dehydration is moderate. In adults (over 50 kg), it is recommended to give 2,000-4,000 ml of ORS.

The administration will be in small, frequent doses to prevent vomiting, especially in children. In the following hours, continue with ORS, self-administered by the patients according to their own needs, then gradually reintroduce food.

In cases of hypernatremic dehydration, the standard will be similar to that of isotonic dehydration, but the hydration time will be longer. The higher the value of plasma sodium, the slower rehydration should be.

Intravenous rehydration

Isotonic dehydration

- First phase or emergency (0-2 hours): Administer 20-30 ml/kg of Lactated Ringer or Plasma-lyte at 10 ml/kg/h. Treat shock if any¹⁵.
- Second-phase or repletion (2-18 hours): Aimed at re-establishing extracellular fluid and correcting deficiencies of the acid-base state. Give fluids similar to those from the first phase at a slower pace, administering 2,000-4,000 ml in 24 hours depending on the degree of dehydration. If acidosis

Table II
Oral rehydration solutions composition

Components	Normal sueroral	Hyposodic sueroral	Ions	Normal sueroral	Hyposodic sueroral
Main Compounds	Amounts	Amounts		mmol/l	mmol/L
NaCl	3.5	1.2	Na ⁺	90	50
KCl	1.5	1.5	K ⁺	20	20
Sodium Citrate	2.9	2.9	Cl ⁻	80	41
Glucose	20.0	20.0	Citrate	10	10
Excipients			Glucose	111	111
Acesulfame Potassium (E950)	0.280 g				
Orangish yellow (E110)	0.0350 g				

is severe (HCO_3^- less than 10 mEq/L) add HCO_3^- at a rate of 1 mEq/kg.

- Third or early recovery phase (18 hours to 2–4 days after beginning the therapy: If the patient has recovered diuresis, add K^+ (not exceeding 3 mEq/kg/24h). Administer 2,000–2,500 ml/day. Increase caloric and protein intake (after 24 hours) guaranteeing a total of 2,000–2,500 ml/day of liquids.

Hypotonic dehydration^{20,21}

The treatment is similar to the isotonic one but in the first, Physiological Serum is used, taking into account the losses of Na^+ to calculate the electrolyte contribution with the following formula:

$$\text{Na}^+ \text{ Deficiency (mEq)} = (\text{desired Na}^+ - \text{current Na}^+) \times 0.6 \times \text{weight in kg}$$

The desired Sodium is usually 135, and the replacement will be done in 24–48 hours, trying not to sharply raise the serum concentrations of Na^+ (no more than 10 mEq/L in the first 24 hours or more than 18 mEq/L in the first 48 hours).

In case of seizures, it is recommended to use a 3% hypertonic saline solution (500 mL of 0.9% PSS + 60 ml of NaCl at 20% = 513 mEq/L) at 1–2 ml/kg/h, evaluating the increase of sodium at 2 hours:

- If it is less than 1 mEq/L, increase the infusion rate by 50–100%.
- If it is between 1–6 mEq/L, maintain the same infusion rate.
- If it is greater than 6 mEq/L, stop administration.

Evaluate plasma sodium two hours after the last measurement:

- If Na^+ is less than 120 mEq/L and/or the increase is less than 2 mEq/L from the initial measurement, with persistent severe symptoms, increase infusion rate by 50–100 % and re-evaluate again in two hours; if the symptoms are mild, keep infusion rate and reassess after 4–6 hours.
- If Na^+ is between 120–130 mEq/L and/or the increase is greater than 6 mEq/L from the beginning, stop administration.
- If Na^+ is greater than 130 mEq/L or the increase is greater than 8 mEq/L from the beginning, discontinue administration and evaluate correction standard with 5% SG to 6 ml/kg/h for 2 hours or Desmopressin 1–2 g SC or IV every 6 hours.

Hypertonic dehydration

- Restoration phase of the circulation (initial): The shock should be treated similarly to other types of

dehydration. If the predominant clinical findings are extracellular volume depletion, treatment should begin with a Lactated Ringer or PSS, to quickly replenish the extracellular volume. If the neurological effects of hypertonicity are predominant, treatment should begin with a Saline Solution of 0.45%. The Isotonic Saline Serum does not provide free water; therefore, the deficit of water has to be administered as an estimated 5% Glucose.

- Replacement phase of the deficiency in 48–72 hours: The composition of the rehydration fluid is less important than the slow and gradual correction of the deficiency, which is calculated using the formula:

$$\text{Water deficiency (Liters)} = (0.6 \times \text{kg of weight} \times \text{current Na}^+ / \text{desired Na}^+) - (0.6 \times \text{kg of weight})$$

Water deficiency is replenished with 5% glucose, and associated metabolic acidosis, treat it only if pH is below 7.0, and at a half dose. Cases of severe hypernatremia (Na^+ greater than 190 mEq/L) may require dialysis. Hypocalcemia is frequently present when treating hypernatremia, in which case, if the levels of Ca^{2+} are less than 7 mg/dl, add a vial of Calcium Gluconate at 10% for each 500 ml of fluid replacement, without mixing it with a bicarbonate.

Guidelines proposals for standard fluid therapy

To avoid common standards that alternate glucose serums with saline and which have an insufficient amount of glucose and excessive amounts of sodium and glucose, these new guidelines of standard fluid therapy have been proposed, always integrating a *sodium glucosaline serum at 5%*. For example the standard of 2,500 ml without potassium will have 2,500 ml of low sodium glucosaline at 5%, which gives a total of 125 g of glucose, 127 mMol of Cl^- and 127 mMol of Na^+ .

For safety reasons, whenever the addition of Potassium is required, serums will be used that already have the pre-diluted potassium and then vials of NaCl will be added to ensure the supply of sodium.

Hyperhydration

In these patients and depending on the excess of total body water, we must start measures to restrict fluid intake and in some cases administer diuretics to force diuresis.

Monitoring

An adequate fluid therapy is aimed at estimating and correcting the defects of the circulatory preload,

avoiding poor tissue perfusion and achieving effective circulating volume. The response to the administration of fluids will be measured by clinical signs and symptoms: dry mucous membranes, skin turgor, consciousness, etc. In addition to the measurement of other objective parameters such as diuresis and/or water balance, weight, blood pressure, heart rate, temperature, respiratory rate, and by laboratory tests: serum ions, venous blood gases, lactic acid, urea, creatinine, plasma osmolality and urine, and concentration of sodium in urine.

A strict fluid balance should be performed in all critically ill patients, those treated with parenteral nutrition or who have relevant extraordinary losses.

In critically ill patients it is important to maintain a mean Arterial Pressure above 65 mmHg, Diuresis greater than 0.5 ml/kg/h, Central venous saturation of oxygen greater than 70%, mixed venous saturation greater than 65%, and central venous pressure 8–12 mmHg.

Conclusions

We consider that the development of this protocol is very important for the clinical practice at our hospital, and once implemented, we will assess the results obtained in order to determine the introduction or not of modifications or other new corrective measures. The long-term effects will be evaluated in future studies.

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Total body water as a possible marker of the altered metabolism in obese children and adolescents

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Abstract

Introduction: Obesity is well known to be related to the percentage of Total Body Water (TBW) and inflammation, but the relationship between TBW and inflammation remains still unconfirmed.

Aim: To evaluate whether TBW is associated with inflammatory markers in obese children and adolescents.

Material and methods: Thirty four obese children (7.0–10.9 yrs) and 49 obese adolescents (11.0–15.0 yrs) were recruited. Body mass index (BMI Z-score) and several serum biomarkers such as lipid profile, C-Reactive Protein (CRP), sE-selectin, sL-selectin, soluble Intercellular Adhesion Molecule-1 (s-ICAM-1) and soluble Vascular Cell Adhesion Molecule-1 (s-VCAM-1) were determined. TBW was obtained by Bioelectrical measurements. Bilateral partial correlation test was used to analyze associations controlled by sex, age, and/or BMI Z-score.

Results: A negative correlation was found between TBW and BMI Z-score in both children and adolescents ($r = -0.581$, $p < 0.001$; $r = -0.368$, $p < 0.011$, respectively) that remained in both sex, separately ($r = -0.540$, $p < 0.001$; $r = -0.505$, $p < 0.001$). In addition, TBW was also negatively correlated with CRP ($r = -0.438$, $p < 0.001$) in both groups ($r = -0.560$, $p = 0.002$; $r = -0.436$, $p = 0.007$, respectively). When analyzed by sex, TBW was associated with CRP only in boys ($r = -0.588$, $p = 0.027$; $r = -0.652$, $p = 0.005$). TBW was negatively correlated with sE-selectin ($r = -0.236$, $p = 0.039$) only in adolescents ($r = -0.320$, $p = 0.032$). When analyzed by sex, TBW was associated with sE-selectin only in girls ($r = -0.432$, $p = 0.035$).

Conclusions: TBW may be considered as a marker not only of the hydration status, but also of the metabolic disorder in a low-grade inflammatory process such as obesity in children and adolescents.

Key words: TBW. BMI Z-score. Inflammatory markers. Obesity. Children and adolescents.

PORCENTAJE DE AGUA CORPORAL TOTAL COMO POSIBLE MARCADOR DE ALTERACIONES DEL METABOLISMO EN NIÑOS Y ADOLESCENTES OBESOS

Resumen

Introducción: Se conoce la relación de la obesidad con el porcentaje de agua corporal total (ACT) y con la inflamación, pero no se ha demostrado aún la posible asociación entre ACT y la inflamación.

Objetivo: Evaluar si la ACT (como marcador de estado de hidratación) se asocia con marcadores de inflamación en niños y adolescentes obesos.

Material y métodos: Los sujetos de este estudio fueron 34 niños obesos (7,0–10,9 años) y 49 adolescentes obesos (11,0–15,0 años). Se determinó el índice de masa corporal (IMC Z-score) y en suero se analizaron perfil lipídico, proteína C-reactiva (PCR), sE-selectina, sL-selectina, las moléculas de adhesión intercelular soluble-1 (s-ICAM-1) y vascular soluble-1 (s-VCAM-1). El ACT se obtuvo mediante impedancia bioeléctrica. Se utilizó la prueba de correlación parcial bilateral para analizar las asociaciones relacionadas con el sexo, la edad y/o IMC Z-score.

Resultados: Se observó una correlación negativa entre el ACT y el IMC Z-score en niños y adolescentes ($r = -0.581$, $p < 0.001$; $r = -0.368$, $p < 0.011$, respectivamente), que se mantuvo tanto en niños como en niñas ($r = -0.540$, $p < 0.001$; $r = -0.505$, $p < 0.001$). Además, el ACT también se correlacionó negativamente con la PCR ($r = -0.438$, $p < 0.001$) en ambos grupos ($r = -0.560$, $p = 0.002$; $r = -0.436$, $p = 0.007$, respectivamente). Cuando se analiza por sexo, ACT se asoció con la PCR sólo en los varones ($r = -0.588$, $p = 0.027$; $r = -0.652$, $p = 0.005$). ACT se correlacionó negativamente con la sE-selectina ($r = -0.236$, $p = 0.039$) sólo en el grupo de adolescentes ($r = -0.320$, $p = 0.032$). Cuando se analiza por sexo, ACT se asoció con la sE-selectina sólo en las niñas ($r = -0.432$, $p = 0.035$).

Conclusiones: ACT puede ser considerado como un marcador no sólo del estado de hidratación, sino también del trastorno metabólico en un proceso inflamatorio de bajo grado como en el caso de la obesidad en niños y adolescentes.

Palabras clave: Porcentaje de agua corporal total. IMC Z-score. Marcadores de inflamación. Obesidad. Niños. Adolescentes.

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Abbreviations and acronyms

BIA: Bioelectrical impedance analysis.
BMI: body mass index.
CRP: C-Reactive Protein.
CVD: Cardiovascular Disease.
FFM: Fat Free Mass.
HDL-C: High-Density Lipoprotein-Cholesterol.
LDL-C: Low-Density Lipoprotein Cholesterol.
MS: Metabolic Syndrome.
R: Resistance.
SD: Standard deviation.
s-ICAM-1: soluble Intercellular Adhesion Molecule-1.
s-VCAM-1: soluble Vascular Cell Adhesion Molecule-1.
TBW: Total Body Water.
TC: Total Cholesterol.
TG: Triglyceride.

Introduction

Overweight and obesity have significantly increased in the pediatric population¹. Both childhood and adolescence are critical periods for the onset of obesity and for obesity associated morbidity in later life². Obesity is often associated with metabolic complications, reduced capacity for physiological activity³ and increased development of chronic and degenerative diseases through adulthood⁴. The metabolic modifications by the energy imbalance in young obese subjects is associated with modifications in the body features⁵ and increased circulating levels of soluble vascular markers^{6,7}. These modifications are evaluated by determining body composition as well as blood biomarkers that are applied as useful tools, which allow an overall assessment of the general nutritional status of children.

Childhood obesity and Total Body Water (TBW)

The body water volume of individuals reflects the hydration status of the body and the chemical spectrum of the water within their environment that is available for drinking, excluding those chemicals that are or can be concentrated within the body or that are removed during renal filtration⁸. Values of TBW volumes, proportions of body constituents and their associations with age and fatness are considered as interesting biomarkers to assess adiposity⁸. Changes in body weight and fat-free mass (FFM) are usually related to changes in TBW. It is important to highlight that TBW levels can be modified in subjects with overweight and obesity⁸. Under this situation, as body fatness increases, TBW volume also increases, but it declines as a percentage of body weight⁸. In obese subjects, the TBW calculation from bioelectrical impedance analysis (BIA) has been extensively validated^{9,10}.

BIA estimates FFM by measuring resistance (R) of body tissues to a weak imperceptible current. R measure

is first of all used to estimate TBW⁹. TBW shows changes over age, nevertheless it is known that TBW% is relatively stable in adults.

In clinical practice, the analysis of the different water compartments into the organism has been performed during the course of diseases such as renal disease¹¹, cerebral palsy patients¹², patients with short bowel¹³ and newborns with parenteral nutrition¹⁴ with the purpose of relating these variables of body composition with the nutritional status of patients. However, in all these patients the relationship between TBW and biological markers in blood has not been established.

Childhood obesity and biomarkers

The onset of pediatric forms of chronic diseases such as hypertension, early signs of atherosclerosis, type 2 diabetes, non-alcoholic fatty liver disease, dyslipidemias or endothelial dysfunction contribute to increase cardiovascular (CVD) risk in adulthood¹⁵. All these chronic diseases that occur as a consequence of obesity are grouped under the title of metabolic syndrome (MS)¹⁶. Therefore, the study of blood levels of some biomarkers is essential to assess the status and level of a low-grade inflammation status and the disease severity of obese children and adolescents.

Studies in obese populations have found associations between insulin resistance and low-grade inflammatory status, with higher levels of C-Reactive Protein (CRP) both in adults as well as in children and adolescents¹⁷⁻²⁰. CRP has also shown significant associations with CVD, and this inflammatory protein is well recognized as a potent predictor CVD risk factor²¹.

Furthermore, the endothelium dysfunction and metabolic changes developed in overweight and obese individuals can be assessed by measuring the cell adhesion molecules and inflammatory proteins levels in plasma. In obese children and adolescents some molecules such as soluble Intercellular Adhesion Molecule-1 (s-ICAM-1), soluble Vascular Cell Adhesion Molecule-1 (s-VCAM-1), and E-selectin are elevated, indeed a positive association has been found between Body Mass Index (BMI) and those molecules²².

In summary, any alteration in the biomarkers' levels can be linked to modifications in body composition. With the aim to search new markers of non-invasive character, which can be rapidly and reliably assessed, the evaluation whether TBW is associated with inflammatory and cardiovascular biomarkers in obese children and adolescents (fig. 1) may be of interest for nutritional status assessment and intervention studies.

Material and methods

Study design and subjects

A randomized controlled trial was performed including thirty-four obese children (7.0-10.9 yrs) and

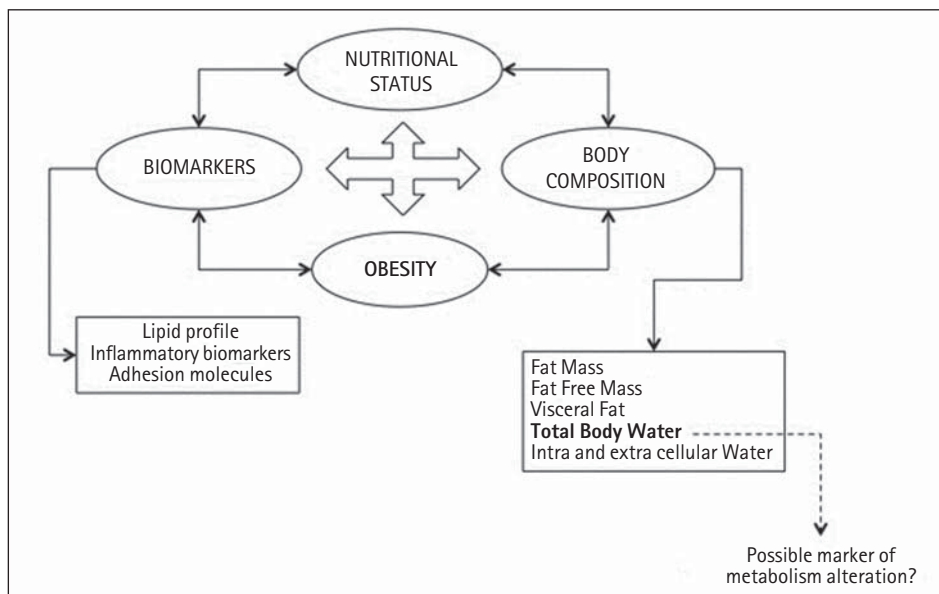


Fig. 1.—Interaction among nutritional status, body composition and biomarkers in obese subjects.

forty-nine obese adolescents (11.0–15.0 yrs, (BMI Z-score ≥ 2). Subjects were selected, according to the pubertal development degree (established by clinical criteria, Tanner stage and biochemical sex hormones), matched by sex and age. All obese children and adolescents were recruited in primary care centers in the cities of Cordoba and Granada, then referred for further studies to the Pediatric Endocrinology Unit, at University Hospital Reina Sofia (Córdoba) and the Pediatric Endocrinology Unit, University Hospital Virgen de las Nieves (Granada), respectively.

The exclusion criteria to recruit these subjects were: 1) not meeting the age range criteria, 2) presenting or having previously presented based diseases, 3) receiving or having received medication with known metabolic side effects, such as corticosteroids, 4) children undergoing long periods of medication rest.

Procedures

The subjects recruited visited the centers after 12 h fast for BIA assessment and blood draw. Body weight (kg) was measured by using Tanita (BC 418-MA Segmental) precision 100 g, range 0–150 kg. Height (cm) was measured by using a precision stadiometer (Seca), precision 0.2 cm, range 70–200 cm. BMI Z-score values were calculated based on height, weight, BMI media and standard deviations for the Spanish children population, considering sex and age as published by Sobradillo et al²³. TBW was derived from BIA measurements.

Biochemical markers

Lipid profile, inflammation and cardiovascular markers were measured in serum samples. The lipid profile (total cholesterol (TC), high-density lipoprotein

cholesterol (HDL-C), and triglyceride (TG) levels) was determined by standard automated techniques. Low-density lipoprotein cholesterol (LDL-C) was calculated by using Friedewald's formula. High sensitivity C-Reactive Protein (CRP) was analyzed by "Roche Hitachi Modular DPP (Roche Diagnostics Spain, S.L., Barcelona)". soluble Intercellular Adhesion Molecule-1 (s-ICAM-1), soluble Vascular Cell Adhesion Molecule-1 (s-VCAM-1), sE-selectin and sL-selectin were measured by xMAP technology in a Luminex 200 equipment.

Sample size and statistical analysis

On the basis of previous studies, this sample size was sufficient to identify differences in the parameters assessed.

Data were expressed as mean and standard deviation (SD). Firstly, we adjusted for group of age (children: 7.0–10.9 yrs, and adolescents: 11.0–15.0 yrs). The associations between all variables of this study were determined by using bilateral partial correlation, controlling by sex, age, and/or BMI Z-score and these results have been confirmed by the Pearson correlation by sex and age. All tests were analyzed using the statistical package SPSS version 20.0. Differences were considered significant at $p < 0.05$.

Ethics

The protocol was performed in accordance with the Declaration of Helsinki (Edinburgh 2000 revised) and following the recommendations of the Good Clinical Practice of the CEE (Document 111/3976/88 July 1990) and the legal in-force Spanish regulation that regulates Clinical Investigation in human beings (RD 223/04 about Clinical Assays). It was approved by the Ethics

Committee on Human Research of the University of Granada and the Ethics Committee of the Reina Sofia University Hospital of Cordoba.

Results

Correlations between TBW and other variables

Distributions of baseline characteristics, lipid profile, inflammatory and cardiovascular markers including all subjects and in study groups are summarized in table I. Only obese subjects were included. For the screening of obese children and adolescents the values of BMI, considering sex and age as published by Cole TJ et al²⁴, were used.

To assess the relationships between TBW and other study variables, we performed bilateral partial correlation analysis both including all subjects and also, by age and sex groups. We observed a negative correlation between TBW and BMI Z-score in both children and adolescents ($r -0.581$, $p < 0.001$; $r -0.368$, $p < 0.011$, respectively) that remained both in boys and girls, separately ($r -0.540$, $p < 0.001$; $r -0.505$, $p < 0.001$) (figs. 2A and 2B). On the other hand, we did not observe any significant differences in study groups in the lipid profile.

CRP correlates negatively with TBW when adjusted by sex ($r -0.438$, $p < 0.001$). This result was confirmed in children ($r -0.560$, $p = 0.002$) and in adolescents ($r -0.436$, $p = 0.007$). Separately when analyzed by sex groups, TBW was associated with CRP only in boys ($r -0.588$, $p = 0.027$ children; $r -0.652$, $p = 0.005$ adolescents) (fig. 2C). Furthermore, a significant relationship between both markers ($r -0.721$, $p = 0.002$; $r -0.570$, $p = 0.014$, respectively) were confirmed by Pearson's correlations in children and adolescent boys.

In addition, TBW was also negatively correlated with sE-selectin ($r -0.236$, $p = 0.039$). This finding was confirmed in adolescents ($r -0.320$, $p = 0.032$) but not in children. When analyzed by sex, TBW was associated with sE-selectin only in adolescent girls ($r -0.432$, $p = 0.035$) (fig. 2D). Additionally, when these data were analyzed by Pearson's correlations a trend was only observed in adolescent girls between both parameters ($r -0.383$, $p = 0.059$). No significant correlation between TBW and the other cardiovascular markers (sL-selectin, s-ICAM-1, s-VCAM-1) was found. All these correlations have been controlled by BMI Z-score and age.

Discussion

TBW represents the basic solvent in which all life processes occur, depicting the most abundant chemical in the human body. This compartment plays a central role in cell volume regulation, nutrient transport, waste removal and thermoregulation²⁵. Water is found only in FFM, and fat is anhydrous. This outcome allows determining both compartments by measuring TBW. Although TBW is a well-known marker used in clinical practice, its relationship with other blood markers is still unknown and has been hypothesized to be a critical variable in some cases²⁶⁻²⁸.

In the current study a significant negative correlation between TBW and BMI Z-score was found, both in children and in adolescents. This association was adjusted for age and sex. This finding could be of public health interest because of the increasing prevalence of childhood obesity, a significant determinant of obesity and cardiovascular complications in later life^{7,29}.

To the best of our knowledge, no association between inflammatory markers levels (CRP, sE-selectin, sL-

Table I
Descriptives values of BMI Z-score, lipid profile, TBW, inflammatory and cardiovascular markers in obese children and adolescents

Parameters	(7-16 yrs)		(7.0-10.9 yrs)		(11.0-16.0 yrs)	
	Mean	SD	Mean	SD	Mean	SD
BMI Z-score	3.85	1.31	3.71	1.22	3.94	1.38
Total Cholesterol (mg/dL)	167.15	26.81	170.94	24.74	164.62	28.08
Triglycerides (mg/dL)	87.45	40.03	92.37	46.12	84.17	35.54
Cholesterol HDL-C (mg/dL)	49.59	12.82	49.34	15.92	49.75	10.45
Cholesterol LDL-C (mg/dL)	96.70	20.15	96.31	16.52	96.96	22.40
HDL-C/LDL-C	0.54	0.19	0.54	0.22	0.54	0.17
TBW (%)	44.85	3.97	45.13	3.61	44.65	4.23
CRP (mg/dL)	2.66	2.55	1.68	1.98	3.41	2.70
s-ICAM-1 (ng/mL)	126.43	36.55	127.60	34.07	125.60	38.58
s-VCAM-1 (ng/mL)	978.96	184.02	971.74	165.28	983.46	196.39
sE-Selectin (ng/mL)	43.29	13.44	46.34	12.18	41.17	13.99
sL-Selectin (mg/l)	1775,67	1376,97	2072,72	1377,12	1575,61	1354,16

Results are shown as mean and SD, unless otherwise indicated.

Descriptive values of BMI Z-score, lipid profile, TBW (as hydration status marker), CRP (as inflammatory marker), and s-ICAM-1 and s-VCAM-1, sE-selectin and sL-selectin (as cardiovascular markers) in the whole group and in two age subgroups.

BMI = Body Mass Index; HDL-C = High-Density Lipoprotein Cholesterol; LDL-C = Low-Density Lipoprotein Cholesterol; TBW = Total Body Water; CRP = C-Reactive Protein; s-ICAM-1 = soluble Intercellular Adhesion Molecule-1; s-VCAM-1 = soluble Vascular Cell Adhesion Molecule-1.

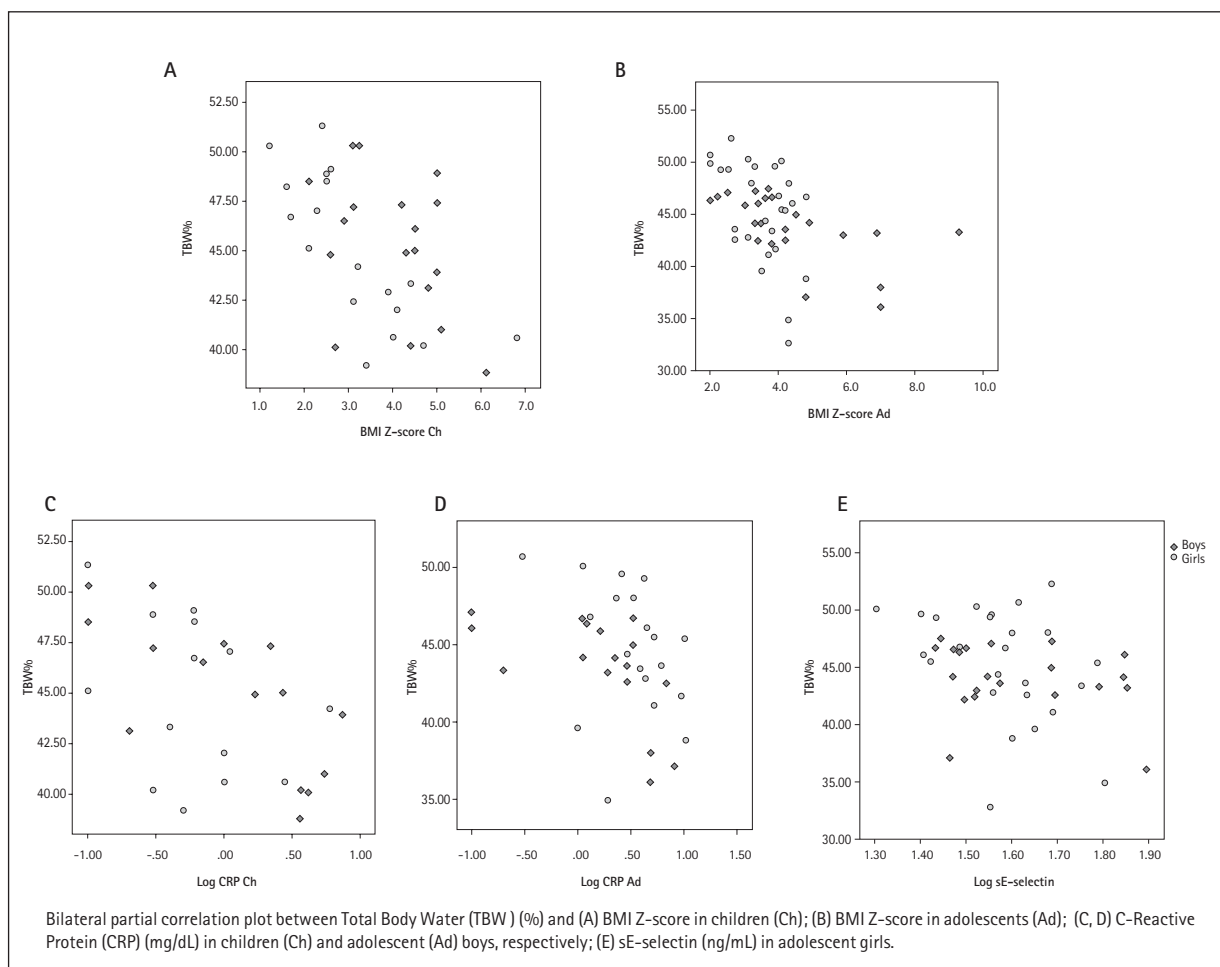


Fig. 2.—Bilateral partial correlation plot between TBW and other variables.

selectin, s-ICAM-1, s-VCAM-1) and TBW percentage has been previously described.

CRP has been defined to be an important sign of the inflammatory process course, since it has been shown to be increased in obese subjects^{30,31} and to act as a strong independent predictor of a possible future myocardial infarction, stroke, and subclinical atherosclerosis³². The relationship between CRP and the body composition variables has been scarcely studied. However, a significant positive correlation between CRP and body fat composition as well as the metabolic syndrome features has been described in obese patients being more relevant in women³². In addition, CRP levels have been positively correlated with visceral fat and total fat levels. However, the relationship between CRP and TBW as well as the extracellular and intracellular compartments has not been still described. In the current study CRP has been negatively associated to TBW.

High levels of adhesion molecules (e.g. sE-selectin, sICAM-1 and sVCAM-1) have been described in obese adolescents²², finding positive correlations between s-ICAM-1 and BMI, may be due to a relationship between these two variables and s-VCAM-1 with TC levels²².

Our results show that TBW was negatively correlated with sE-selectin in adolescents and also when analyzed by sex. However, there was no significant correlation between TBW and lipid profile, and the other cardiovascular markers (sL-selectin, s-ICAM-1, s-VCAM-1).

Significant age-adjusted correlations between TBW and other parameters were found, as expected. It is well-known that TBW content increases with age, and extracellular/intracellular space ratio decreases during growth³³. Therefore, age was used as an adjustment factor in the analysis³⁴. However the correlations between CRP and TBW were found both in children and adolescents, which reinforces the utility of measuring TBW as a marker of metabolic alterations in both life periods.

When determining body composition in children and adolescents, the complex changes due to maturation and growth should be taken into account, as already described³⁵, thus emphasizing the regular increased FFM density from birth to 22 years of age in men. Moreover, men show higher FFM values than women, tending to have more water weight. This finding could support our results when the association between TBW percentage and the biochemical parameters has been found to be dependent on sex and age.

The hydration status hence might influence the levels of inflammation and CVD risk markers.

Several limitations of this analysis need to be mentioned. Firstly, the Pronaos Study is not a fully representative Spanish sample as it is restricted to four samples (Córdoba, Granada, Madrid and Zaragoza) and in the current study we used only samples from three of them (Córdoba, Granada and Madrid). In addition, a control group was not used although the aim of this study was to evaluate possible associations of different biomarkers within obese children and adolescents.

To our knowledge, we have demonstrated for the first time that there is a relationship between TBW and the most relevant inflammatory marker (CRP) and also a cardiovascular marker such as sE-selectin, suggesting that TBW percentage may be a good inflammatory marker in obese childhood.

Conclusions

TBW may be considered as a marker not only of the hydration status, but also of the metabolic disorder in a low-grade inflammatory process such as obesity in children and adolescents. Our study suggests that TBW should be evaluated in obese subjects, at least at this period of growth in follow-up studies in order to validate these associations and clarify the biological significance of these findings.

Appendix

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Conflict of interest

The authors declare there are no competing financial interests in relation to the work described in this article.

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Association between sodium intake and hydration status amongst community-dwelling elderly people

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Abstract

Dehydration is a common condition in older people and it has been associated with the development of many diseases. The aim of this study was to assess the association between hydration status in community-dwelling elderly people.

Data were gathered in 74 community-dwelling elderly individuals (28 males) and included the collection of 24-h urine samples, which were screened for validity using 24-h urinary creatinine excretion in relation to body weight, anthropometric, physical activity, and sociodemographic variables. Hydration status was assessed using urinary indicators (24-h volume, osmolality and urine specific gravity) and sodium intake was assessed by 24-h urinary sodium excretion. Linear regression analysis was performed to quantify the association between sodium excretion (independent variables) and hydration biomarkers (dependent variables). No significant differences were found between males and females in 24-h urine volume ($1,982.5 \pm 654.5$ mL vs $1,832.0 \pm 655.8$ mL, $p = 0.341$), 24-h urine osmolality (454.0 ± 158.5 mOsm/kg vs 402.7 ± 149.4 mOsm/kg, $p = 0.204$) and 24-h urine specific gravity (1.015 ± 0.006 vs 1.013 ± 0.005 , $p = 0.131$). Urine volume and osmolality showed a positive and significant association with sodium excretion ($\beta = 0.314$, 95%CI: 0.095,0.562 and $\beta = 0.390$, 95%CI: 0.195,0.679, respectively), even after adjusting for confounders (age, sex, body mass index, and physical activity). Our findings showed that community-dwelling elderly individuals with a higher level of sodium intake had a higher 24-h urine volume and a higher 24-h urine osmolality. These findings suggest that a higher sodium intake is associated with a poorer hydration status in this elderly population, assessed by urine osmolality.

Key words: Hydration status. Sodium. Community-dwelling elderly. Urinary osmolality. Urinary volume.

ASOCIACIÓN ENTRE LA INGESTA DE SODIO Y EL ESTADO DE HIDRATACIÓN EN PERSONAS MAYORES QUE VIVEN EN CENTROS COMUNITARIOS

Resumen

La deshidratación es un problema común en las personas mayores y ha sido asociado con el desarrollo de muchas enfermedades. El objetivo de este estudio consiste en la evaluación de la asociación entre la ingesta de sodio y el estado de hidratación en personas mayores que viven en centros comunitarios.

Los datos fueron recopilados a partir de 74 personas mayores que vivían en centros comunitarios (28 varones) e incluyeron tomas de muestras de orina de 24h, que fueron examinadas para determinar su validez empleando excreción urinaria de creatinina de 24h en relación con variables de peso corporal, antropometría, actividad física y variables sociodemográficas. El estado de hidratación fue evaluado empleando indicadores urinarios (volumen en 24h, osmolalidad y gravedad específica de la orina) y la ingesta de sodio fue evaluada mediante excreción urinaria de sodio de 24h. Se realizó un análisis de regresión lineal para cuantificar la asociación entre excreción de sodio (variables independientes) y biomarcadores de hidratación (variables dependientes).

No se encontraron diferencias significativas entre varones y mujeres en el volumen de orina de 24h ($1,982.5 \pm 654.5$ mL vs $1,832.0 \pm 655.8$ mL, $p = 0.341$), 24-h orina osmolalidad (454.0 ± 158.5 mOsm/kg vs 402.7 ± 149.4 mOsm/kg, $p = 0.204$) y gravedad específica de la orina en 24h (1.015 ± 0.006 vs 1.013 ± 0.005 , $p = 0.131$). El volumen de orina y la osmolalidad mostraron una asociación positiva y significativa con la excreción de sodio ($\beta = 0.314$, 95% CI: 0.095, 0.562 y $\beta = 0.390$, 95% CI: 0.195, 0.679, respectivamente), incluso después de ajustar factores de distorsión (edad, sexo, índice de masa corporal y actividad física).

Nuestros resultados demostraron que las personas mayores en centros comunitarios, con un mayor nivel de ingesta de sodio, tenían un mayor volumen de orina de 24h y una mayor osmolalidad de la orina de 24-h.

Estos resultados sugieren que una mayor ingesta de sodio estaría asociada a un peor estado de hidratación en esta población de mayores, evaluado mediante la osmolalidad de la orina.

Palabras clave: Estado de hidratación. Sodio. Personas mayores que viven en centros comunitarios. Osmolalidad urinaria. Volumen urinario.

Introduction

Dehydration is a common condition in the elderly and is a frequent cause of hospitalization among geriatric population. Since dehydration manifest in multiple forms¹, its assessment may be difficult. This condition can be associated with the development of many chronic diseases, such as an increased risk for urolithiasis, constipation, asthma, urinary tract infections and hypertension².

Hydration status can be assessed through subjective observations and by objective noninvasive measurements³. The subjective observations, such as skin turgor, thirst sensation or mucous membrane moisture, were described as less reliable due to the lack of consistency of measurements between measurers, despite being simpler, faster and more economical, compared to objective laboratorial measurements³. Current evidence select urine indices, as more sensitive than other methods³, especially osmolality as the most accurate mean to assess an individual's hydration status^{3,4}. Another potential hydration marker is urine-specific gravity, which has been argued that may be used interchangeably with urine osmolality⁵, although this is yet a controversial topic.

The identification of the determinants of hydration status is crucial, although data on this topic is scarce, namely regarding the impact of dietary intake on hydration physiology⁶. The hydration status is mainly influenced by water⁴, which may be obtained from drinking-water and other beverages and moisture content in food^{7,8}. Since the excretion of excess sodium requires the excretion of water through urine, a high sodium intake may also have an impact on hydration status⁷. However, to our best knowledge, no data have been published regarding the effect of sodium intake on urine osmolality, urine specific gravity and 24 h urine volume.

The aim of this study was to assess the existence of an association between hydration status and sodium intake in community-dwelling elderly people.

Methods

Study Design

A cross-sectional study was conducted between November 2012 and April 2013.

This study was approved by the Ethical Committees of University of Porto and the Portuguese Data Protection Authority. All participants gave written informed consent for their participation.

Subjects

The study enrolled community-dwelling elderly individuals from a Physical Activity Program from the Faculty of Sport of University of Porto and elderly care

center from Gondar (Guimarães), selected on the basis of convenience sampling.

One hundred thirteen individuals, aged sixty-year or older, accepted to perform 24-h urine collection. There was no recruitment of subjects from institutionalized places, however elderly care center provided part of the daily diet (breakfast, lunch and snack) of six subjects; the others were responsible for preparing their meals. Participants were instructed to continue their usual daily activities and food patterns.

Of the 113 individuals initially enrolled, 39 were excluded, due to the fact that they were taking diuretics, or exhibited cognitive impairment assessed by the Mini Mental State Examination score^{9,10} and/or had an incomplete 24-hour urine collection according to creatinine coefficient.

The final analysis included 74 participants (28 males).

Socio-demographic, general health and physical activity

Data collection was carried out by trained interviewers. A standardized questionnaire was used to obtain socio-demographic (age, gender, and education level), physical activity (assessed by the International Physical Activity Questionnaire, which was validated in Portuguese adults¹¹, and categorized in low, moderate and high level), and general health (use of drugs, and medical history).

Depression status was assessed using the Geriatric Depression Scale (GDS) developed by Yesavage and colleagues in 1983¹², which is designed as a 30-item inventory, with an yes/no type of answer. The GDS was adapted and validated for use in Portuguese elders by Pocinho et al. (2009)¹³.

Anthropometric measures

Body weight and height were assessed according standardized procedures¹⁴. Body mass index (BMI) was calculated as weight (kg) divided by square height (m²), and participants were classified according to WHO BMI reference values¹⁵, in underweight, normal weight, overweight, and obesity.

Urine collection and hydration markers

Participants received oral and written instructions on how to collect 24-h urine samples. All participants were instructed to discard the first morning void and to collect all urine over the following 24-h including the first void on the next morning. During the collection period, subjects were asked to store collected urine in a cool place. All samples were sent to a certified laboratory (LabMED, Porto) to be analyzed. Completeness of 24-h urine collection was checked by the analysis of creatinine excretion in relation to body weight (creati-

nine coefficient = creatinine [mg/day]/body weight [kg]). Thus, participants with creatinine coefficients out of reference levels (14.4 to 33.6 in men and 10.8 to 35.3 in women) were not included in the analyses¹⁶.

Urine samples were analyzed for urinary creatinine (mg/day), and urinary sodium (mEq/day); sodium excretion was reported in mEq/day, however, for comparative purposes, it was converted to mg/day by using the molecular weight of sodium (23 mg Na = 1 mmol Na or 1 mEq Na).

Hydration status was assessed using urinary markers, namely 24-h urinary volume (mL), 24-h urinary osmolality (UOSM, mOsm/kg), and 24-h urinary specific gravity (USG).

Statistical analysis

Shapiro-Wilk test was performed to test variables for normality. T-test for independent samples was used for normally distributed variables and Mann-Whitney U test was used for not normally distributed variables.

For the linear regression analysis, it was made a logarithmic transformation of the variables that did not follow a normal distribution (USG and osmolality) as well as for volume and sodium urinary excretion. Linear regression was used to estimate the association between the 24-h urinary sodium excretion and the urinary parameters. Analysis included a crude model – Model 1, and an adjusted model – Model 2, adjusted for age, sex, BMI and physical activity level.

All statistical analyses were performed using SPSS 21.0 Inc., Version 21.0. A p-value < 0.05 was considered to indicate statistical significance.

Results

A total of 74 elderly individuals were eligible for the final analysis. General characteristics of the subjects are presented in table I. Socio-demographic data and anthropometric evaluation showed a similar distribution of categories amongst males and females participants. Participants were more frequently females (62.2%)

Table I
Participants characteristics by sex

	Males (n = 28)	Females (n = 46)	p-value
Age (years), mean \pm SD	70.0 \pm 4.9	70.3 \pm 6.6	0.960*
Education level, n (%)			
Illiterate	3 (10.7%)	11 (23.9%)	0.555†
Primary School	11 (39.3%)	18 (39.1%)	
Middle School	8 (28.6%)	11 (23.9%)	
Secondary School	4 (14.3%)	2 (4.3%)	
Higher School	2 (7.1%)	4 (8.7%)	
BMI (kg/m ²), mean \pm SD	27.5 \pm 3.3	26.9 \pm 4.0	0.499†
BMI (kg/m ²), n (%)			
Underweight	0 (0.0%)	2 (4.3%)	0.667†
Normal Weight	6 (21.4%)	12 (26.1%)	
Overweight	15 (53.6%)	22 (47.8%)	
Obesity	7 (25.0%)	10 (21.7%)	
Health Condition, n (%)			
Hypertension	13 (48.1%)	26 (57.8%)	0.427†
Dyslipidemias	14 (51.9%)	23 (51.1%)	0.951†
Diabetes mellitus	4 (14.8%)	6 (13.3%)	0.861†
Renal Impairment	1 (3.6%)	4 (8.7%)	0.116†
Depression status, n (%)			
Absence	24 (88.9%)	27 (60.0%)	0.009†
Presence	3 (11.1%)	18 (40.0%)	
Physical activity, n (%)			
Low	6 (21.4%)	7 (15.2%)	0.450†
Moderate	11 (39.3%)	14 (30.4%)	
High	11 (39.3%)	25 (54.3%)	
Urinary parameters, mean \pm SD;			
24-h urine volume, mL	1982.5 \pm 654.2	1832.0 \pm 655.8	0.341†
24-h UOSM, mOsm/kg	454.0 \pm 158.5	402.7 \pm 149.4	0.204*
24-h USG	1.015 \pm 0.006	1.013 \pm 0.005	0.131*
24-h sodium excretion, mg/day	4492.4 \pm 1485.3	3495.0 \pm 1084.9	0.003†

*Mann-Whitney U test; † T-test for independent samples; ‡ Chi-square test.

BMI – Body mass index

UOSM – Urine osmolality; USG – Urine specific gravity.

females) and with a mean age of 70.3 ± 6.6 years. About half of men and approximately two thirds of women have attended less than five schooling years, and nearly one fourth of the participants were obese. More than half of the sample reported hypertension or dyslipidemia, and depression was more frequent reported by women (40.0% versus 10.1%, $p = 0.009$). Regarding physical activity, the majority exhibited moderate or high levels. The biomarkers of hydration status (24-h urinary volume, UOSM and USG) did not differ significantly by sex. Conversely, the mean of urinary sodium excretion was significantly higher in males than females (4492.4 ± 1485.3 mg/day and 3495.0 ± 1084.9 mg/day, $p < 0.003$), table I.

Two linear regression analysis models (crude and adjusted for age, gender, BMI and physical activity level) were used to describe the relation between urinary sodium excretion and hydration status (table II). Both models clearly showed a significant and positive association between urinary sodium excretion and 24-h urine volume (Model 1, $\beta = 0.314$, 95%CI: 0.095,0.562; Model 2, $\beta = 0.313$, 95%CI: 0.069,0.584), and 24-h UOSM (Model 1, $\beta = 0.390$, 95%CI: 0.195,0.679; Model 2, $\beta = 0.372$, 95%CI: 0.155,0.678). However, the 24-h USG was not significantly associated with sodium excretion (table II).

Discussion

Our results showed that sodium had an effect in the hydration status measured by the 24-h volume and 24-h UOSM, while there was no association with the 24-h USG. These results suggest that a high sodium diet, assuming that all urinary sodium come from diet, lead to a higher 24-h urine volume, that can be explained by the fact that the excretion of excess sodium requires the excretion of water through urine⁷. This relationship between sodium intake and urine volume was similar to that found in a cross-sectional observation study that involved 634 essential hypertension patients, who were studied on their usual diet and collected a 24-hour urine sample¹⁷.

The 24-h urine sodium excretion showed a positive association with 24-h urine osmolality, which may predict a poorer hydration status in free-living elderly participants with higher sodium intake. Nonetheless, the

24-h urine specific gravity failed to predict the hydration status. A cross-sectional study with seventy-one adults (aged 25–40 years), that were classified according to daily fluid intake (low and high drinkers), showed a significant association between lower drinkers and lower urine volumes coupled with higher osmolality and specific gravity⁶. In our study, the results allow to hypothesize that a high 24-h urine volume may arise from a high sodium diet, with concomitant low total water intake, with water provided from beverages and water supplying foods, which consequently results in a poorer hydration status shown by the higher urine osmolality. Conversely, the DONALD study showed an increased beverage consumption to compensate the higher water requirement induced by an increased consumption of sodium^{7,8}. Additionally, Alexy et al. showed a positive association between sodium excretion and free-water reserve (FWR, mL/day) in girls, and therefore, a slightly better hydration status assessed by urine volume⁷. Probably, elderly may not compensate the higher sodium intake by increasing their fluid intake^{18–20}. Thus, the consequent lower fluid intake may be insufficient to reduce the urine osmolality.

In our sample, after further adjustment for age, sex, BMI and physical activity level, there was still a significant relation between urinary sodium excretion and urinary parameters (24-h urine volume and 24-h urine osmolality).

The results of the present study did not show differences in urine biomarkers (24-h urine volume, 24-h UOSM and 24h USG) between males and females, despite 24-h urinary sodium excretion was different between sexes. Considering this result and the small number of men involved in the study, the analysis of associations between urine biomarkers and sodium excretion was not stratified by sex. In this sample, the average urinary sodium excretion was significantly higher in men than in women ($4,492.4 \pm 1,485.3$ mg/day and $3,495.0 \pm 1,084.9$ mg/day, $p = 0.003$), a value above the WHO maximum level of 2,000 mg/day²¹. These differences in sodium excretion between males and females may be explained by the differences in energy needs and energy intake, as reported in other studies^{22–24}.

To our knowledge, this is the first study examining the relation between urinary sodium excretion and hydration status in community-dwelling elderly.

Table II
Relation of 24-h urinary sodium excretion with urinary biomarkers

	Model 1†		Model 2†	
	β (95% CI)	p value	β (95% CI)	p value
24-h Urinary Sodium				
24-h Urine volume, mL	0.314 (0.095,0.562)	0.006*	0.313 (0.069,0.584)	0.014*
24-h Urine osmolality, mOsm/kg	0.390 (0.195,0.679)	0.001*	0.372 (0.155,0.678)	0.002*
24-h urine specific gravity	0.142 (-0.001,0.005)	0.227	0.069 (-0.002,0.004)	0.571

†Crude model; ‡Adjusted for age, gender, BMI and physical activity level;

*significant ($p < 0.05$); CI – Confidence Interval.

Given the absence of a consensual gold standard biomarker of hydration status in the general population⁶, three urinary parameters were used in the present study. The 24-h urine indices reflect recent volume of fluid consumed²⁵, although some authors indicate a lower intraindividual variance in 24-h urine volume²⁶. However, elderly show great difficulty in collecting 24-h complete urine samples, a fact that was supported by the results 11.5% of the individuals were excluded due to incomplete 24-h urine samples.

A major limitation of this study was the fact of having a convenience sample, which did not allow the extrapolation of the results to all community-dwelling elderly individuals. However, this analysis suggests that a higher sodium intake is associated with a poorer hydration status in this elderly population, assessed by urine osmolality, providing the basis for future research on the different urinary hydration markers in community-dwelling elderly.

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Beverages consumption evaluation in spanish households according to the food consumption survey 2000-2012

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Abstract

Objectives: To evaluate alcoholic and non-alcoholic beverages intake in the Spanish population according to the whole diet context, disaggregated by regions, socioeconomic levels, habitat size and typology of the main responsible for food/beverages basket. To analyze the beverages trends historically but mainly in recent years as well as their nutritional impact for the Spanish population.

Methods/Design: This study is based on the household consumption (Food Consumption Survey) assessed by the National Institute of Statistics (INE) and the Spanish Ministry of Agriculture, Food and Environment (MAGRAMA), in collaboration with the Spanish Nutrition Foundation (FEN). The sample consisted of all homes in the Iberian Peninsula plus Balearic and Canary Islands.

Results: In 2012 the average consumption of non-alcoholic beverages was 316 g/person/day, and alcohol beverages consumption represented 81 g/person/day. Non-alcoholic drinks consumption has increased by 31,7% from 2000 to 2012 whereas for alcoholic drinks was only 3,3%. By regions, alcoholic beverages intake was higher in Murcia with 113 g/person/day whereas for non-alcoholic was higher in Canary Islands with 538 g/person/day. As for socioeconomic status it was observed that both, alcohol and non-alcoholic beverages consumption is higher for high and medium-high status. Alcoholic beverages provide roughly 2.2% of total energy and 0.7% of carbohydrate whereas non-alcoholic beverages provide 2.6% of the energy and 5.8% the carbohydrates.

Conclusions: There has been a dramatic increase in non-alcoholic drinks consumption in recent years and very small change for alcoholic drinks. Energy contribution of these groups should be considered low mainly when compared to other European countries.

Key words: Beverages. Non-alcoholic drinks. Alcoholic drinks. Food consumption survey. Diet quality. Hydration.

EVALUACIÓN DEL CONSUMO DE BEBIDAS EN HOGARES ESPAÑOLES DE ACUERDO AL PANEL DE CONSUMO ALIMENTARIO 2000-2012

Resumen

Objetivos: Evaluar la ingesta en hogares españoles de bebidas alcohólicas y no alcohólicas, en el contexto global de la dieta, y de acuerdo también a factores como la zona geográfica, nivel socioeconómico, tamaño del lugar de residencia, o actividad principal del responsable de la compra de alimentos. Igualmente, analizar las tendencias históricas en el consumo de bebidas, así como su impacto potencial en el estado nutricional de la población española.

Métodos/diseño: El estudio se basa en el Panel de Consumo Alimentario, que desarrollan el Instituto Nacional de Estadística (INE), y el Ministerio de Agricultura, Alimentación, y Medio Ambiente (MAGRAMA), estando la responsabilidad de la interpretación de la dieta a cargo de la Fundación Española de la Nutrición (FEN). La muestra, representativa a nivel nacional, ha incluido los hogares tanto de la España Peninsular como de las Islas Canarias y Baleares.

Resultados: En el año 2012, el consumo medio de bebidas no alcohólicas por la población adulta española fue de 316 g/persona/día, y de 81 g/persona/día en el caso de las bebidas alcohólicas. Desde el año 2000, el incremento en el consumo de bebidas no alcohólicas ha sido aproximadamente de un 31,7%, y únicamente del 3,3% para las de contenido alcohólico. Por Comunidades Autónomas, es Murcia quien destaca en el consumo de bebidas alcohólicas (113 g/persona/día), mientras que para las de contenido no alcohólico, son las Islas Canarias las que lo tienen más elevado (538 g/persona/día). Por otro lado, son los adultos con nivel socioeconómico medio y alto los que presentan un mayor consumo, de ambos tipos. Como media, el aporte de energía a partir de las bebidas alcohólicas es de un 2,2% al total, y un 0,7% a los hidratos de carbono. Por su parte, las bebidas no alcohólicas están contribuyendo con un 2,6% del total de energía, y un 5,8% de los carbohidratos.

Conclusiones: Se ha producido en la última década un incremento muy marcado en el consumo de bebidas no alcohólicas en España, siendo sin embargo muy reducido para las de contenido alcohólico. En cualquier caso, y al comparar su contribución al total de energía con otros países europeos, se puede considerar todavía como relativamente bajo o moderado, aunque es necesaria mayor información y educación nutricional para una correcta elección de las bebidas de la dieta en el adulto.

Palabras clave: Bebidas. Bebidas no alcohólicas. Bebidas alcohólicas. Encuesta sobre consumo de alimentos. Calidad de la dieta. Hidratación.

Introduction

Spain has undergone dramatic socioeconomic changes since the 1960s, including massive rural-urban migration, but also a generalized incorporation of females into the active work-force added to rapid urbanization processes in the 1980s, an accelerating factor for dietary change due to factors such as family life organization and home meals¹. An increasing number of people using catering services, restaurants and vending machines², both during weekdays and weekends, is also a key factor for understanding changes in diet, even though the present economical crisis leads to more people eating at home. In addition, there has been a rapid increase in the immigrant population, which now represents about 8-10% of the total population, although a marked decrease due to economical recession in the country is also observed³. The relationship between nutrition and health is well documented. These changes in dietary patterns and lifestyle potentially appear to have had negative consequences for present and future populations, since overweight and/or obesity affects more than 50% of the adult population and almost 30% of the infant/young population⁴.

Social and economic changes have led to important modifications in food patterns in the last few decades. Some changes have had a potential positive impact, such as increasing variety in the diet and improved access to food, but are not consistent with an adequate food selection as described for a healthy Mediterranean type of diet^{5,6}. In accordance, it must be remembered that dietary patterns involves food and beverage consumption, being this last group often misleading.

The *Food Consumption Survey* (FCS), conducted in Spain since 1987, shows trends in consumption of different food groups and provides data of the place of consumption, i.e. either at home, institutions, catering, restaurants, etc⁷. The *Spanish Nutrition Foundation* (FEN) is in charge of evaluating the dietary trends and nutritional status of the population derived from the FCS. This information is also essential in order to obtain information on the nutritional parameters and diet quality that allow the identification of the dietary patterns for the Spanish population^{2,8}.

The main goal of this article is to analyze the beverages intake evolution in Spanish households according to the *Food Consumption Survey* (FCS) 2000-2012, in the context of the whole diet; in addition, to evaluate alcoholic and non-alcoholic beverages intake stratified by regions, socioeconomic level, habitat size, work activity and age of food purchase responsible, as well as the contribution to total energy intake and some nutrients status.

Methods

The results are about shopping and product entrance into the home obtained from the FCS from 2000 to 2012.

In order to calculate the contributed the average energy and nutrients intake, has been faced against the needs of men and women aged between 20 and 40 years old because this age group includes the population segment which the *National Statistical Institute* considered demographically the largest in Spain.

The most thorough analysis belongs to household. A "household" is considered to be the person or group of people who occupy a family house together or part of it, and consume foods/beverages and other goods bought from the same budget. Data for the products in the home were registered by a scanner on the same day as product acquisition and for seven consecutive days. Data from the households have also been considered according to geographical areas; socioeconomic level; size of habitat; number of household members; age of the person responsible for food purchase; occupation of the person in charge of purchases; number of children and age. The location of the study was inland Spain plus the Balearic and Canary Islands.

A two-stage sampling method was carried out for the whole sample studied. In the first stage, the units to be sampled were towns or local entities in the national territory, and in the second stage households that were going to be part of the final sample from those entities were selected.

The obtained data allowed calculation of energy and nutrient intakes, using food composition tables containing over 600 foods and beverages, distributed in 15 groups. The data were also compared to the most updated *Recommended Nutrient Intakes* for the Spanish population to evaluate the adequacy of the diet⁹.

Results

Analysis of food consumption data for per capita availability based on the food surveys by the Ministry of Agriculture, Food and Environment (MAGRAMA, Spain) panel, over the period of years 2000 to 2012, allows estimation of the average *daily menu* in Spain and the associated distribution of the different food groups as shown in figure 1. Therefore, as shown, in 2012 the average consumption of nonalcoholic beverages was 316 g/person/day, and alcohol beverages consumption represented 81 g/person/day. Non-alcoholic drinks consumption has increased by 31.7% from 2000 to 2012 whereas for alcoholic drinks this increase was 3.3% (table I).

Alcoholic beverages consumption has undergone a slow decline during recent years. Within this group, wine as a beverage traditionally included in the Mediterranean diet concept, only represented a 23.5% of the total alcoholic beverages consumption whereas it accounted a 62% of the total consumption in 1991. In the last few years, a gradual substitution of wine with beer has occurred, which represents almost a 70% of the total alcoholic beverage consumption at present. An important additional point is that almost 70% of these beverages were consumed out of home. One of the most

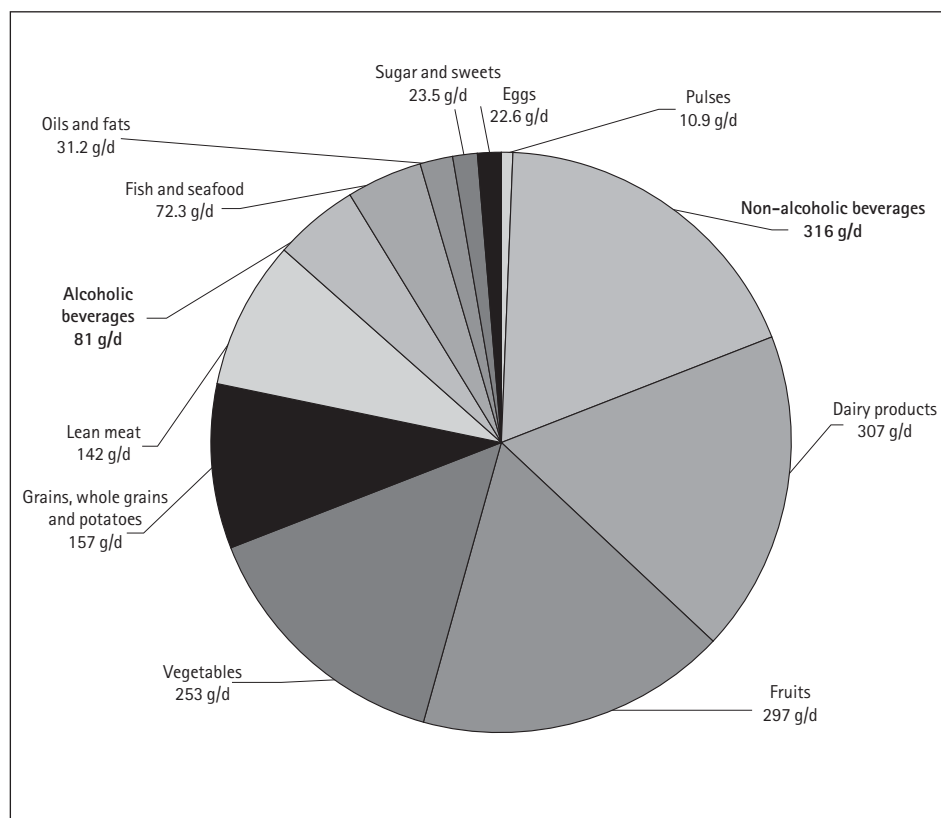


Fig. 1.—Distribution of the different food and beverages groups at Spanish households in 2012 (g/person per day).

Table I
Evolution of beverages consumption at homes in Spain: years 2000-2012 (g/person per day)

	2000	2003	2006	2009	2010	2011	2012	Evolution 2000-2012 (%)	
Alcoholic beverages	78.4	79.0	76.6	70	68.9	70.2	81.0	+3.3	↑
Evolution (%)		+0.8	-3.0	-8.6	-1.6	+1.9	+15.4		
Non-alcoholic beverages	240	276	291	338	330	328	316	+31.7	↑
Evolution (%)		+15.0	+5.4	+16.2	-2.4	-0.6	-3.7		

striking change has been the enormous increase in non-alcoholic beverages consumption, since almost a ten-fold increase was observed since 1964.

Milk and derivatives consumption, another important contributor for an adequate hydration status, is quantitatively one of the most important in the present Spanish diet. However, a significant decrease is shown in the recent years. Eggs consumption has steadily decreased since the year 2000. In that year, 4.3 medium sized eggs per week were consumed, whereas for the year 2012 the mean consumption of medium sized eggs was just 3.5 per week.

Vegetable and greens consumption, including potatoes, remained largely unchanged (a slight increase) from year 2000 to 2012. This was not the case when comparing the results with those obtained in 1964, when more than 450 g/day were consumed, for this food group. This has been mainly caused by a steady decrease in potato consumption. In fact, the overall decline for

the last forty years has exceeded 200g/person/day. This trend showed a marked tendency of traditional staple foods being increasingly replaced by more processed alternatives. However, consumption of vegetables and greens (excluding potatoes) was calculated and showed an increase of 220 g/person/day since 1964. Fruit consumption, including dried fruits, showed a positive increase trend from year 2000 (278 g/person/day) to year 2012 (305 g/person/day). When compared to 1964 data, fruit consumption has nearly doubled. The consumption of legumes and pulses has decreased when compared to the 1990 results. However, it seems that there is nowadays a slight increase due to a combination of its low price in a crisis context, their gastronomic chances, the nutrient density (source of protein, complex carbohydrates, fiber, vitamins and minerals, but also low in fat). In addition, it has to be remained that this food group play a key role in the Mediterranean dietary pattern.

Cereals and derivatives consumption has shown a marked decrease over the last fifty years. Bread is still the most important food within this group, although a steadily decline has also been observed (368 g/d in 1964 vs 139 g/d in 2012). As for oils and fats consumption, an overall decrease over the last forty years has been observed (approximately 20 g/person/day since 1964). The decrease in consumption was more noticeable for olive oil (a fall of over 27 g/person/day). However, more than 90% of the total consumption of oils and fats is still of vegetable origin, mainly olive oil, which represented roughly 60% of the total. Other culinary and spread fats such as butter and margarine only represented a 7% of the total oils and fats consumed.

As for the meats and derivatives food group, it is maintained steadily high for over the last twelve years. It should be noticed that the food group has increased by roughly 300% when compared to the 1960 years data. The mean consumption of fish and shellfish was considered high, positive and potentially beneficial, according to present national dietary guidelines, and it is even higher than forty years ago. Moreover, oily fish repre-

sented approximately 40% of total fish consumption, which may make a clear contribution to adequate intake of omega-3 fatty acids.

A more detailed analysis of several factors that may influence beverages drinking pattern has been taken into consideration. Therefore, according to the Spanish regions, in 2012 alcoholic drinks intake was much higher in the southern part of the country (e.g. Murcia, 113 g/person/day) and much lower in a central area such as Castilla la Mancha with just 56.9 g/person/day. As for non alcoholic drinks, the highest consumption was observed in Canary Islands (538 g/person/day), whereas in contrast the Basque Country only represented 179 g/person/day as average (table II).

We were also interested in looking to the potential impact of the socioeconomic status on drinking patterns. Clearly, it was observed that both, alcohol and non-alcoholic beverage consumption is higher in high and medium-high socioeconomic level (table III).

Results have also been considered according to habitat size: alcoholic drinks intake was higher in larger (> 500,000 inhabitants towns) (table IV). As also shown,

Table II
Beveraages consumption by Spanish regions at households: years 2011-2012 (g/person/day)

	<i>Alcoholic beverages</i>		<i>Non-alcoholic beverages</i>	
	<i>2011</i>	<i>2012</i>	<i>2011</i>	<i>2012</i>
Andalucía	92.2	92.5	342	346
Aragón	66.6	66.2	269	290
Asturias	60.6	61.5	245	259
Baleares	84.2	89.4	473	514
Canarias	59.1	66.8	498	538
Cantabria	52.9	65.5	267	295
Castilla la Mancha	80.1	83.3	326	331
Castilla León	60.6	61.9	244	263
Cataluña	78.5	88.0	361	368
Extremadura	77.9	78.9	307	302
Galicia	60.0	61.1	239	244
Madrid	81.5	85.3	226	230
Murcia	101	113	340	365
Navarra	65.8	56.9	184	194
País Vasco	69.9	74.4	163	179
La Rioja	75.2	70.5	223	251
Valencia	81.3	78.9	348	347
Nacional	70.2	81.0	328	316

Table III
Beverages consumption according to the socioeconomic level at homes: years 2011-2012 (g/person/day)

	<i>Low</i>		<i>Medium-low</i>		<i>Medium</i>		<i>High/Medium high</i>	
	<i>2011</i>	<i>2012</i>	<i>2011</i>	<i>2012</i>	<i>2011</i>	<i>2012</i>	<i>2011</i>	<i>2012</i>
Alcoholic beverages	64.4	66.2	74.5	77.9	82.4	84.2	90.3	97.1
Non-alcoholic beverages	258	269	312	330	329	328	336	351

Table IV
Beverages consumption according to the habitat/town size: years 2011-2012 (g/person/day)

	< 2,000		2,000-10,000		10,001-100,000		100,001-500,000		> 500,000	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Alcoholic beverages	64.4	66.2	74.5	77.9	82.4	84.2	90.3	97.1	64.4	66.2
Non-alcoholic beverages	258	269	312	330	329	328	336	351	258	269

average intake for non-alcoholic was higher in medium size towns (table IV).

When the main work activity of food purchase responsible is analyzed, alcohol and non-alcoholic beverages consumption is higher in households where the person responsible works outside the home. By age of food purchase responsible, alcoholic drinks consumption intake was higher in households where the person responsible was over 65 years, whereas for non-alcoholic drinks was higher in households where the person responsible was between 50 and 64 years old, although only with slight differences between the different age groups (table V).

Energy and Nutrient Intake

Firstly, the mean energy intake for the Spanish adult population at present is calculated at 2,609 kcal/person/d, which is much lower than in 1964 (3,008 kcal/person/d). The food groups contributing the most to energy consumption are cereals and derivatives (24.6%), meats and meat products (14.3%), oils and fats (13.6%) and milk and derivatives (12.5%). By contrast, fish and shellfish (3%), non-alcoholic beverages (2.8%), alco-

holic beverages (2.4%) showed clearly a much lower contribution to total energy intake. Moreover, when considering potential contribution to the hydration status, non-alcoholic beverages showed a remarkable contribution to total water intake (23%) followed by milk and dairy products (table VI). In contrast, alcoholic beverages contribution to total water intake represented a 6.4%, even though the energy percentage is quite similar.

As diet quality index, the energy profile has been calculated, in other words, the macronutrient (proteins, fat and carbohydrates) and alcohol (if consumed) energy contribution to the total energy of the diet, expressed in percentages. Just as a remainder, the recommended energy profile is: proteins (10-15% of the total energy); lipids, less than 35% of the total energy; carbohydrates (50-60% of the total energy), whereas for alcohol in case of, it should contribute less than 10% of the total energy. On average, alcohol consumption was within the recommended limits –for adults–. No year ever exceeded 10% of the total energy of the diet. When dividing up data in households, the catering trade and institutions, it was noticed that alcohol was mostly consumed in the catering trade, where since the year 2000 there has been a decrease in the total energy

Table V
Beverages consumption according to work activity and age of food purchase responsible at homes (g/person/day)

	Alcoholic beverages		Non-alcoholic beverages	
	2011	2012	2011	2012
Work outside the home	70.0	71.5	303	309
Work at home	84.6	89.4	317	330
≤ 35 years	53.3	51.7	318	316
35-39 years	66.2	66.0	292	307
50-64 years	94.9	103	322	339
≥ 65 years	99.5	108	317	332

Table IV
Beverages consumption according to the habitat/town size: years 2011-2012 (g/person/day)

	% energy		% water		% protein		% lipids		% carbohydrates		% sugar	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Alcoholic beverages	2.2	2.4	6.1	6.4	0.3	0.2	0.0	0.0	0.9	0.9	2.1	2.1
Non-alcoholic beverages	2.8	2.8	22.2	23.0	1.0	1.1	0.2	0.3	6.2	5.9	14.1	13.2

intake. But it is also interesting to evaluate the whole "picture": the percentage of proteins to the total energy (14%) kept constant since the year 2000 and adjusted to that recommended although slightly high. On the contrary, the percentage of lipids exceeded the recommendations at the expense of carbohydrates, which had a lower than expected contribution. When analyzing the development, over time, of the energy profile, it can be noticed that the percentage of carbohydrates has decreased more than 10% since 1960. In that year, the profile adjusted to recommendations. This worsening is linked to the decrease in the consumption of food included in the cereal and derivatives, legumes and pulses, and potatoes groups.

Discussion

Several nutrition surveys based on the National Institute of Statistics' Household Budgetary Surveys provide evidence of evolving trends in energy and nutrient intake estimates between 1961 and 1991¹⁰⁻¹³. Since the beginning of the 1990s, a number of Spanish regions have also accomplished randomised population nutrition surveys, including food intake surveys of individuals. These are a valuable source of information from a public health perspective, enabling a more descriptive analysis of the food and nutrition situation of the Spanish population^{14,15}. The present study, conducted at national level, updates the beverages and food habits and nutritional aspects of importance for the Spanish population. In addition, trends emerging from the other surveys above mentioned were considered.

The Spanish beverages pattern, and consequently diet trends, may be still considered varied and healthy, although some trends need to be corrected. More education and information on the large beverages market offer in Spain is needed since many myths and errors exist.

Importantly, the contribution to total energy content from beverages consumption is much lower than in other countries such as United States or Central Europe. Moreover, correlations between energy contribution and water intake according to the different drinks groups is urgently needed in specific studies for this issue. Besides the drinking patterns, a more detailed analysis of food consumption at present and evolutionary trends reveals some significant findings. A large proportion of the young adult Spanish population, mainly women, wrongly consider that potatoes and bread are "fattening" foods. However, potatoes are still included among the five most consumed types of food by more than 95% of the population. The decline in egg consumption is probably due to the general concern that eggs are "unhealthy", based on their relatively high cholesterol content. When compared with other countries, in the pan-European DAFNE study only Greece presented a higher consumption of the vegetables group. From a nutritional point of view, the vegetables and greens group (increasingly being introduced also as

beverages in different presentations contributed 66% of total carotenoid intake in the diet in 2012. The high fruit consumption from different origin is clearly a positive aspect, as this food group will provide antioxidant vitamins and other components, such as pectins, fructose, β -carotenoids and polyphenols, which may be beneficial in helping to prevent chronic degenerative diseases. Just as an example, in year 2012 the fruit group contributed over 40% of the total vitamin C consumed within the diet in Spain. By contrast, legumes and pulses consumption seems to be too low according to the nutritional importance of this group; moreover, this group also provides high quality dietary protein and fibre at relatively low cost that is being skipped. As for cereals and derivatives group contributed roughly a 43% of total dietary carbohydrate consumption and approximately 70% of the total starch. The food culture of the Spanish society is established within the Mediterranean diet frame, which is considered a healthy eating pattern mainly due to its potential protective role against the most common chronic diseases. It is generally agreed that the main components of the Mediterranean diet include a high intake of plant foods (vegetables, fruits, cereals, legumes, nuts and seeds, and olive oil); a low to moderate intake of dairy products (in the form of cheese or yogurt), low to moderate consumption of poultry and eggs; a moderately high intake of fish and shellfish; low intake of red meat and processed meat products, and a moderate intake of wine during meals. However, at present there is a high concern that the so-called Mediterranean diet is more a *theoretical* reference pattern based on the diet that existed in the 60's in some regions on the Mediterranean coast, and that it has been preserved to some extent in just a few Mediterranean locations. This seems to also be partially the case for Spain. Paradoxically, Spain is a major producer and exporter of typical Mediterranean products, a factor that amplifies the importance of maintaining a Mediterranean diet pattern.

In conclusion from the main goal of this article, it may be concluded that there has been a dramatic increase in non-alcoholic drinks consumption in recent years whereas it is unremarkable quantitatively for the alcoholic beverages, being profound for the type of drink for the latest. Moreover, contribution to total energy intake from both groups, however, should be considered low.

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Consumption of non alcoholic beverages and physical activity in childhood and adolescents in Spain

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Abstract

Objectives: To analyze the patterns of non-alcoholic beverage consumption in Spanish children and young people based on the type of physical activity performed.

Methods: We included a sample of 3,137 2-24 year-old individuals who participated in the EnKid study and completed a food frequency questionnaire and a physical activity questionnaire. We analyzed the consumption of non-alcoholic drinks (ml/day) in relation to the level of physical activity performed at school, and during leisure time, in energy-expenditure MET tertiles.

Results: In all age groups significant differences were observed when analyzing the consumption of non-alcoholic beverages based on tertiles of physical activity at school and during leisure time. In all cases, the consumption of non-alcoholic beverages increased with increasing physical activity (being greater than 200 ml/day on average between extreme tertiles). Likewise, an age-related increasing linear trend of consumption of non-alcoholic beverages was observed.

Conclusions: The increase in non alcoholic beverage consumption associated with physical activity by children and adolescents is highlighted.

Key words: Children. Adolescent. Beverages. Physical activity. Hydration.

CONSUMO DE BEBIDAS NO ALCOHOLICAS Y ACTIVIDAD FISICA EN NINOS Y ADOLESCENTES ESPANOLES

Resumen

Objetivos: Analizar los patrones de consumo de bebidas no alcohólicas en niños y jóvenes españoles en función del tipo de actividad física realizada.

Métodos: La muestra incluyó 3.137 individuos de 2 a 24 años de edad que participaron en el estudio EnKid y completaron un cuestionario de frecuencia de consumo de alimentos y un cuestionario de actividad física. Se analizó el consumo de bebidas no alcohólicas (ml/día) en relación con el nivel de actividad física (tertiles de gasto energético, MET) realizada en la escuela/trabajo y durante el tiempo libre.

Resultados: Se observaron diferencias significativas en todos los grupos de edad al analizar el consumo de bebidas no alcohólicas en función de los tertiles de la actividad física realizada en la escuela y durante el tiempo de ocio. En todos los casos, el consumo de bebidas no alcohólicas aumentó al aumentar la actividad física (con un incremento promedio superior a 200 ml/día entre los tertiles extremos de actividad física). Del mismo modo, se observó una tendencia lineal de incremento del consumo de bebidas no alcohólicas ligada con la edad.

Conclusiones: Se resalta el incremento del consumo de bebidas no alcohólicas asociado con la actividad física en niños y adolescentes.

Palabras clave: Niños. Adolescentes. Bebidas. Actividad física. Hidratación.

Introduction

Proper hydration may be achieved by foods and the consumption of water and other liquids. Water constitutes a critical nutrient whose absence can have mortal effects within a matter of days. The importance of water for the prevention of nutrition-related noncommunicable diseases has more recently come to light given the trend that large proportions of consumed fluids are derived from caloric beverages. Nonetheless, hydration

status is rarely measured in epidemiological studies and there is limited knowledge in regards to the measurement of total fluid intake and hydration status at the population level^{1,2}.

Children, the elderly or people with medical conditions, as well as those working in hot environments, constitute population groups who are most vulnerable to the effects of dehydration. However, many adults may also be inadequately hydrated at any given moment³. Children may be at greater risk for voluntary dehydration when performing physical activity. They may not recognize the need to replace lost fluids, and both children as well as coaches need specific guidelines for fluid intake⁴. Moreover, inadequate hydration can influence cognition. Mild levels of dehydration can interfere with mood and cognitive functioning and are a special concern for children, the elderly, individuals living in hot climates,

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and those engaging in vigorous exercise². Mild dehydration causes alterations in a variety of critical cognitive functions such as concentration, alertness and short-term memory in children⁵ young adults⁶⁻⁸ and in the elderly⁹.

In general there is a lack of hydration data, with the majority of studies focusing on beverage consumption and calorie intake, especially sugar sweetened beverages and their impact on obesity and cardiometabolic status¹⁰⁻¹². Fluid consumption data in children were presented in the Helena Study, evaluating 2,741 adolescents aged 12.5-17.5 years, which showed that across Europe the largest amount of per capita fluid consumed in this age group came from water, followed by fruit juice, other beverages, and low-fat milk. Sugar-sweetened beverages accounted for the largest amount of per capita energy intake from beverages, followed by sweetened milk. This suggests that although a greater amount of fruit juice (in fluid ml) was consumed, sweetened milk provided more energy overall in the adolescent population¹³.

Recent studies in the United States and France on meeting recommendations of total water intake (volume/day) and for adequate hydration (volume/1000 Kcal) in children have shown inadequate intakes. In the US, data from three National Health and Nutrition Examination Survey (NHANES) cycles provided a nationally representative sample of 4,766 children age 4-13 years. At least 72% of children age 4-13 years failed to meet the European Food Safety Administration (EFSA) guidelines for total water intake¹⁴. Another study evaluating total water intake in a sample of 3,978 American children aged 2-19 showed that for boys, 15-60% had usual intakes that met or exceeded the AI; for girls, the corresponding estimates were 10-54%¹⁵. In France, Bellisle's study described the potential in certain segments of the sample population, which included 566 children (aged 6-11 years) and 333 adolescents (aged 12-19 years), to be at risk of insufficient hydration given the large variations around mean values obtained (1.05 l/day in children and 1.1 l/day in adolescents)¹⁶. In Spain, hydration was evaluated in a population based study by De Francisco et al, which evaluated hydration status in 6,508 adults aged 18 to > 65. Using a 2 l/day standard for adequate consumption, only 52.6% of the study sample was found to be adequately hydrated (58% in the younger cohort aged 18-29) and beverage consumption was found to increase with higher levels of physical activity¹⁷.

Guidelines have been established to determine how much water humans require (on average) to avoid dehydration and to optimise physical and psychological function. The Spanish Society of Community Nutrition (SENC) has developed guidelines for the Spanish population, which include, among others, 10 servings (200-250 ml) of liquids a day with preferential consumption of water over other beverages, consuming fluids at meals and in between feedings and not waiting for signs of thirstiness to appear, increasing consumption of fruits, salads and other vegetables and matching fluid intake to physical activity levels, health needs and lifestyle¹⁸.

The purpose of this study was to evaluate non-alcoholic beverage consumption and physical activity levels in Spanish children and young adults, considering the factors of energy expenditure and types of beverages as well as the context in which physical activity was realised.

Methodology

The sample consisted of 3,137 (1,443 male, 1,694 female) 2-24 year-old individuals from all of Spain who participated in the EnKid study and completed a food frequency questionnaire and a physical activity questionnaire. The consumption of non-alcoholic beverages (ml/day) was analyzed in relation to overall physical activity and also for physical activity performed at school/work and during leisure time, measured as energy-expenditure (METs, Metabolic equivalent task) in tertiles. Beverage intake was also compared to the SENC hydration recommendations.

The EnKid study on the nutritional status and food habits of Spanish children and young people is a cross-sectional study carried out between 1998 and 2000 within a random sample of the Spanish population aged 2-24 years. The methodology of the study has been described elsewhere¹⁹. Dietary questionnaires (24 hours recalls and a quantitative food frequency questionnaire of 180 items) and a global questionnaire incorporating questions related to socioeconomic status, educational level, and lifestyle factors (physical activity engaged in out of school, and number of hours dedicated to study, to play, to reading, to listening to music, or to practicing sports) were administered. The physical activity questions were adapted from the physical activity questionnaires used by the World Health Organization's Countrywide Integrated Noncommunicable Diseases Intervention (CINDI)²⁰ and the Minnesota Leisure Time Physical Activity Questionnaire²¹. They included questions about the type and frequency of usual sports activity at school (or at work) and out of school (months per year, days per week or month, and total hours per day), number of hours walking per day, and total number of staircases climbed per day.

Energy expenditure associated with physical activity at school/work and during leisure was calculated as the product of the total time spent doing physical activity during leisure time and at school/work, and the intensity of each activity. The created variables were categorized according to tertiles for each age group and gender²².

For this analysis beverage consumption used dietary data derived from the food frequency questionnaire (ml/day). When non alcoholic beverage consumption was evaluated with respect to physical activity, the following items constituted the beverage group: coffee, tea, sugar sweetened soft drinks, sugar-free soft drinks and water.

For the comparison of fluid intake with the SENC hydration pyramid recommendations¹⁸, additional items were included such as milk (whole, semi and skimmed), fresh juice, packaged juice and alcoholic beverages

(non-alcohol beer, beer, cider, wine and champagne, vermouth, sweet wine, rum-whisky-cognac, fruit liquors and herbal liquors. The analysis presents daily intakes of beverages and beverage groups in ml/day and in servings (1 serving = 200 ml).

The fieldwork was initiated on May 1998 and ended on April 2000. Home interviews were conducted by dietitians. For children aged 6 to 12 years, the interviews were answered by the children themselves, with support from the caretaker responsible for his/her education. Data were analyzed using the statistical package SPSS for Windows version 18.0.

Results

The sample analyzed included 1443 males and 1694 females aged 2 to 24 years from the EnKid study. Table I shows beverage consumption (ml/day) by tertiles of total energy expenditure (metabolic equivalent, or MET) and age group. Beverage consumption grouped according to the SENC hydration pyramid is also presented in ml/d and in the number of 200 mL servings consumed per day.

On classifying beverages according to the recommendations of the SENC¹⁸, pyramid for healthy hydration the following was observed:

- Level 1. Primarily composed of water. Water consumption increased with age and level of physical activity level, with intake being lower for males aged 2-5 years at the lower tertile of physical activity (523 ml/day) and higher in older youth who realised more physical activity (1,125 ml/day). Significant differences were observed for all age groups between the lowest and highest tertiles of physical activity.
- Level 2: represents consumption of coffee, teas, and sugar-free soft drinks. Intake increased with age and physical activity, being greatest for those aged 18-24 in the highest tertile of physical activity (89.5 ml/day).
- Level 3: includes beverages with a certain calorie level and nutrients of interest such as: fresh juices, milk (whole, low fat and skim) and non alcoholic beer. Consumption of this group decreased with age, primarily due to lower consumption of milk and juices (going from 526 ml/day in the younger cohort to 375 ml/day in the older).
The sum of intakes from levels 1,2, and 3, converted into servings (1 serving = 200 ml) showed an increase in the consumption of beverage servings with age. Intakes increased from 5.25 beverage servings consumed by children aged 2 to 5 with low physical activity to 8.17 servings in those aged 18 to 24 at the highest tertile of physical activity.
- Level 4 represents beverages that should be consumed occasionally (weekly frequency). Intakes also rose with age, increasing from 0.5 servings/day in the youngest group to 1.2 in the oldest.

The consumption of non alcoholic beverages (water, coffee, tea, soft drinks), in children and adolescents by level of physical activity performed at school by age group is shown in figure 1. Figure 2 presents beverage consumption as related to the amount of physical activity performed during leisure time by age group.

In all age groups significant differences were observed when analyzing the consumption of non-alcoholic drinks based on tertiles of physical activity at school and during leisure time. In all cases, the consumption of non-alcoholic drinks increased with increasing physical activity (being greater than 200 ml/day on average between extreme tertiles). Likewise, an age-related increasing linear trend of consumption of non-alcoholic beverages was observed.

Discussion

This study evaluated the pattern of beverage consumption in relation to physical activity levels in the Spanish population. The analysis showed that the main sources of fluid intake were plain water and milk, followed by fruit juices (natural or juice beverages) and soft drinks, both of them having a lower contribution to the total beverage intake. The fluid intake pattern was similar across all age groups analyzed.

Spanish children and adolescents that were more physically active had higher intakes of non alcoholic beverages than those that were more inactive. The more active individuals tended to consume higher quantities of plain water, milk (for those aged 18 to 24 years old) and non alcoholic beverages than their more inactive peers. The results were similar to those found in the literature. The HELENA study with data from more than 3,000 European adolescents showed that the least active females had a lower intake of milk products compared to the most active²³. Tomlin in a study conducted in Switzerland found that adolescents (mean age of 9.9 years) reporting participation in organized sports consumed higher quantities of non-flavored milk, and showed a higher daily frequency consumption of milk and 100% fruit juice. No differences in sugar sweetened beverages or sports drink consumption were observed between those who were and were not involved in organized sports²⁴.

Cavadini et al showed that among adolescents classified as being active, a higher percentage of individuals (boys) consumed milk (at least once a day), fruit juice, diet soft drinks (boys) and sports drinks than their non-active peers. The consumption of soft drinks was similar among active and non active individuals²⁵. In the present study the consumption of sugar sweetened drinks decreased in relation to physical activity level, but was only statistically significant for children in the age group of 6 to 9 years.

Ranjit et al in a study conducted in the USA evaluated the relationship between physical activity, sedentary activities (amount of vigorous physical activity, partici-

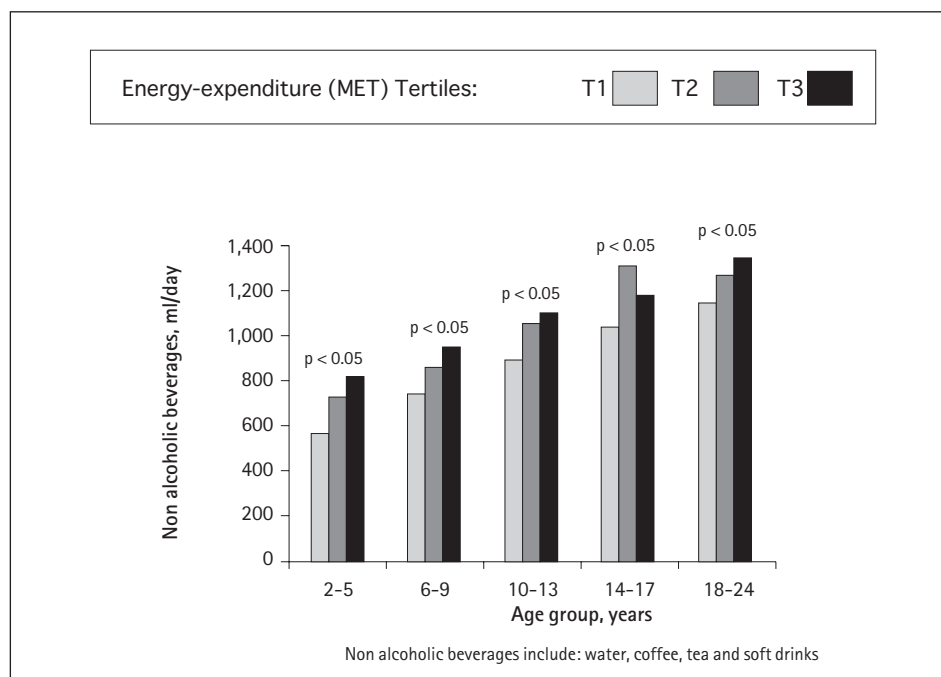


Fig. 1.—Non alcoholic beverage intake in children and adolescents and level of physical activity performed at school/work.

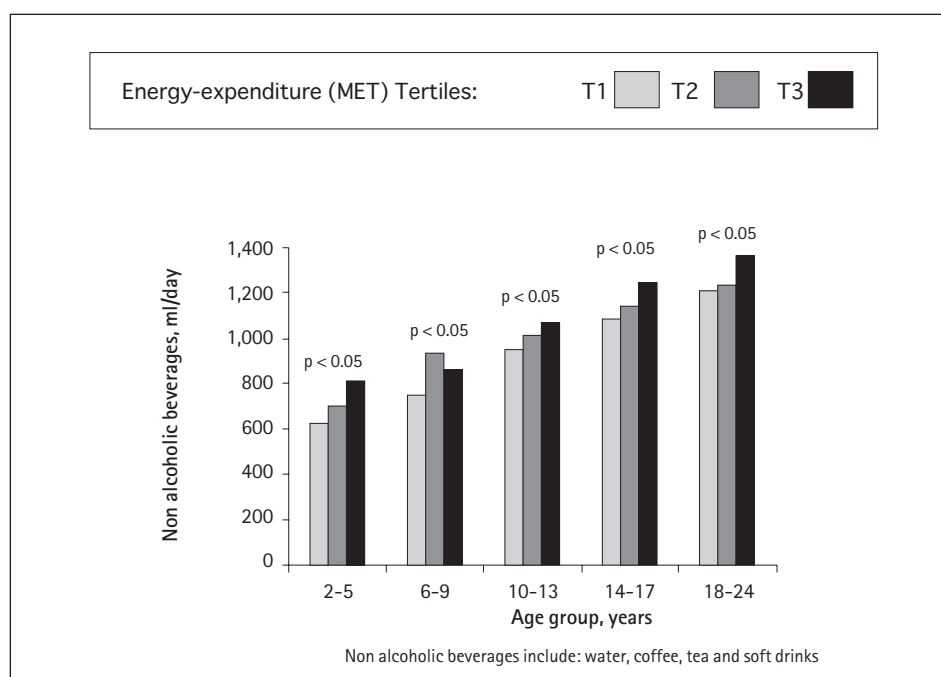


Fig. 2.—Non alcoholic beverage intake in children and adolescents and level of physical activity performed during leisure time.

pation in school physical education classes, and participation in organized sports activity and hours spent watching TV, on the computer, and with video games) and beverage intake. They observed a decrease of soda consumption and an increase of flavored and sports beverage consumption in those individuals with higher levels of physical activity, especially among boys. Moreover, the sedentary activity measures increased with soda consumption in both girls and boys²⁶.

Regarding water intake, we observed that for all age groups, more physically active individuals drank more

water, which is consistent with previous studies. For instance, Park et al.²⁷ found that adolescents from Florida (US) who had participated in team or individual sports during the previous year were likely to drink more water than those who did not. Also in the US, Kant¹⁵ found higher plain water consumption among children and adolescents from 2 to 19 years old.

The Spanish Society of Community Nutrition recommends a daily beverage consumption of at least 10 servings, provided mainly by plain water, non caloric soft drinks, coffee and tea, herbal teas, 100% fruit juices,

skimmed non-sugared dairy products and non alcoholic beverages, among others. In the present study the most active individuals demonstrated higher fluid intake consumption, with those pertaining to the oldest group age coming closest to meeting the SENC recommendations of 10 servings per day¹⁸. As the water content in food was not considered for the analysis, it is likely that the most active individuals met the recommendations.

The limitations of the study are related to the food intake and physical activity data collection method. On one hand, the food frequency questionnaire administered to estimate beverage intake may overestimate consumption. However a nutritionist-led interview for data collection was employed, so as to increase the accuracy of intake measurement. On the other hand, intake could be underreported given the closed nature of the food list, which did not specify certain foods such as soups, sports drinks, etc. It should also be taken into consideration that there has been an increase in consumption over the last decade in low or non-caloric beverages and low fat dairy drinks, all of which had low consumption levels at the time the study was conducted.

In addition, the self-reported physical activity questionnaire may also overestimate true physical activity. Strengths of the study rely on the large population-based representative study sample.

Conclusions

The increase in non alcoholic beverage consumption associated with physical activity by children and adolescents is highlighted.

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Normas de Publicación para Autores de: Revista Española de nutrición comunitaria

Spanish Journal of Community Nutrition

LA REVISTA ESPAÑOLA DE NUTRICIÓN COMUNITARIA, es la publicación científica oficial de la Sociedad Española de Nutrición Comunitaria y del Grupo Latinoamericano de Nutrición Comunitaria.

Publica trabajos en castellano e inglés sobre temas relacionados con el vasto campo de la nutrición. El envío de un manuscrito a la revista implica que es original y no ha sido publicado, ni está siendo evaluado para publicación, en otra revista y deben haberse elaborado siguiendo los Requisitos de Uniformidad del Comité Internacional de Directores de Revistas Médicas en su última versión (versión oficial disponible en inglés en <http://www.icme.org>; correspondiente traducción al castellano en: http://www.metodo.uab.es/enlaces/Requisitos_de_Uniformidad_2006.pdf).

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Será estructurado en el caso de originales, originales breves y revisiones, cumplimentando los apartados de Introducción, Objetivos, Métodos, Resultados y Discusión (Conclusiones, en su caso). Deberá ser comprensible por sí mismo y no contendrá citas bibliográficas.

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Revisión	Estructurado 250 palabras	Estructurado 6.000 palabras	6	150
Notas clínicas	150 palabras	1.500 palabras	2	10
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