ISSN: 1135-3074

Revista Española de Nutrición Comunitaria

Spanish Journal of Community Nutrition

Vol. 20 - Suplemento 1
Marzo
2014

I International and III National Hydration Congress

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

RENC

Sociedad Española de Nutrición Comunitaria

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Organo de expresión de la Sociedad Española de Nutrición Comunitaria
Órgano de expresión del Grupo Latinoamericano de Nutrición Comunitaria

www.nutricióncomunitaria.org

Vol. 20 - Suplemento 1 - Marzo 2014

Edición y Administración
GRUPO AULA MÉDICA, S.L.

OFICINA
Isabel Colbrand, 10-12
Oficina 140 Planta 5.ª - 28050 Madrid
Tel.: 913 446 554 - Fax: 913 446 586
www.aulamedica.es

Dep. Legal: B-18798/95
Publicación autorizada como soporte válido
ISSN (Versión papel): 1135-3074

aulamédica
formación en salud

www.aulamedica.es · www.libreriasaulamedica.com

© SOCIEDAD ESPAÑOLA DE NUTRICIÓN COMUNITARIA, 2014
© GRUPO AULA MÉDICA, 2014

Reservados todos los derechos de edición. Se prohíbe la reproducción o transmisión, total o parcial de los artículos contenidos en este número, ya sea por medio automático, de fotocopia o sistema de grabación, sin la autorización expresa de los editores.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Vol. 20 - Suplemento 1 - Marzo 2014

Órgano de expresión de la Sociedad Española de Nutrición Comunitaria

Órgano de expresión del Grupo Latinoamericano de Nutrición Comunitaria www.nutricioncomunitaria.org

Director
Javier Aranceta Bartrina

Editores Asociados
Lluís Serra Majem
Carmen Pérez Rodrigo

Redactor Jefe
Joan Quiles Izquierdo

Secretarios de Redacción
Victoria Arija Val
Joan Fernández Ballart
Emilio Martínez de Vitoria
Rosa Ortega Anta
Amelia Rodríguez Martín
Gregorio Varela Moreiras
Lourdes Ribas Barba
Ana María López Sobaler
Josep A. Tur Marí

Indexada en
EMBASE/Excerpta Médica
IBECS (Índice Bibiliográfico en Ciencias de la Salud)
IME (Índice Médico Español)
Journal Citation Reports/Science Edition
Science Citation Index Expanded (SciSearch®)
SIIC Data Bases
SCOPUS
MEDES

Director

Javier Aranceta Bartrina

Editores Asociados

Lluis Serra Majem
Carmen Pérez Rodrigo

Redactor Jefe

Joan Quiles Izquierdo

Consejo editorial

Victoria Arija Val
Joan Fernández Ballart
Emilio Martínez de Vitoria
Rosa Ortega Anta
Amelia Rodríguez Martín
Gregorio Varela Moreiras
Lourdes Ribas Barba
Ana María López Sobaler
Josep A. Tur Marí

Junta Directiva de la SENC

Presidente:
Carmen Pérez Rodrigo

Vicepresidentes:
Rosa M. Ortega Anta
Emilio Martínez de Vitoria

Secretario General:
Josep Antoni Tur Marí

Tesorera:
Gemma Salvador i Castell

Vocales:
Gregorio Varela Moreiras
Joan Quiles Izquierdo
Victoria Arija Val
Mercé Vidal Ibáñez
Maria Lourdes de Torres Aured
Amelia Rodríguez Martín
Francisco Rivas García

Presidente Fundador:
José Mataix Verdú

Presidente de Honor:
Lluis Serra Majem

Presidente Comité Científico:
Javier Aranceta Bartrina

Comité de Expertos

Presidente: Lluis Serra Majem

Expertos

Victoria Arija (Reus, España)
José Ramón Banegas (Madrid, España)
Susana Bejarano (La Paz, Bolivia)
Josep Boatella (Barcelona, España)
Benjamín Caballero (Baltimore, EE.UU)
Jesús Contreras (Barcelona, España)
Carlos H. Daza (Potomac, México)
Gerard Debry (Nancy, Francia)
Miguel Delgado (Jaén, España)
Herman L. Delgado (Guatemala, Guatemala)
Alfredo Entrala (Madrid, España)
Mª Cecilia Fernández (San José, Costa Rica)
Joaquín Fernández Crehuet-Navajas (Málaga, España)
Anna Ferro-Luzzi (Roma, Italia)
Marius Foz (Barcelona, España)
Silvia Franceschi (Aviano, Italia)
Flaminio Fidanza (Perugia, Italia)
Santiago Funes (México DF, México)
Pilar Galán (París, Francia)
Reina García Closas (Tenerife, España)
Isabel García Jalón (Pamplona, España)
Patricio Garrido (Barcelona, España)
Lydia Gorgojo (Madrid, España)
Santiago Grisolía (Valencia, España)
Arturo Hardisson (Tenerife, España)
Elisabet Helsing (Copenague, Dinamarca. OMS)
Serge Hercbeg (Paris, Francia)
Manuel Hernández (La Habana, Cuba)
Philip James (Aberdeen, Inglaterra)
Arturo Jiménez Cruz (Tijuana, México)
Carlo La Vecchia (Milan, Italia)
Federico Leighton (Santiago, Chile)
Consuelo López Nomdedeu (Madrid, España)
Juan Llopis (Granada, España)
John Lupien (Massachusetts, EE.UU.)
Herlinda Madrigal (México DF, México)
Rocío Maldonado (Barcelona, España)
Francisco Mardones (Santiago, Chile)
Abel Mariné Font (Barcelona, España)
José Mª Martín Moreno (Madrid, España)
Endre Morava (Budapest, Hungría)
Olga Moreiras (Madrid, España)
Cecilio Morón (Santiago, Chile)
Mercedes Muñoz (Navarra, España)
Moisés Palma (Santiago, Chile)
Marcela Pérez (La Paz, Bolivia)
Andrés Petrasovits (Otawa, Canadá)
Eusebi Puyaltó (Barcelona, España)
Fernando Rodríguez Artalejo (Madrid, España)
Montserrat Rivero (Barcelona, España)
Joan Sabaté (Loma Linda, CA, EE.UU.)
Jordi Salas (Reus, España)
Gemma Salvador (Barcelona, España)
Ana Sastre (Madrid, España)
Jaume Serra (Barcelona, España)
Paloma Soria (Madrid, España)
Angela Sotelo (México DF, México)
Delia Soto (Chile)
Antonio Sierra (Tenerife, España)
Noel Solomons (Ciudad de Guatemala, Guatemala)
Ricardo Uauy (Santiago, Chile)
Wija van Staveren (Wageningen, Holanda)
Antonia Trichopoulou (Atenas, Grecia)
María Daniel Vaz de Almeida (Oporto, Portugal)
Ricardo Velázquez (México DF, México)
Jesús Vioque (Alicante, España)
Josef Vobecky (Montreal, Canadá)
Walter Willett (Boston, EE.UU.)

Coordinadores del Grupo Latinoamericano de Nutrición Comunitaria (GLANC)

Gemma Salvador i Castell
Emilio Martínez de Vitoria

Instituciones promotoras de la Sociedad Española de Nutrición Comunitaria

Casa Santiveri S.A.
Danone S.A.
Kellogg's España S.A.
Productora Alimenticia General Española, S.A. (PAGESA)
Whitehall (Grupo Wyeth Lederle)

Cualquier forma de reproducción, distribución, comunicación pública o transformación de esta obra sólo puede ser realizada con la autorización de sus titulares, salvo excepción prevista por la ley. Diríjase a CEDRO (Centro Español de Derechos Reprográficos, www.cedro.org) si necesita fotocopiar o escanear algún fragmento de esta obra.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Vol. 20. Suplemento 1. Marzo 2014

I International and III National Hydration Congress

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

ORGANIZED BY:

The Coca-Cola Company
Hydrating the World since 1886

WITH THE COLLABORATION OF:

Nutrition and Dietetic Societies

Spanish Nutrition and Food Sciences Academy **(AEN)**

Spanish Federation of Nutrition, Food and Dietetic Societies **(FESNAD)**

Spanish Nutrition Society **(SEN)**

Spanish Society for Community Nutrition **(SENC)**

Spanish Endocrinology and Nutrition Society **(SEEN)**

Spanish Nutrition Foundation **(FEN)**

Spanish Foundation for Nutritional Research **(FIN)**

Network for Research on Physical activity and Health for Special Populations **(EXERNET)**

Nutrition Studies Association **(ASEN)**

Dieticians - Nutricionists Spanish Association **(AEDN)**

Spanish Nurses Association of Dietetic and Nutrition **(ADENYD)**

WITH THE COLLABORATION OF:

National Authorities

National Sports Council (**CSD**)

Spanish Agency for Health Protection at Sport **(AEPSAD)**

International Scientific Societies

European Hydration Institute **(EHI)**

Beverage Institute for Health&Wellness. The Coca Cola Company

Latin-American Group of Community Nutrition

Portuguese Association of Dietitians **(APD)**

Iberoamerican Nutrition Foundation **(FINUT)**

Portuguese Association of Nutritionists **(APN)**

Turkish Dietician Association **(TDD)**

WITH THE PARTICIPATION OF:

National Medical Societies

Royal National Academy of Medicine

Spanish Society of Residences Doctors **(SEMER)**

Spanish Federation of Sport Medicine **(FEMEDE)**

Spanish Association of Gastroenterology **(AEG)**

Spanish Society of Family Physicians **(SEMERGEN)**

Spanish Society of Gynecology and Obstetrics **(SEGO)**

Spanish Society of Geriatrics and Gerontology **(SEGG)**

Spanish Society of Familiy and Community Medicine **(semFYC)**

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Vol. 20. Suplemento 1. Marzo 2014

WITH THE PARTICIPATION OF:

International Medical Societies

Portuguese Society
of Gastroenterology **(SPG)**

Pharmaceutical Societies

General Council of Official
Pharmacists Colleges
(CGCOF)

Foundations

Diabetes
Foundation **(FD)**

Federation of Spanish
Diabetics **(FEDE)**

Spanish Cardiology Society **(SEC)**
Spanish Heart Foundation **(FEC)**

Conin
Foundation

Nutrition
Without Borders

Age & Life
Foundation

WITH THE SUPPORT OF:

National Universities

Technical University of Madrid **(UPM)**
Faculty of Physical Activity and Sports
Sciences **(INEF)**

CEU San Pablo
University

Autónoma University
of Madrid **(UAM)**

University of Las Palmas
de Gran Canaria **(ULPGC)**

University
of Barcelona **(UB)**

Camilo José Cela
University **(UCJC)**

Complutense University
of Madrid **(UCM)**

Castilla-La Mancha
University **(UCLM)**

University
of Granada **(UGR)**

University of
Baleares Islands **(UIB)**

National Distance
Education University **(UNED)**

WITH THE SUPPORT OF:

International Universities

University of Lisbon

University of North Alabama

The University of North Dakota

The Centre of Postgraduate Medical Education **(CMKP)**

National Research Centres

Institute for Health Research La Paz University Hospital

Nutrition and Food Technology Institute-UGR

Biopolis S.L.

Alimentómica

Improvement of Health by Fitness, Nutrition and Exercise Research Group

Biosearch Life

Biomedical Network Research Centre in Physiopathology of Obesity and Nutrition

International Research Centres

Georgia Institute of Technology

Bielanski Hospital

Sport Science Insights

Institute for Biomedicine of Aging

ORGANIZING COMMITTEE

- **The Coca-Cola Company**

SCIENTIFIC COMMITTEE

- **Prof. Dr. Ángel Gil, PhD.** Professor of Biochemistry and Molecular Biology. University of Granada. Granada. Spain.
- **Prof. Dr. Andreu Palou, PhD.** Professor of Biochemistry and Molecular Biology. University of Baleares. Palma de Mallorca. Spain.
- **Prof. Dr. Arturo Anadón, PhD.** Professor of Toxicology and Pharmacology. Complutense University of Madrid. Madrid. Spain.
- **Prof. Dr. Ascensión Marcos, PhD.** Research Professor at the Spanish National Research Council. Madrid. Spain.
- **Prof. Dr. Carmen Gómez-Candela, MD, PhD.** Head of Clinical Nutrition Department. La Paz University Hospital. Madrid. Spain.
- **Dr. Carmen Pérez-Rodrigo, MD, PhD.** President of Spanish Society of Community Nutrition. Bilbao. Spain.
- **Dr. Claudio Maffeis, MD.** Head of the Unit of Clinical Nutrition and Obesity, Regional Centre for Juvenile Diabetes. University of Verona. Verona. Italy.
- **Prof. Dr. Daniel Ramón, PhD.** Scientific Chairman of Biopolis S.L. Valencia. Spain.
- **Prof. Dr. Emilio Martínez de Victoria, PhD.** Head of the Nutrition and Food Technology Institute "José Mataix". University of Granada. Granada. Spain.
- **Prof. Dr. Gregorio Varela-Moreiras, PhD.** Professor of Nutrition and Bromathology. Head of Health and Pharmacist Sciences Department. CEU San Pablo University. Madrid. Spain.
- **Dr. Hans Braun, PhD.** Sport Nutrition in the German Sport University of Cologne and the German Research Centre of Elite Sport. Cologne. Germany.
- **Prof. Dr. Isabel Polanco, MD, PhD.** Professor of Paediatrics. Autónoma University of Madrid and Head of Department of Paediatric Gastroenterology and Nutrition. Universitary Hospital La Paz. Madrid. Spain.
- **Prof. Dr. Javier Aranceta, MD, PhD.** Associate Professor at University of Navarra. Pamplona. Spain.
- **Prof. Dr. Lluís Serra-Majem, MD, PhD.** Professor of Preventive Medicine and Public Health. University of Las Palmas de Gran Canaria. Las Palmas de Gran Canaria. Spain.
- **Prof. Dr. Manuel Díaz-Rubio, MD, PhD.** Professor of Medicine. Complutense University of Madrid. Madrid. Spain.
- **Prof. Dr. Marcela González-Gross, PhD.** Professor for Sports Nutrition and Exercise Physiology. Department of Health and Human Performance. Technical University of Madrid. Madrid. Spain.
- **Prof. Dr. María Kapsokefalou, PhD.** Associate Professor in Human Nutrition. Agricultural University of Athens. Athens. Greece.
- **Dr. Nieves Palacios, MD, PhD.** Head of Department of Medicine, Endocrinology and Nutrition at the Sports Medicine Center. National Sport Council. Madrid. Spain.
- **Dr. Pilar Riobó, MD, PhD.** Head of Nutrition and Endocrinology Service. Hospital of Jimenez Díaz Foundation. Madrid. Spain.
- **Prof. Dr. Ryszard Gellert, MD, PhD.** Professor of Nephrology and Head of Department of Nephrology. Centre of Posgraduate Medical Education. Head of Nephrology Unit. Bielański Hospital. Warsaw, Poland.
- **Prof. Dr. Ronald J. Maughan, PhD.** Professor of Sport and Exercise Nutrition. Loughborough University. Loughborough. United Kingdom.
- **Prof. Dr. Rosa Mª Ortega, PhD.** Professor of Nutrition. Complutense University of Madrid. Madrid. Spain.

SCIENTIFIC SECRETARIAT

- **Prof. Dr. Elena Alonso-Aperte, PhD.** Senior Lecturer Assistant in Nutrition and Bromathology. Vice Dean of Pharmacy Faculty. CEU San Pablo University. Madrid. Spain.
- **Prof. Dr. Teresa Partearroyo, PhD.** Associate Professor of Nutrition and Bromathology. CEU San Pablo University. Madrid. Spain.
- **Dr. Rafael Urrialde, PhD.** Health and Nutrition Manager. Coca-Cola Iberia.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):1
ISSN 1135-3074

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 being 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 Maffeis, 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 Mª 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 Rupertoz.*
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

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):2-12
ISSN 1135-3074

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

Lluis Serra-Majem[1] and Angel Gil[2]

[1]Professor 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. [2]Professor 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 Maffeis, 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 Kapsokefalou, 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 Mª 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 hypohydration 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 increas 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 de 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 faecesl). 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 beverages 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. Pro. 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. Lluis 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 Baleares. 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 biompedance 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, Gautemala.*

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 where 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 wells 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 the 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.

Selected References on Hydration (1990-2014)

1. Goldberg LR, Heiss CJ, Parsons SD, Foley AS, Mefferd AS, Hollinger D, Parham DF, Patterson J. Hydration in older adults: The contribution of bioelectrical impedance analysis. *Int J Speech Lang Pathol* 2014 Feb 13.
2. Armstrong LE, Ganio MS, Klau JF, Johnson EC, Casa DJ, Maresh CM. Novel hydration assessment techniques employing thirst and a water intake challenge in healthy men. *Appl Physiol Nutr Metab* 2014 Feb; 39 (2): 138-44.
3. Killer SC, Blannin AK, Jeukendrup AE. No evidence of dehydration with moderate daily coffee intake: a counterbalanced cross-over study in a free-living population. *PLoS One* 2014 Jan 9; 9 (1): e84154.
4. Malisova O, Protopappas A, Nyktari A, Bountziouka V, Antsaklis A, Zampelas A, Kapsokefalou M. Estimations of water balance after validating and administering the water balance questionnaire in pregnant women. *Int J Food Sci Nutr* 2013 Dec 3.
5. Clark WF, Sontrop JM, Huang SH, Gallo K, Moist L, House AA, Weir MA, Garg AX. The chronic kidney disease Water Intake Trial (WIT): results from the pilot randomised controlled trial. *BMJ* Open. 2013 Dec 20; 3 (12): e003666.
6. Higgins I, van der Riet P, Sneesby L, Good P. Nutrition and hydration in dying patients: the perceptions of acute care nurses. *J Clin Nurs* 2013 Dec 20.
7. Spector DA, Deng J, Stewart KJ. Hydration status affects sodium, potassium, and chloride transport across rat urothelia. *Am J Physiol Renal Physiol* 2013 Dec 15; 305 (12): F1669-79.
8. Bardis CN, Kavouras SA, Arnaoutis G, Panagiotakos DB, Sidossis LS. Mild dehydration and cycling performance during 5-kilometer hill climbing. *J Athl Train* 2013 Nov-Dec; 48 (6): 741-7.
9. Nissensohn M, Ruano C, Serra-Majem L. Validation of beverage intake methods vs. hydration biomarkers: a short review. *Nutr Hosp* 2013 Nov 1; 28 (n06): 1815-9.
10. Pettersson S, Berg CM. Hydration Status in Elite Wrestlers, Judokas, Boxers and Taekwondo Athletes on Competition Day. *Int J Sport Nutr Exerc Metab* 2013 Nov 25.
11. Stookey JD, Klein A, Hamer J, Chi C, Higa A, Ng V, Arieff A, Kuypers FA, Larkin S, Perrier E, Lang F. RBC deformability and amino acid

concentrations after hypo-osmotic challenge may reflect chronic cell hydration status in healthy young men. *Physiol Rep* 2013 Oct; 1 (5): e00117.
12. Montenegro-Bethancourt G, Johner SA, Remer T. Contribution of fruit and vegetable intake to hydration status in schoolchildren. *Am J Clin Nutr* 2013 Oct; 98 (4): 1103-12.
13. Moreno IL, Vanderlei LC, Pastre CM, Vanderlei FM, de Abreu LC, Ferreira C. Cardiorespiratory effects of water ingestion during and after exercise. *Int Arch Med* 2013 Sep 23; 6 (1): 35.
14. Hosseinlou A, Khamnei S, Zamanlu M. The effect of water temperature and voluntary drinking on the post rehydration sweating. *Int J Clin Exp Med* 2013 Sep 1; 6 (8): 683-7. eCollection 2013.
15. Perrier E, Demazières A, Girard N, Pross N, Osbild D, Metzger D, Guelinckx I, Klein A. Circadian variation and responsiveness of hydration biomarkers to changes in daily water intake. *Eur J Appl Physiol* 2013 Aug; 113 (8): 2143-51.
16. Kaiser KA, Shikany JM, Keating KD, Allison DB. Will reducing sugar-sweetened beverage consumption reduce obesity? Evidence supporting conjecture is strong, but evidence when testing effect is weak. *Obes Rev* 2013 Aug; 14 (8): 620-33.
17. Sutton D, Stroud M. Does hands-free drinking improve patient hydration? *Nurs Times* 2013 Jul 24-30; 109 (29): 14-6.
18. Maughan RJ, Meyer NL.Hydration during intense exercise training. *Nestle Nutr Inst Workshop Ser* 2013; 76: 25-37.
19. Drewnowski A, Rehm CD, Constant F. Water and beverage consumption among children age 4-13y in the United States: analyses of 2005-2010 NHANES data. *Nutr J* 2013 Jun 9; 12 (1): 85.
20. Silva AM, Júdice PB, Matias CN, Santos DA, Magalhães JP, St-Onge MP, Gonçalves EM, Armada-da-Silva P, Sardinha LB. Total body water and its compartments are not affected by ingesting a moderate dose of caffeine in healthy young adult males. *Appl Physiol Nutr Metab* 2013 Jun; 38 (6): 626-32.
21. Polkinghorne BG, Gopaldasani V, Furber S, Davies B, Flood VM. Hydration status of underground miners in a temperate Australian region. *BMC Public Health* 2013 May 2; 13: 426.
22. Goodman AB, Blanck HM, Sherry B, Park S, Nebeling L, Yaroch AL. Behaviors and attitudes associated with low drinking water intake among US adults, Food Attitudes and Behaviors Survey, 2007. *Prev Chronic Dis* 2013 Apr 11; 10: E51.
23. Block JP, Gillman MW, Linakis SK, Goldman RE. "If it tastes good, I'm drinking it": qualitative study of beverage consumption among college students. *J Adolesc Health* 2013 Jun; 52 (6): 702-6.
24. Arnaoutis G, Kavouras SA, Kotsis YP, Tsekouras YE, Makrillos M, Bardis CN. Ad libitum fluid intake does not prevent dehydration in suboptimally hydrated young soccer players during a training session of a summer camp. *Int J Sport Nutr Exerc Metab* 2013 Jun; 23 (3): 245-51.
25. Rush EC. Water: neglected, unappreciated and under researched. *Eur J Clin Nutr* 2013 May; 67 (5): 492-5.
26. Raines J, Snow R, Petersen A, Harvey J, Nichols D, Aisbett B. The effect of prescribed fluid consumption on physiology and work behavior of wildfire fighters. *Appl Ergon* 2013 May; 44 (3): 404-13.
27. Perrier E, Vergne S, Klein A, Poupin M, Rondeau P, Le Bellego L, Armstrong LE, Lang F, Stookey J, Tack I. Hydration biomarkers in free-living adults with different levels of habitual fluid consumption. *Br J Nutr* 2013 May; 109 (9): 1678-87.
28. Logan-Sprenger HM, Spriet LL. The acute effects of fluid intake on urine specific gravity and fluid retention in a mildly dehydrated state. *J Strength Cond Res* 2013 Apr;27 (4): 1002-8.
29. Benefer MD, Corfe BM, Russell JM, Short R, Barker ME. Water intake and post-exercise cognitive performance: an observational study of long-distance walkers and runners. *Eur J Nutr* 2013 Mar; 52 (2): 617-24.
30. Matarese LE. Nutrition and fluid optimization for patients with short bowel syndrome. *JPEN J Parenter Enteral Nutr* 2013 Mar; 37 (2): 161-70.
31. Peacock OJ, Thompson D, Stokes KA. Impact of a carbohydrate-electrolyte drink on ingestive behaviour, affect and self-selected intensity during recreational exercise after 24-h fluid restriction. *Appetite* 2013 Jan; 60 (1): 5-12.
32. Nissensohn M, Castro-Quezada I, Serra-Majem L. Beverage and water intake of healthy adults in some European countries. *Int J Food Sci Nutr* 2013; 64 (7): 801-5.
33. O'Neal EK, Poulos SP, Bishop PA. Hydration profile and influence of beverage contents on fluid intake by women during outdoor recreational walking. *Eur J Appl Physiol* 2012 Dec; 112 (12): 3971-82.
34. Fadda R, Rapinett G, Grathwohl D, Parisi M, Fanari R, Calò CM, Schmitt J. Effects of drinking supplementary water at school on cognitive performance in children. *Appetite* 2012 Dec; 59 (3): 730-7.
35. Maughan RJ. Hydration, morbidity, and mortality in vulnerable populations. *Nutr Rev* 2012 Nov; 70 (Supl. 2): S152-5.
36. Proceedings on the Second International Conference on Hydration and Health, November 15-16, 2011, Miami Beach, Florida. *Nutr Rev* 2012 Nov; 70 (Supl. 2): S97-155.
37. Millard-Stafford M, Wendland DM, O'Dea NK, Norman TL. Thirst and hydration status in everyday life. *Nutr Rev* 2012 Nov; 70 (Supl. 2): S147-51.
38. Kenefick RW, Cheuvront SN. Hydration for recreational sport and physical activity. *Nutr Rev* 2012 Nov; 70 (Supl. 2): S137-42.
39. Goulet ED. Dehydration and endurance performance in competitive athletes. *Nutr Rev* 2012 Nov; 70 (Supl. 2): S132-6.
40. Maughan RJ. Investigating the associations between hydration and exercise performance: methodology and limitations. *Nutr Rev* 2012 Nov; 70 (Supl. 2): S128-31.
41. Armstrong LE. Challenges of linking chronic dehydration and fluid consumption to health outcomes. *Nutr Rev* 2012 Nov; 70 (Supl. 2): S121-7.
42. Akter MD, Kabir N, Shah MS, Islam F, Tasnim S. Effect of maternal oral hydration therapy in oligohydramnios. *Mymensingh Med J* 2012 Oct; 21 (4): 723-8.
43. Weir K, McMahon S, Chang AB. Restriction of oral intake of water for aspiration lung disease in children. *Cochrane Database Syst Rev* 2012 Sep 12; 9: CD005303.
44. Carter JM, Loney T, Blacker SD, Nicholson GF, Wilkinson DM. Hydration status of Arabic adolescents and young men: measurement, evaluation, and a school-based initiative to improve drinking behavior. *Int J Sport Nutr Exerc Metab* 2012 Aug; 22 (4): 257-66.
45. Armstrong LE, Johnson EC, Munoz CX, Swokla B, Le Bellego L, Jimenez L, Casa DJ, Maresh CM. Hydration biomarkers and dietary fluid consumption of women. *J Acad Nutr Diet* 2012 Jul; 112 (7): 1056-61.
46. Kaiser KA, Cofield SS, Fontaine KR, Glasser SP, Thabane L, Chu R, Ambrale S, Dwary AD, Kumar A, Nayyar G, Affuso O, Beasley M, Allison DB. Is funding source related to study reporting quality in obesity or nutrition randomized control trials in top-tier medical journals? *Int J Obes* 2012 Jul; 36 (7): 977-81.
47. Burdon CA, Johnson NA, Chapman PG, O'Connor HT. Influence of beverage temperature on palatability and fluid ingestion during endurance exercise: a systematic review. *Int J Sport Nutr Exerc Metab* 2012 Jun; 22 (3): 199-211.
48. Manz F, Johner SA, Wentz A, Boeing H, Remer T. Water balance throughout the adult life span in a German population. *Br J Nutr* 2012 Jun; 107 (11): 1673-81.
49. Cleary MA, Hetzler RK, Wasson D, Wages JJ, Stickley C, Kimura IF. Hydration behaviors before and after an educational and prescribed hydration intervention in adolescent athletes. *J Athl Train* 2012 May-Jun; 47 (3): 273-81.
50. Bloomfield J, Pegram A. Improving nutrition and hydration in hospital: the nurse's responsibility. *Nurs Stand* 2012 Apr 25-May 1; 26 (34): 52-6; quiz 58.
51. Sécher M, Ritz P. Hydration and cognitive performance. *J Nutr Health Aging* 2012 Apr; 16 (4): 325-9.
52. Williams J, Tzortziou Brown V, Malliaras P, Perry M, Kipps C. Hydration strategies of runners in the London Marathon. *Clin J Sport Med* 2012 Mar; 22 (2): 152-6.
53. Malisova O, Bountziouka V, Panagiotakos DB, Zampelas A, Kapsokefalou M. The water balance questionnaire: design, reliability and validity of a questionnaire to evaluate water balance in the general population. *Int J Food Sci Nutr* 2012 Mar; 63 (2): 138-44.
54. Peacock OJ, Thompson D, Stokes KA. Voluntary drinking behaviour, fluid balance and psychological affect when ingesting water or a carbohydrate-electrolyte solution during exercise. *Appetite* 2012 Feb; 58 (1): 56-63.

55. Alexy U, Cheng G, Libuda L, Hilbig A, Kersting M. 24 h-Sodium excretion and hydration status in children and adolescents—results of the DONALD Study. *Clin Nutr* 2012 Feb; 31 (1): 78-84.
56. Hedrick VE, Savla J, Comber DL, Flack KD, Estabrooks PA, Nsiah-Kumi PA, Ortmeier S, Davy BM. Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): sugar-sweetened beverages and total beverage energy intake. *J Acad Nutr Diet* 2012; 112 (6): 840-9.
57. Bonnet F, Lepicard EM, Cathrin L, Letellier C, Constant F, Hawili N, Friedlander G. French children start their school day with a hydration deficit. *Ann Nutr Metab* 2012; 60 (4): 257-63.
58. Maughan RJ, Shirreffs SM. Hydration and performance during Ramadan. *J Sports Sci* 2012; 30 (Supl. 1): S33-41.
59. Khamnei S, Hosseinlou A, Zamanlu M. Water temperature, voluntary drinking and fluid balance in dehydrated taekwondo athletes. *J Sports Sci Med* 2011 Dec 1; 10 (4): 718-24. eCollection 2011.
60. Shepherd A. Measuring and managing fluid balance. *Nurs Times* 2011 Jul 19-25; 107 (28): 12-6.
61. Carvalho P, Oliveira B, Barros R, Padrão P, Moreira P, Teixeira VH. Impact of fluid restriction and ad libitum water intake or an 8% carbohydrate-electrolyte beverage on skill performance of elite adolescent basketball players. *Int J Sport Nutr Exerc Metab* 2011 Jun; 21 (3): 214-21.
62. Peacock OJ, Stokes K, Thompson D. Initial hydration status, fluid balance, and psychological affect during recreational exercise in adults. *J Sports Sci* 2011 Jun; 29 (9): 897-904.
63. Ely BR, Cheuvront SN, Kenefick RW, Sawka MN. Limitations of salivary osmolality as a marker of hydration status. *Med Sci Sports Exerc* 2011 Jun; 43 (6): 1080-4.
64. Benton D. Dehydration influences mood and cognition: a plausible hypothesis? *Nutrients* 2011 May; 3 (5): 555-73.
65. Tang C, Zelenak C, Völkl J, Eichenmüller M, Regel I, Fröhlich H, Kempe D, Jimenez L, Le Bellego L, Vergne S, Lang F. Hydration-sensitive gene expression in brain. *Cell Physiol Biochem* 2011; 27 (6): 757-68.
66. Borges VT, Rososchansky J, Abbade JF, Dias A, Peraçoli JC, Rudge MV. Effect of maternal hydration on the increase of amniotic fluid index. *Braz J Med Biol Res* 2011 Mar; 44 (3): 263-6. Epub 2011 Jan 21.
67. Wilk B, Timmons BW, Bar-Or O. Voluntary fluid intake, hydration status, and aerobic performance of adolescent athletes in the heat. *Appl Physiol Nutr Metab* 2010 Dec; 35 (6): 834-41.
68. Presse N, Ferland G. [Risk factors contributing to insufficient water intake in elderly living in nursing homes and long-term care units: a review of the literature]. *Can J Diet Pract Res* 2010 Winter; 71 (4): e94-9.
69. Leydon C, Wroblewski M, Eichorn N, Sivasankar M. A meta-analysis of outcomes of hydration intervention on phonation threshold pressure. *J Voice* 2010 Nov; 24 (6): 637-43.
70. Leurs LJ, Schouten LJ, Goldbohm RA, van den Brandt PA. Total fluid and specific beverage intake and mortality due to IHD and stroke in the Netherlands Cohort Study. *Br J Nutr* 2010 Oct; 104 (8): 1212-21.
71. Popkin BM, D'Anci KE, Rosenberg IH. Water, hydration, and health. *Nutr Rev* 2010 Aug; 68 (8): 439-58.
72. Wolf R, Wolf D, Rudikoff D, Parish LC. Nutrition and water: drinking eight glasses of water a day ensures proper skin hydration-myth or reality? *Clin Dermatol* 2010 Jul-Aug; 28 (4): 380-3.
73. Godevithanage S, Kanankearachchi PP, Dissanayake MP, Jayalath TA, Chandrasiri N, Jinasena RP, Kumarasiri RP, Goonasekera CD. Spot urine osmolality/creatinine ratio in healthy humans. *Kidney Blood Press Res* 2010; 33 (4): 291-6.
74. Brizot ML, Liao AW, Nomura RM, Francisco RP, Zugaib M. Changes in amniotic fluid index after maternal oral hydration in pregnancies with fetal gastroschisis: initial observations. *Fetal Diagn Ther* 2010; 28 (2): 87-91.
75. De Francisco AL, Martínez Castelao A; Grupo Investigador Bahía 2008. [The Bahía 2008 Study: hydration barometer in the Spanish population]. *Nefrologia* 2010; 30 (2): 220-6.
76. Thornton SN. Thirst and hydration: physiology and consequences of dysfunction. *Physiol Behav* 2010 Apr 26; 100 (1): 15-21.
77. Armstrong LE, Pumerantz AC, Fiala KA, Roti MW, Kavouras SA, Casa DJ, Maresh CM. Human hydration indices: acute and longitudinal reference values. *Int J Sport Nutr Exerc Metab* 2010 Apr; 20 (2): 145-53.
78. Casa DJ, Stearns RL, Lopez RM, Ganio MS, McDermott BP, Walker Yeargin S, Yamamoto LM, Mazerolle SM, Roti MW, Armstrong LE, Maresh CM. Influence of hydration on physiological function and performance during trail running in the heat. *J Athl Train* 2010 Mar- pr; 45 (2): 147-56.
79. Miller VS, Bates GP. Hydration, hydration, hydration. *Ann Occup Hyg* 2010 Mar; 54 (2): 134-6.
80. Jéquier E, Constant F. Water as an essential nutrient: the physiological basis of hydration. *Eur J Clin Nutr* 2010 Feb;64 (2): 115-23.
81. European Food Safety Authority, EFSA Panel on Dietetic Products, Nutrition, and Allergies. Parma, Italy. 2010; Scientific opinion on dietary reference values for water. *EFSA J* 8: 1459, 48 pp.
82. Hedrick VE, Comber DL, Estabrooks PA, Savla J, Davy BM. The beverage intake questionnaire: determining initial validity and reliability. *J Am Diet Assoc* 2010; 110 (8): 1227-32.
83. Montenegro-Bethancourt G, Vossenaar M, Doak CM, Solomons NW. Total daily water intake in Guatemalan children. *Food Nutr Bull* 2009 Dec; 30 (4): 340-50.
84. Volpe SL, Poule KA, Bland EG. Estimation of prepractice hydration status of National Collegiate Athletic Association Division I athletes. *J Athl Train* 2009 Nov-Dec; 44 (6): 624-9.
85. Edmonds CJ, Burford D. Should children drink more water?: the effects of drinking water on cognition in children. *Appetite* 2009 Jun; 52 (3): 776-9.
86. Thornton SN, Even PC, van Dijk G. Hydration increases cell metabolism. *Int J Obes (Lond).* 2009 Mar; 33 (3): 385; author reply 386.
87. Umenai T, Arai N, Chihara E. Effect of the preliminary hydration on gastric emptying time for water in healthy volunteers. *Acta Anaesthesiol Scand* 2009 Feb; 53 (2): 223-6.
88. Shirreffs SM. Conference on "Multidisciplinary approaches to nutritional problems". Symposium on "Performance, exercise and health". Hydration, fluids and performance. *Proc Nutr Soc* 2009 Feb; 68 (1): 17-22.
89. Rodriguez GJ, Cordina SM, Vazquez G, Suri MF, Kirmani JF, Ezzeddine MA, Qureshi AI. The hydration influence on the risk of stroke (THIRST) study. *Neurocrit Care* 2009; 10 (2): 187-94.
90. Rösler A, Lehmann F, Krause T, Wirth R, Renteln-Kruse W. Nutritional and hydration status in elderly subjects: Clinical rating versus bioimpedance analysis. *Archives of Gerontology and Geriatrics* 2009; 18-22, 22459.
91. Aranceta J, De Torres ML, López Rocha A, Moya M, Pérez Rodrigo C, Serra- Majem L. Guía para una hidratación saludable. La declaración de Zaragoza. SENC, 2008. *Revista Española de Nutrición Comunitaria* 2009; 15 (1): 45-7.
92. Maughan RJ, Shirreffs SM. Development of individual hydration strategies for athletes. *Int J Sport Nutr Exerc Metab* 2008 Oct; 18 (5): 457-72.
93. Weinheimer EM, Martin BR, Weaver CM, Welch JM, Campbell WW. The effect of exercise on water balance in premenopausal physically active women. *J Am Diet Assoc* 2008 Oct; 108 (10): 1662-7.
94. Molloy CJ, Gandy J, Cunningham C, Slattery G. An exploration of factors that influence the regular consumption of water by Irish primary school children. *J Hum Nutr Diet* 2008 Oct; 21 (5): 512-5.
95. Beltrami FG, Hew-Butler T, Noakes TD. Drinking policies and exercise-associated hyponatraemia: is anyone still promoting overdrinking? *Br J Sports Med* 2008 Oct; 42 (10): 796-501.
96. Yamamoto LM, Judelson DA, Farrell MJ, Lee EC, Armstrong LE, Casa DJ, Kraemer WJ, Volek JS, Maresh CM. Effects of hydration state and resistance exercise on markers of muscle damage. *J Strength Cond Res* 2008 Sep; 22 (5): 1387-93.
97. Montain SJ. Hydration recommendations for sport 2008. *Curr Sports Med Rep* 2008 Jul-Aug; 7 (4): 187-92.
98. McKiernan F, Houchins JA, Mattes RD. Relationships between human thirst, hunger, drinking, and feeding. *Physiol Behav* 2008 Aug 6; 94 (5): 700-8.

99. Rivera-Brown AM, Ramírez-Marrero FA, Wilk B, Bar-Or O. Voluntary drinking and hydration in trained, heat-acclimatized girls exercising in a hot and humid climate. *Eur J Appl Physiol* 2008 May; 103 (1): 109-16.
100. Vianna LC, Oliveira RB, Silva BM, Ricardo DR, Araújo CG. Water intake accelerates post- exercise cardiac vagal reactivation in humans. *Eur J Appl Physiol* 2008 Feb; 102 (3): 283-8.
101. Maughan RJ, Watson P, Evans GH, Broad N, Shirreffs SM. Water balance and salt losses in competitive football. *Int J Sport Nutr Exerc Metab* 2007 Dec; 17 (6): 583-94.
102. Stahl A, Kroke A, Bolzenius K, Manz F. Relation between hydration status in children and their dietary profile -results from the DONALD study. *Eur J Clin Nutr* 2007 Dec; 61 (12): 1386-92.
103. Hydration and health promotion. Proceedings of the International Life Sciences Institute North America Conference on Hydration and Health Promotion. November 29-30, 2006. Washington, DC, USA. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 529S-623S.
104. Buyckx ME. Hydration and health promotion: a brief introduction. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 533S-4S.
105. Kenefick RW, Sawka MN. Hydration at the work site. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 597S-603S.
106. Sharp RL. Role of whole foods in promoting hydration after exercise in humans. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 592S-596S.
107. Campbell SM. Hydration needs throughout the lifespan. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 585S-587S.
108. Manz F. Hydration in children. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 562S-569S.
109. Manz F. Hydration and disease. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 535S-541S.
110. Judelson DA, Maresh CM, Farrell MJ, Yamamoto LM, Armstrong LE, Kraemer WJ, Volek JS, Spiering BA, Casa DJ, Anderson JM. Effect of hydration state on strength, power, and resistance exercise performance. *Med Sci Sports Exerc* 2007 Oct; 39 (10): 1817-24.
111. Maughan RJ, Shirreffs SM, Leiper JB. Errors in the estimation of hydration status from changes in body mass. J Sports Sci. 2007 May; 25 (7): 797-804. Erratum in: *J Sports Sci* 2008 Sep; 26 (11): 1245.
112. Ganio MS, Casa DJ, Armstrong LE, Maresh CM. Evidence-based approach to lingering hydration questions. *Clin Sports Med* 2007 Jan; 26 (1): 1-16.
113. Jung AP, Dale RB, Bishop PA. Ambient-temperature beverages are consumed at a rate similar to chilled water in heat-exposed workers. *J Occup Environ Hyg* 2007 Jan; 4 (1): 54-7.
114. Armstrong LE. Assessing Hydration Status: The Elusive Gold Standard. *J Am Coll Nutr* 2007; 26 (5): 575S-584S.
115. Fulgoni VL. Limitations of data on fluid intake. *J Am Coll Nutr* 2007; 26: 588S–591S.
116. D'Anci KE, Constant F, Rosenberg IH. Hydration and cognitive function in children. *Nutr Rev* 2006 Oct; 64 (10 Pt 1): 457-64.
117. Mentes J. Oral hydration in older adults: greater awareness is needed in preventing, recognizing, and treating dehydration. *Am J Nurs* 2006 Jun; 106 (6): 40-9; quiz 50.
118. Martin WF, Cerundolo LH, Pikosky MA, Gaine PC, Maresh CM, Armstrong LE, Bolster DR, Rodriguez NR. Effects of dietary protein intake on indexes of hydration. *J Am Diet Assoc* 2006 Apr; 106 (4): 587-9.
119. Popkin BM, Armstrong LE, Bray GM, Caballero B, Frei B, Willett WC. A new proposed guidance system for beverage consumption in the United States. *Am J Clin Nutr* 2006 Mar; 83 (3): 529-42.
120. Kantarci F, Mihmanli I, Adaletli I, Ozer H, Gulsen F, Kadioglu A, Altug A, Uysal O. The effect of fluid intake on renal length measurement in adults. *J Clin Ultrasound* 2006 Mar-pr; 34 (3): 128-33.
121. Montain SJ, Cheuvront SN, Sawka MN. Exercise associated hyponatraemia: quantitative analysis to understand the aetiology. *Br J Sports Med* 2006 Feb; 40 (2): 98-105; discussion 98-105.
122. Dixon CB, LoVallo SJ, Andreacci JL, Goss FL. The effect of acute fluid consumption on measures of impedance and percent body fat using leg-to-leg bioelectrical impedance analysis. *Eur J Clin Nutr* 2006 Jan; 60 (1): 142-6.
123. Sulyok E. Physical water compartments: a revised concept of perinatal body water physiology. *Physiol Res* 2006; 55 (2): 133-8.
124. Bar-David Y, Urkin J, Kozminsky E. The effect of voluntary dehydration on cognitive functions of elementary school children. *Acta Paediatr* 2005 Nov; 94 (11): 1667-73.
125. Lecerf JM. Hydration and its effects on health. *Servir* 2005 Sep-Oct; 53 (5): 248-54.
126. Okamura K, Washimi Y, Endo H, Tokuda H, Shiga Y, Miura H, Nojiri Y. "Can high fluid intake prevent cerebral and myocardial infarction?" Systematic review. *Nihon Ronen Igakkai Zasshi* 2005 Sep; 42 (5): 557-63.
127. Sullivan RJ Jr. Fluid intake and hydration: critical indicators of nursing home quality. *N C Med J* 2005 Jul-Aug; 66 (4): 296-9.
128. The hydration cart: one way to help ensure adequate fluid intake. *Health Care Food Nutr Focus* 2005 Jul; 22 (7): 9-12.
129. Armstrong LE, Pumerantz AC, Roti MW, Judelson DA, Watson G, Dias JC, Sokmen B, Casa DJ, Maresh CM, Lieberman H, Kellogg M. Fluid, electrolyte, and renal indices of hydration during 11 days of controlled caffeine consumption. *Int J Sport Nutr Exerc Metab* 2005 Jun; 15 (3): 252-65.
130. Manz F, Wentz A. Hydration status in the United States and Germany. *Nutr Rev* 2005 Jun; 63 (6 Pt 2): S55-62.
131. Sawka MN, Cheuvront SN, Carter R 3rd. Human water needs. *Nutr Rev* 2005 Jun; 63 (6 Pt 2): S30-9.
132. Ferry M. Strategies for ensuring good hydration in the elderly. *Nutr Rev* 2005 Jun; 63 (6 Pt 2): S22-9.
133. Holman C, Roberts S, Nicol M. Promoting adequate hydration in older people. *Nurs Older People* 2005 Jun; 17 (4): 31-2.
134. Bossingham MJ, Carnell NS, Campbell WW. Water balance, hydration status, and fat-free mass hydration in younger and older adults. *Am J Clin Nutr* 2005 Jun; 81 (6): 1342-50.
135. Casa DJ, Clarkson PM, Roberts WO. American College of Sports Medicine roundtable on hydration and physical activity: consensus statements. *Curr Sports Med Rep* 2005 Jun; 4 (3): 115-27.
136. Kleiner SM. The art and science of hydration. *Acta Paediatr* 2004 Dec; 93 (12): 1557-8.
137. Von Duvillard SP, Braun WA, Markofski M, Beneke R, Leithäuser R. Fluids and hydration in prolonged endurance performance. *Nutrition* 2004 Jul-Aug; 20 (7-8): 651-6.
138. Hunter ML, Chestnutt IG, Evans SM, Withecombe AC. Fluid for thought: availability of drinks in primary and secondary schools in Cardiff, UK. *Int J Paediatr Dent* 2004 Jul; 14 (4): 267-71.
139. Maresh CM, Gabaree-Boulant CL, Armstrong LE, Judelson DA, Hoffman JR, Castellani JW, Kenefick RW, Bergeron MF, Casa DJ. Effect of hydration status on thirst, drinking, and related hormonal responses during low-intensity exercise in the heat. *J Appl Physiol* (1985). 2004 Jul; 97 (1): 39-44.
140. Shirreffs SM, Merson SJ, Fraser SM, Archer DT. The effects of fluid restriction on hydration status and subjective feelings in man. *Br J Nutr* 2004 Jun; 91 (6): 951-8.
141. Kalhoff H. Mild dehydration: a risk factor of broncho-pulmonary disorders? *Eur J Clin Nutr* 2003 Dec; 57 (Supl. 2): S81-7.
142. Keller U, Szinnai G, Bilz S, Berneis K. Effects of changes in hydration on protein, glucose and lipid metabolism in man: impact on health. *Eur J Clin Nutr* 2003 Dec; 57 (Supl. 2): S69-74.
143. Beetz R. Mild dehydration: a risk factor of urinary tract infection? *Eur J Clin Nutr* 2003 Dec; 57 (Supl. 2): S52-8.
144. Bouby N, Fernandes S. Mild dehydration, vasopressin and the kidney: animal and human studies. *Eur J Clin Nutr* 2003 Dec; 57 (Supl. 2): S39-46.
145. Manz F, Wentz A. 24-h hydration status: parameters, epidemiology and recommendations. *Eur J Clin Nutr* 2003 Dec; 57 (Supl. 2): S10-8.
146. Maughan RJ, Griffin J. Caffeine ingestion and fluid balance: a review. *J Hum Nutr Diet* 2003 Dec; 16 (6): 411-20.
147. Grandjean AC, Reimers KJ, Buyckx ME. Hydration: issues for the 21st century. *Nutr Rev* 2003 Aug; 61 (8): 261-71.
148. Laaksonen DE, Nuutinen J, Lahtinen T, Rissanen A, Niskanen LK. Changes in abdominal subcutaneous fat water content with rapid weight loss and long-term weight maintenance in abdominally obese men and women. *Int J Obes Relat Metab Disord* 2003 Jun; 27 (6): 677-83.

149. Hodgkinson B, Evans D, Wood J. Maintaining oral hydration in older adults: a systematic review. *Int J Nurs Pract* 2003 Jun; 9 (3): S19-28.
150. Shirreffs SM . Markers of hydration status. *European Journal of Clinical Nutrition* 2003; 57 (Supl. 2): S6–S9.
151. Manz F, Wentz A, Sichert-Hellert W. The most essential nutrient: defining the adequate intake of water. *J Pediatr* 2002 Oct; 141 (4): 587-92.
152. Malhotra B, Deka D. Effect of maternal oral hydration on amniotic fluid index in women with pregnancy-induced hypertension. *J Obstet Gynaecol Res* 2002 Aug; 28 (4): 194-8.
153. Ainslie PN, Campbell IT, Frayn KN, Humphreys SM, MacLaren DP, Reilly T, Westerterp KR. Energy balance, metabolism, hydration, and performance during strenuous hill walking: the effect of age. *J Appl Physiol* (1985). 2002 Aug; 93 (2): 714-23.
154. Gardner JW. Death by water intoxication. *Mil Med* 2002 May; 167 (5): 432-4.
155. Grandjean AC, Reimers KJ, Haven MC, Curtis GL. The effect on hydration of two diets, one with and one without plain water. *J Am Coll Nutr* 2003 Apr; 22 (2): 165-73.
156. Arnaud MJ. Age-related changes in hydration. *Nestle Nutr Workshop Ser Clin Perform Programme* 2002; 6: 193-205; discussion 205-6.
157. Oppliger RA, Bartok C. Hydration testing of athletes. *Sports Med* 2002; 32 (15): 959-71.
158. Kavouras SA. Assessing hydration status. *Curr Opin Clin Nutr Metab Care* 2002; 5 (5): 519-24.
159. Peyreigne C, Bouix D, Fédou C, Mercier J. Effect of hydration on exercise-induced growth hormone response. *Eur J Endocrinol* 2001 Oct; 145 (4): 445-50.
160. Coen G, Sardella D, Barbera G, Ferrannini M, Comegna C, Ferazzoli F, Dinnella A, D'Anello E, Simeoni P. Urinary composition and lithogenic risk in normal subjects following oligomineral versus bicarbonate-alkaline high calcium mineral water intake. *Urol Int* 2001; 67 (1): 49-53.
161. Sawka MN, Montain SJ, Latzka WA. Hydration effects on thermoregulation and performance in the heat. *Comp Biochem Physiol A Mol Integr Physiol* 2001 Apr; 128 (4): 679-90.
162. Grandjean AC, Reimers KJ, Bannick KE, Haven MC. The effect of caffeinated, non-caffeinated, caloric and non-caloric beverages on hydration. *J Am Coll Nutr* 2000 Oct; 19 (5): 591-600.
163. Burke ER. Healthy hydration. *Occup Health Saf* 2000 May; 69 (5): 52-4.
164. Kovacs EM, Senden JM, Brouns F. Urine color, osmolality and specific electrical conductance are not accurate measures of hydration status during postexercise rehydration. *J Sports Med Phys Fitness* 1999 Mar; 39 (1): 47-53.
165. Rivera-Brown AM, Gutiérrez R, Gutiérrez JC, Frontera WR, Bar-Or O. Drink composition, voluntary drinking, and fluid balance in exercising, trained, heat-acclimatized boys. *J Appl Physiol* (1985). 1999 Jan; 86 (1): 78-84.
166. Sawka MN, Latzka WA, Matott RP, Montain SJ. Hydration effects on temperature regulation. *Int J Sports Med* 1998 Jun; 19 (Supl. 2): S108-10.
167. Armstrong LE, Maresh CM, Gabaree CV, Hoffman JR, Kavouras SA, Kenefick RW, Castellani JW, Ahlquist LE. Thermal and circulatory responses during exercise: effects of hypohydration, dehydration, and water intake. *J Appl Physiol* (1985). 1997 Jun; 82 (6): 2028-35.
168. Piccoli A, Piazza P, Noventa D, Pillon L, Zaccaria M. A new method for monitoring hydration at high altitude by bioimpedance analysis. *Med Sci Sports Exerc* 1996 Dec; 28 (12): 1517-22.
169. Brizzolara A, Barbieri MP, Adezati L, Viviani GL. Water distribution in insulin-dependent diabetes mellitus in various states of metabolic control. *Eur J Endocrinol* 1996 Nov; 135 (5): 609-15.
170. Convertino VA, Armstrong LE, Coyle EF, Mack GW, Sawka MN, Senay LC Jr, Sherman WM. American College of Sports Medicine position stand. Exercise and fluid replacement. *Med Sci Sports Exerc* 1996 Jan; 28 (1): i-vii.
171. Dowd TT, Campbell JM, Jones JA. Fluid intake and urinary incontinence in older community-dwelling women. *J Community Health Nurs* 1996; 13 (3): 179-86.
172. O'Brien C, Freund BJ, Sawka MN, McKay J, Hesslink RL, Jones TE. Hydration assessment during cold-weather military field training exercises. *Arctic Med Res* 1996 Jan; 55 (1): 20-6.
173. Greenleaf JE, Jackson CG, Lawless D. CD4+/CD8+ T-lymphocyte ratio: effects of rehydration before exercise in dehydrated men. *Med Sci Sports Exerc* 1995 Feb; 27 (2): 194-9.
174. Armstrong LE, Maresh CM, Castellani JW, Bergeron MF, Kenefick RW, LaGasse KE, Riebe D. Urinary indices of hydration status. *Int J Sport Nutr* 1994 Sep; 4 (3): 265-79.
175. Kilpatrick SJ, Safford KL. Maternal hydration increases amniotic fluid index in women with normal amniotic fluid. *Obstet Gynecol* 1993 Jan; 81 (1): 49-52.
176. Horber FF, Thomi F, Casez JP, Fonteille J, Jaeger P. Impact of hydration status on body composition as measured by dual energy X-ray absorptiometry in normal volunteers and patients on haemodialysis. *Br J Radiol* 1992 Oct; 65 (778): 895-900.
177. Adan A. Cognitive performance and dehydration. *J Am College of Nut* 2012;31 (2): 71-8.
178. Hamilton MT, González-Alonso J, Montain SJ, Coyle EF. Fluid replacement and glucose infusion during exercise prevents cardiovascular drift. *J Appl Physiol* 1991; 71: 871-7.
179. González-Alonso J, Heaps CL, Coyle EF. Rehydration after exercise with common beverages and water. *Int J Sports Med* 1992; 13: 399-406.
180. Heaps CL, González-Alonso J, Coyle EF. Hypohydration causes cardiovascular drift without reducing blood volume. *Int J Sports Med* 1994; 15: 74-9.
181. Below PR, González-Alonso J, Mora-Rodríguez R, Coyle EF. Fluid and carbohydrate ingestion individually benefit intense exercise lasting one-hour. *Med Sci Sports Exerc* 1995; 27: 200-10.
182. González-Alonso J, Mora-Rodríguez R, Coyle EF. Dehydration markedly impairs cardiovascular function in hyperthermic endurance athletes during exercise. *J Appl Physiol* 1997; 82: 1229-36.
183. González-Alonso J, Dalsgaard MK, Osada T, Volianitis S, Dawson EA, Yoshiga CC, Secher NH. Brain and central haemodynamics and oxygenation during maximal exercise in humans. *J Physiol* 2004; 557: 331-42.
184. González-Alonso J. Hyperthermia impairs brain, heart and muscle function in exercising humans. *Sports Med* 2007; 37: 371-3.
185. González-Alonso J, Crandall CG, Johnson JM.The cardiovascular challenge of exercising in the heat. *J Physiol* 2008; 586: 45-53.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):13-19
ISSN 1135-3074

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

María José Soto-Méndez[1,2], Raquel Campos-Oliva[1], Concepción María Aguilera[2], Noel W. Solomons[1], Klaus Schümann[3] and Ángel Gil[2]

[1]Centre for the Studies of Sensory Impairment, Aging, and Metabolism –CeSSIAM- Guatemala City, Guatemala. [2]Department of Biochemistry and Molecular Biology II, Institute of Nutrition and Food Technology, Centre of Biomedical Research, University of Granada, Granada, Spain. [3]Molecular Nutrition Unit, ZIEL, Research Centre for Nutrition and Food Science, Technische Universität München, Freising, Germany.

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 -80º, 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 mlL; 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 (-80ºC), 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.*

Correspondence: María José Soto Méndez.
Centre for the Studies of Sensory Impairment, Aging, and Metabolism - CeSSIAM
Guatemala City. Guatemala.
E-mail: clinicanutricion@gmail.com

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 nutrient[1]. 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 disease[2]. 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 proposition[3]. Manz[4] 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 volumes[5]. 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 challenge[13].

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 km^2 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 cultures[14]. 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 world[15]. 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 km^2 and 24 municipalities[16]; 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. Amost 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 0ºC 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 -80ºC in an ultra-cold freezer in Guatemala City. One of those specimens was shipped to Granada, Spain, on dry ice and stored at -80ºC 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 transferredto the measurement vessels for the Löser osmometer and the Osmomat model, respectively. Results are expressed in milliosmoles per kilogram of urine (mOms/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 Remer[17] 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 criterion[17] ($p = 0.120$), 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 = 0.0.025), 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 0ºC 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 Osomat 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 adults[18-21] 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 study[17] 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 study[8] 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

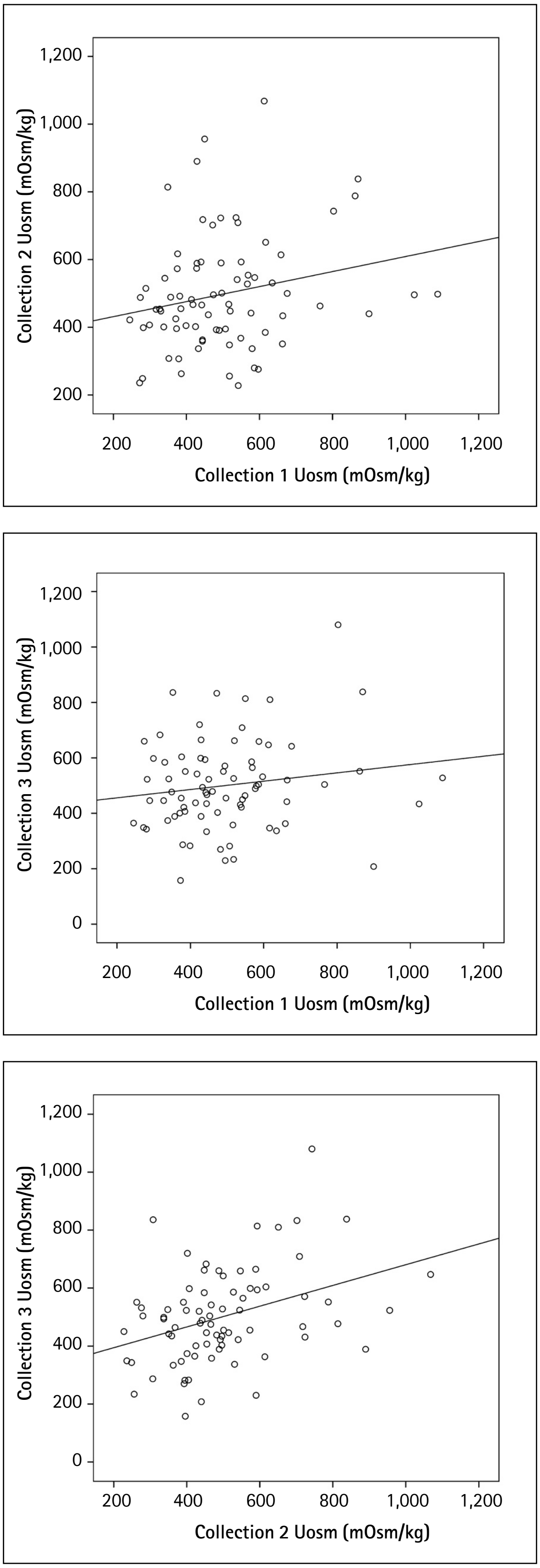


Fig. 1.—Association or Urinary Osmolality Measurement Between Collections.

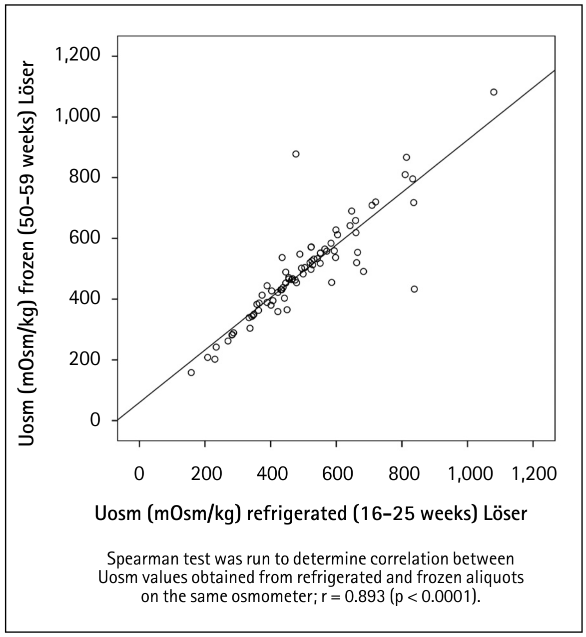


Fig. 2.—Comparison of Urinary Osmolality Measurements between Zero- and minus Eighty-degree Storage Temperatures, Third Collection Specimens.

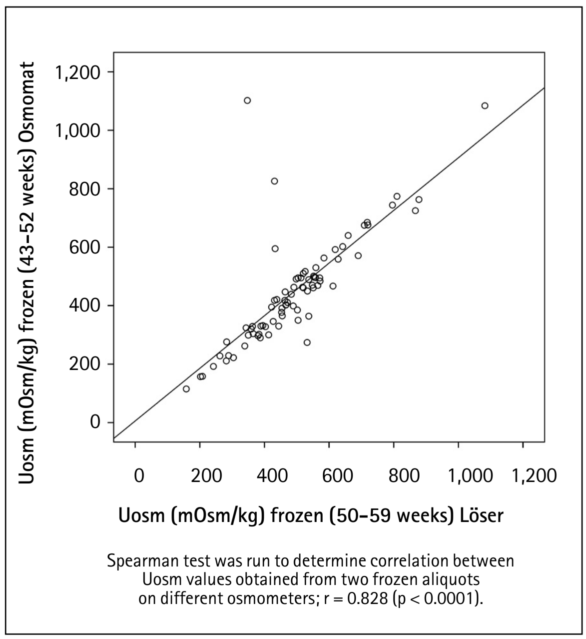


Fig. 3.—Comparison of Urinary Osmolality Measurements between Osmometers in Deep-Frozen, Third Collection Specimens.

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 distortionof 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.

Acknowledgements

We thank FINUT of Granada, Spain, and the Hildegard Grunow-Foundation of Munich, Germany, for funding. We are grateful to Dr. Randall Lou for arranging for the measurement of urinary creatinine through Fundación del Niño Enfermo Renal (FUNDANIER). Our appreciation go to Victoria Pérez, Jeniece Alvey and Maria Eugenia Romero-Abal from CeSSIAM; also to daycare centre's personnel and parents from the SOSEP community for their assistance with collection of urine.

References

1. Manz F, Wentz A, Sichert-Hellert W. The most essential nutrient: Defining the adequate intake of water. *J Pediatr* 2002; 141 (4): 587–92.
2. Kleiner S. Water: An essential but overlooked nutrient. *J Am Diet Assoc* 1999; 99: 200–6.
3. Armstrong LE. Assessing hydration status: the elusive gold standard. *J Am Coll Nutr* 2007 Oct; 26 (Supl. 5): 575S–584S.
4. Manz F, Wentz A. 24-H Hydration Status: Parameters, Epidemiology and Recommendations. *Eur J Clin Nutr* 2003 Dec; 57 (Supl. 2): S10–8.
5. Bockenhauer D, Aitkenhead H. The kidney speaks: interpreting urinary sodium and osmolality. *Arch Dis Child Educ Pr Ed* 2011; 96 (6): 233–7.
6. Robers F, Manz F. For liquid supply in childhood. *Sozialpäd. KiPra* 1996; 18: 85–9.
7. Remer T, Fonteyn N, Alexy U, Berkemeyer S. Longitudinal examination of 24-h urinary iodine excretion in schoolchildren as a sensitive, hydration status-independent research tool for studying iodine status. *Am J Clin Nutr* 2006 Mar; 83 (3): 639–46.
8. Stolley H, Schlage C. Water balance and water requirement of preschool children. *Nutr Metab* 1977; 21 (Supl. 1): 15–7.
9. Phillip M, Singer A, Chaimovitz C, Golinsky D. Urine osmolality in nursery school children in a hot climate. *Isr J Med Sci* 1993; 29.
10. Chaptal J, Jean R, Guillaumot R, Morel G. Etude statistique de l'elimination urinaire des electrolytes chez l'enfant normal a differents ages. *J Pediatr* 1963; 20: 905–31.
11. Rittig S, Knudsen U, Norgaard J, Pedersen E, Djurhuus J. Abnormal diurnal rhythm of plasma vasopressin and urinary output in patients with enuresis. *Am J Physiol* 1989; 256: F664–F671.
12. VandeWalle J, Thijs J, VanLaecke E, Hoebeke P. Nocturnal enuresis related to the abnormalities of the nycthemeral rhythm of diuresis on renal function and salt handling and bladder dysfunction. *Pediatr Nephrol* 2000; 14: C61.
13. Crofton P, Squires N, Davidson D, Henderson P, Taheri S. Reliability of urine collection pads for routine and metabolic biochemistry in infants and young children. *Eurpean J Pediatr* 2008; 167 (11): 1313–9.
14. FAO. Guatemala, información sobre el país. 2010. Available from: http://coin.fao.org/cms/world/guatemala/InformaccionSobreElPais.html
15. Urcullo G, Bitran R. Sinergias entre educación, salud y nutrición en Guatemala. 1993. USAID Bitrán & Asociados para PHRplus: 1-8.
16. Municipalidad de Quetzaltenango. Quetzaltenango en la Historia. 2008. Available from: http://www.muniquetzaltenango.com/newsite/historia/
17. 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.
18. Hamouti N, Del Coso J, Avila A, Mora-Rodriguez R. Effects of athletes' muscle mass on urinary markers of hydration status. *Eur J Appl Physiol* 2010; 109 (2): 213–9.
19. Utter A, Quindry J, Emerenziani G, Valiente J. of rooibos tea, bottled water, and a carbohydrate beverage on blood and urinary measures of hydration after acute dehydration. *Res Sport Med* 2010; 18 (2): 85–96.
20. Godevithanage S, Kanankearachchi P, Dissanayake M, Jayalath T, Chandrasiri N, Jinasena R, et al. Spot urine osmolality/creatinine ratio in healthy humans. *Kidney Blood Press Res* 2010; 33 (4): 291–6.
21. Peacock O, Stokes K, Thompson D. Initial hydration status, fluid balance, and psychological affect during recreational exercise in adults. *J Sport Sci* 2011; 29 (9): 897–904.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):20-25
ISSN 1135-3074

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

Bricia López Plaza[1], Thabata Koester Weber[1], Laura María Bermejo López[1], Samara Palma Milla[1], Dolores Sarrión[2], María José Ariza Astolfi[2] and Carmen Gómez Candela[1]

[1]Nutrition Department. [2]Gastroenterology Department. La Paz University Hospital. Institute for Health Research (IdiPAZ). University Autonoma of Madrid. Spain.

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.

Objetive: 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/m^2. HS was measured by bioelectrical impedance (BIA) with a standarized 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-sensible 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/m^2. The average intake of water from foods and beverages was not adequate enough (1,411.6 ± 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 IFNγ (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 ± 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.*

Correspondence: Bricia López Plaza.
Research Unit.
La Paz University Hospital.
Paseo de la Castellana, 261.
28046 Madrid.
E-mail: bricia.plaza@idipaz.es

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 homesostasis 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/m^2. 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 ± 4,9 años y el IMC fue de 28,2 ± 4,7 kg/m^2. El consumo medio de agua proveniente de los alimentos y las bebidas realizado por los participantes no fué suficiente (1.411,6 ± 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 IFNγ (2,7 ± 2,4 *vs* 6,4 ± 4,3 pg/ml; $p < 0,05$) e IL6 séricos (5,5 ± 13,3 *vs* 6,4 ± 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 ± 615 *vs* 1194,0 ± 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 bioimpedacnia.*

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 metabolism[1]. 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-threatening[4].

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 deficit[5]. Mild levels of dehydration can produce disruptions in mood and cognitive functioning[6] 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 infarct[7]. Some of these diseases present a low-grade inflammation which plays a role in their evolution[8]. 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 hypovolemia[9]. It has been observed that some pro-inflammatory cytokines as TNFα induced weight loss in mice due, at least in part, to dehydration[10]. Even thought there is some evidence that dehydration stimulus can increase pro-inflammatory cytokines in animals[11], 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/m^2 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 declaration[12]. 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, Fl, 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 dehydraton 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-

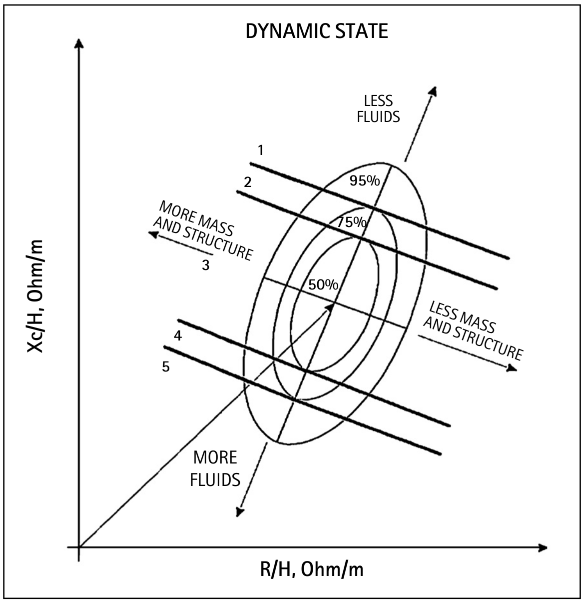


Fig. 1.—Classification of hydration status by Standardized Biovectornormogram.

dized protocol and IFNγ, IL10, IL1β, IL6, MCP1 and TNFα 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 TGFβ (TGFB-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 ultracentrifuged 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) × 100/energy expenditure[13]. 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 ± 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 ± 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 ± 539.1 ml/day. In this sense the underreporting of the diet was 8.2 ± 11.2% without significant differences between groups.

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

Variable	*Hydrated*	*Well hydrated*
n (%)	77 (89.9)	9 (10.5)
Age (years)	51.4 ± 5.1	50.1 ± 2.3
Weight (kg)	76.9 ± 15.3	68.9 ± 14.6
BMI (kg/m²)	28.4 ± 4.5	26.3 ± 5.7
Normal (%)	27.3	44.5
Overweight (%)	39	33.3
Obesity (%)	33.7	22.2
Water Consumption (ml)	1,412 ± 442	1,406 ± 287
Recommended intake (RI) (ml)	2,691 ± 537	2,411 ± 513
RI Contribution (%)	60.2 ± 15	54 ± 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 ± SD)

Variable	*Well Hydrated*	*Dehydrated*
TGFβ (pg/ml)	34,037.83 ± 8,368.69	31,096.67 ± 11,408.49
IL10 (pg/ml)	3.79 ± 9.87	4.72 ± 4.72
IFNγ (pg/ml)	2.75 ± 2.5	6.48 ± 4.37*
IL1β (pg/ml)	2.85 ± 5.51	1.85 ± 1.21
IL6 (pg/ml)	3.94 ± 2.27	15.86 ± 33.95**
MCP1 (pg/ml)	257.48 ± 827.5	700.44 ± 357.52°
TNFα (pg/ml)	24.12 ± 38.96	26.1 ± 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 ± SD)

Variable	*Well Hydrated*	*Dehydrated*
IL10 (pg/ml)	1.99 ± 1.63	2.51 ± 1.03
IL4 (pg/ml)	8.2 ± 8.26	6.56 ± 4.45
IL2 (pg/ml)	13.57 ± 24.94	9.83 ± 6.31
IL6 (pg/ml)	6.45 ± 16.35	5.57 ± 13.38
IL8 (pg/ml)	3.44 ± 14.56	2.78 ± 2.89
VEGF (pg/ml)	167.47 ± 261.99	238.3 ± 184.96
IFNγ (pg/ml)	2.57 ± 3.99	1.93 ± 1.81
TNFα (pg/ml)	9.34 ± 6.96	12.71 ± 5.06
IL1α (pg/ml)	648.34 ± 615.88	1,194.01 ± 561.25*
IL1β (pg/ml)	11.66 ± 36.16	11.91 ± 16.29
MCP1 (pg/ml)	9.36 ± 21.62	8.12 ± 8.03
EGF (pg/ml)	30.27 ± 89.67	20.36 ± 41.28

Significant differences between groups: *p < 0.05.

Otherwise, volunteers who had a good hydration status showed lower values of IFNγ (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 poor hydration status (table II). Serum monocyte chemotactic protein-1 (MCP1) presented the same tendency (257.4 ± 827.7 *vs* 700 ± 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 TGFβ 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 IL1α than those dehydrated (648.3 ± 615 *vs* 1,194.0 ± 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.

Discusion

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 mechanism[14]. Even thought 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 procedures[15]. BIA is easy, non-invasive, and relatively inexpensive and can be performed in almost any subject because it is portable. Using a standardized biovectornormogram 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 models[16]. 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 consumption 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 where 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 consume 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 exposure[17] on a basic underlying pattern of consumption. Although the total water consumption was below the recommendation used, which was made according to actual body weigh, and this was higher than showed in another studies in Spain[18] 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 (IFNγ and IL6) than those poor hydrated. It has well known that inflammation is a potential mechanism linking obesity[21]. 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 mediators[22]. 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/m^2 without abnormal hydration[23]. 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 animals[11]. 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 hormone[24]. In this study, IL1α 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.

References

1. Ritz P, Berrut G. The importance of good hydration for day-to-day health. *Nutr Rev* 2005; 63 (6 Pt 2): S6-13.
2. Lohman TG. Applicability of body composition techniques and constants for children and youths. *Exerc Sport Sci Rev* 1986; 14: 325-57.
3. Wang Z, Deurenberg P, Wang W, Pietrobelli A, Baumgartner RN, Heymsfield SB. Hydration of fat-free body mass: review and critique of a classic body-composition constant. *Am J Clin Nutr* 1999; 69: 833-41.

4. Naghii MR. The significance of water in sport and weight control. *Nutr Health* 2000; 14 (2): 127-32.
5. Popkin BM, D'Anci KE, Rosenberg IH. Water, hydration, and health. *Nutr Rev* 2010; 68 (8): 439-58.
6. Benton D. Dehydration influences mood and cognition: a plausible hypothesis? *Nutrients* 2011; 3 (5): 555-73.
7. Manz F, Wentz A. The importance of good hydration for the prevention of chronic diseases. *Nutr Rev* 2005; 63 (6 Pt 2): S2-5.
8. Schiffrin EL. Immune mechanisms in hypertension and vascular injury. *Clin Sci* (Lond) 2014; 126 (4): 267-74.
9. Luz PA, Andrade L, Miranda N, Pereira V, Fregoneze J, De Castro e Silva E. Inhibition of water intake by the central administration of IL-1beta in rats: role of the central opioid system. *Neuropeptides* 2006; 40 (2): 85-94.
10. Mahony SM, Tisdale MJ. Reversal of weight loss induced by tumour necrosis factor-alpha. *Cancer Lett* 1989; 45 (3): 167-72.
11. Ghorbel MT, Sharman G, Leroux M, Barrett T, Donovan DM, Becker KG, Murphy D. Microarray analysis reveals interleukin-6 as a novel secretory product of the hypothalamo-neurohypophyseal system. *J Biol Chem* 2003: 23; 278 (21): 19280-5.
12. WMA. Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects. World Medical Association: Seoul, Korea, 2008.
13. Johnson RK, Goran MI, Poehlman ET. Correlates of over and under-reporting of energy intake in healthy older men and women. *Am J Clin Nutr* 1994; 59: 1286-90.
14. Armstrong LE. Assessing hydration status: The elusive gold standard. *J Am Coll Nutr* 2007; 26: 575S–784S.
15. Kyle UG, Bosaeus I, De Lorenzo AD et al. Bioelectrical impedance analysis-part I: review of principles and methods. *Clin Nutr* 2004; 23 (5): 1226-43.
16. Piccoli A, Pillon L, Dumler F. Impedance vector distribution by sex, race, body mass index, and age in the United States: standard reference intervals as bivariate Z scores. *Nutrition* 2002; 18: 153–67.
17. Fulgoni VL. Limitations of data on fluid intake. *J Am Coll Nutr* 2007; 26: 588S–591S.
18. Spanish Agency for Food Safety and Nutrition 2011. Encuesta Nacional de Ingesta Dietética Española (ENIDE). AESAN. Available at: http://www.aesan.msc.es. Accessed on January 2012.
19. De Vriese S, Huybrechts I, Moreau M, van Oyen H. 2006. De Belgische Voedselconsumptiepeiling 1-2004. Reports No. 2006-016. Brussels: Scientific Institute of Public Health/Epidemiology Unit Karlsruhe: Bundesforschungsinstitut für Ernhrung und Lebensmittel (Federal Research Institute for Nutrition and Food). 280 pp.
20. Max Rubner-Institut. Nationale Verzehrsstudie II. Ergebnisbericht Teil 2. Die bundesweite Befragung zur Ernährung von Jugendlichen und Erwachsenen (National Food Intake Study II. Results Part 2. Country-wide assessment of nutrition in adolescents and adults) 2008.
21. Phillips CM, Perry IJ. Does inflammation determine metabolic health status in obese and nonobese adults? *J Clin Endocrinol Metab* 2013; 98 (10): E1610-9.
22. Odegaard JI, Chawla A. Mechanisms of macrophage activation in obesity-induced insulin resistance. *Nat Clin Pract Endocrinol Metab* 2008; 4 (11): 619–26.
23. Kyle UG, Bosaeus I, De Lorenzo AD et al. Bioelectrical impedance analysis-part II: utilization in clinical practice. *Clin Nutr* 2004; 23 (6): 1430-53.
24. Sandle GI, Keir MJ, Record CO. The effect of hydrocortisone on the transport of water, sodium, and glucose in the jejunum. Perfusion studies in normal subjects and patients with coeliac disease. *Scand J Gastroenterol* 1981; 16 (5): 667–71.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):26-33
ISSN 1135-3074

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

Ana María López-Sobaler[1,2], Napoleón Pérez-Farinós[3,4], Carmen Villar Villalba[3], Liliana Guadalupe González-Rodríguez[2,5] and Rosa María Ortega Anta[1,2]

[1]Department of Nutrition. Faculty of Pharmacy. Complutense University of Madrid. Spain. [2]UCM Research Group VALORNUT (920030). Department of Nutrition. Faculty of Pharmacy. Complutense University of Madrid. Spain. [3]Spanish Agency for Food Safety and Nutrition (AESAN). Ministry of Health, Social Services and Equality. Madrid. Spain. [4]Department of Preventive Medicine and Public Health. Faculty of Medicine. Complutense University of Madrid. Spain. [5]Faculty of Health Sciences. Alfonso X El Sabio University. Villanueva de la Cañada. Madrid. Spain.

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 SSB 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.*

Correspondence: Ana M. López Sobaler.
Departamento de Nutrición.
Facultad de Farmacia. UCM.
Ciudad Universitaria, s/n.
28040 Madrid.
E-mail: asobaler@ucm.es

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

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 si 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 world[1]. In Spain 18.3% of the schoolchildren between 6 and 9 years of age are obese[2]. 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 reviews[5-7]. However, not all studies have observed this association or conclude that the results are still inconsistent[7-9].

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 beverages[12].

Only few studies have analyzed the determinants of soft drink consumption in schoolchildren[13], 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 described[2]. 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 countries[14].

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) is 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, precision 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 followed[15]. Body mass index (BMI) was calculated thus: BMI = Weight (kg)/height^2 (m^2). The prevalence of overweight and obesity was determined to using WHO growth standards[16].

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 criteria[17]. 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 Kolgomorov-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 Chi^2 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/m²), 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/day[12].

In our study boys consumed SSD more frequently than girls. This was also observed in other studies in adults[22] 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

	Never drinkers (n = 3,781)	*Occasionally drinkers (n = 2,603)*	*Frequent drinkers (n = 685)*	*p**
Children data				
Age (y), mean ± SD	7.48 ± 1.11[a]	7.58 ± 1.13[b]	7.61 ± 1.12[b]	< 0.001
Weight (kg), mean ± SD	30.14 ± 7.4	30.66 ± 7.66	30.26 ± 7.72	0.520
Height (cm), mean ± SD	129.19 ± 8.53[a]	129.75 ± 8.59[b]	129.66 ± 8.45[a,b]	0.003
Waist (cm), mean ± SD	60.43 ± 7.55	60.88 ± 7.77	60.63 ± 7.67	0.097
Hip (cm), mean ± SD	70.92 ± 7.94	71.33 ± 8.16	70.63 ± 8.01	0.513
BMI (kg/m^2), mean ± SD	17.85 ± 2.88	17.99 ± 2.93	17.77 ± 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 Chi^2 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 USA[19], but disagree with other performed in a group of similar age[18]. 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 adolescents[30]. 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 diabetes[31].

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 capacity[6]. Some authors suggest that children drinking SSB on a regular basis intake a 17% to 20% more calories[9], and Cullen et al.[32] found that children between 9 and 12 years of age in the third tertil 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 boys[35]. 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 groups[36].

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*				
	Never drinkers (n = 3,781)	*Occasionally drinkers (n = 2,603)*	*Frequent drinkers (n = 685)*	*p**
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/m²), 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/m2), 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 Chi^2 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 obesity[9], and suggest that a higher control of the exposure of children to television can be an effective measure to improve the drinking habits in children[20].

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 children[40].

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 offspring[34]. For example, children aged 18 months with smoker mothers are more likely to drink SSD[44]. Children of mothers and fathers who smoke followed less healthy diets[45]. 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 adolescents[27]. It has been suggested that the level of education of the parents is likely to influence literacy, knowledge on nutrition, and health-related behaviour[48]. 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 household[51], while soft drink availability at home and parental soft drink consumption seem the strongest factors associated with soft drink consumption in children[52].

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.

Acknowledgements

The present study was supported by the AESAN (Spanish Agency for Food and Nutritional Safety, Spanish Ministry of Health and Consumer Affairs, Spain) (Expte.2010-030013). UCM Research Group VALORNUT (920030) was supported by the "Research Funding Program for Consolidated Groups Santander-UCM" (Ref: GR35/10-A).

Conflicts of interest

None.

References

1. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. *Int J Pediatr Obes* 2006; 1: 11-25.
2. Pérez-Farinós N, López-Sobaler AM, Dal Re MA et al. The ALADINO study: a national study of prevalence of overweight and obesity in Spanish children in 2011. *Biomed Res Int* 2013. p. 163687.
3. Raben A, Vasilaras TH, Moller AC et al. Sucrose compared with artificial sweeteners: different effects on ad libitum food intake and body weight after 10 wk of supplementation in overweight subjects. *American Journal of Clinical Nutrition* 2002; 76: 721-9.
4. Mourao DM, Bressan J, Campbell WW et al. Effects of food form on appetite and energy intake in lean and obese young adults. *Int J Obes* (Lond) 2007; 31: 1688-95.
5. Malik VS, Pan A, Willett WC et al. Sugar-sweetened beverages and weight gain in children and adults: a systematic review and meta-analysis. *American Journal of Clinical Nutrition* 2013; 98: 1084-102.
6. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. *American Journal of Clinical Nutrition* 2006; 84: 274-288.
7. Pérez-Morales E, Bacardi-Gascón M, Jiménez-Cruz A. Sugar-sweetened beverage intake before 6 years of age and weight or BMI status among older children; systematic review of prospective studies. *Nutr Hosp* 2013; 28: 47-51.
8. Gibson S, Neate D. Sugar intake, soft drink consumption and body weight among British children: further analysis of National Diet and Nutrition Survey data with adjustment for under-reporting and physical activity. *Int J Food Sci Nutr* 2007; 58: 445-60.
9. Forshee RA, Anderson PA, Storey ML. Sugar-sweetened beverages and body mass index in children and adolescents: a meta-analysis. American Journal of Clinical Nutrition 2008; 87: 1662-71.
10. Popkin BM. Patterns of beverage use across the lifecycle. *Physiol Behav* 2010; 100: 4-9.
11. Bleich SN, Wang YC, Wang Y et al. Increasing consumption of sugar-sweetened beverages among US adults: 1988-1994 to 1999-2004. *American Journal of Clinical Nutrition* 2009; 89: 372-81.
12. Duffey KJ, Huybrechts I, Mouratidou T et al. Beverage consumption among European adolescents in the HELENA study. *European Journal of Clinical Nutrition* 2012; 66: 244-52.
13. Van der Horst K, Oenema A, Ferreira I et al. A systematic review of environmental correlates of obesity-related dietary behaviors in youth. *Health Educ Res* 2007; 22: 203-26.
14. WHO Regional Office for Europe (2012) European Childhood Obesity Surveillance Initiative (COSI). http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/activities/monitoring-and-surveillance/who-european-childhood-obesity-surveillance-initiative-cosi
15. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. Geneva: World Health Organization. Technical Report Series 854, 1995.
16. De Onis M, Onyango AW, Borghi E et al. Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization* 2007; 85: 660-7.
17. WHO. Programme of Nutrition, Family and Reproductive Health. Obesity. Preventing and managing the global epidemic. report of a WHO consultation on obesity. Geneva, 3-5 June, 1997, [WH Organization, editor]. Geneva: World Health Organization, 1998.
18. DeBoer MD, Scharf RJ, Demmer RT. Sugar-Sweetened Beverages and Weight Gain in 2-to 5-Year-Old Children. *Pediatrics* 2013; 132: 413-20.
19. Striegel-Moore RH, Thompson D, Affenito SG et al. Correlates of beverage intake in adolescent girls: the National Heart, Lung, and Blood Institute Growth and Health Study. *J Pediatr* 2006; 148: 183-7.
20. Grimm GC, Harnack L, Story M. Factors associated with soft drink consumption in school-aged children. *J Am Diet Assoc* 2004; 104: 1244-9.
21. Jensen BW, Nichols M, Allender S et al. Consumption patterns of sweet drinks in a population of Australian children and adolescents (2003-2008). *Bmc Public Health* 2012; 12: 771.
22. French S, Rosenberg M, Wood L et al. Soft drink consumption patterns among Western Australians. *J Nutr Educ Behav* 2013; 45: 525-32.
23. Pabayo R, Spence JC, Cutumisu N et al. Sociodemographic, behavioural and environmental correlates of sweetened beverage

consumption among pre-school children. *Public Health Nutrition* 2012; 15: 1338-46.
24. Forshee RA, Storey ML. Total beverage consumption and beverage choices among children and adolescents. *Int J Food Sci Nutr* 2003; 54: 297-307.
25. Harnack L, Stang J, Story M. Soft drink consumption among US children and adolescents: nutritional consequences. *J Am Diet Assoc* 1999; 99: 436-41.
26. Bere E, Glomnes ES, Velde SJ et al. Determinants of adolescents' soft drink consumption. *Public Health Nutrition* 2008; 11: 49-56.
27. Vereecken CA, Inchley J, Subramanian SV et al. The relative influence of individual and contextual socio-economic status on consumption of fruit and soft drinks among adolescents in Europe. *Eur J Public Health* 2005; 15: 224-32.
28. Lien N, Jacobs DR, Jr., Klepp KI. Exploring predictors of eating behaviour among adolescents by gender and socio-economic status. *Public Health Nutrition* 2002; 5: 671-81.
29. Jensen BW, Nielsen BM, Husby I et al. Association between sweet drink intake and adiposity in Danish children participating in a long-term intervention study. *Pediatr Obes* 2013; 8: 259-70.
30. Jensen BW, Nichols M, Allender S et al. Inconsistent associations between sweet drink intake and 2-year change in BMI among Victorian children and adolescents. *Pediatr Obes* 2013; 8: 271-83.
31. Malik VS, Popkin BM, Bray GA et al. Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: a meta-analysis. *Diabetes Care* 2010; 33: 2477-83.
32. Cullen KW, Ash DM, Warneke C et al. Intake of soft drinks, fruit-flavored beverages, and fruits and vegetables by children in grades 4 through 6. *American Journal of Public Health* 2002; 92: 1475-8.
33. Affinita A, Catalani L, Cecchetto G et al. Breakfast: a multidisciplinary approach. *Italian Journal of Pediatrics* 2013; 39.
34. Ortega RM, López-Sobaler AM, Pérez-Farinós N. Associated factors of obesity in Spanish representative samples. *Nutr Hosp* 2013; 28 (Supl. 5): 56-62.
35. Vagstrand K, Linne Y, Karlsson J et al. Correlates of soft drink and fruit juice consumption among Swedish adolescents. *Br J Nutr* 2009; 101: 1541-8.
36. Verzeletti C, Maes L, Santinello M et al. Soft drink consumption in adolescence: associations with food-related lifestyles and family rules in Belgium Flanders and the Veneto Region of Italy. *Eur J Public Health* 2010; 20: 312-7.
37. Powell LM, Szczypka G & Chaloupka FJ. Adolescent exposure to food advertising on television. *Am J Prev Med* 2007; 33: S251-256.
38. Powell LM, Szczypka G, Chaloupka FJ. Trends in exposure to television food advertisements among children and adolescents in the United States. *Arch Pediatr Adolesc Med* 2010; 164: 794-802.
39. Olafsdottir S, Berg C, Eiben G et al. Young children's screen activities, sweet drink consumption and anthropometry: results from a prospective European study. *Eur J Clin Nutr* 203.
40. Fiorito LM, Marini M, Mitchell DC et al. Girls' early sweetened carbonated beverage intake predicts different patterns of beverage and nutrient intake across childhood and adolescence. *J Am Diet Assoc* 2010; 110: 543-50.
41. Ortega RM, Requejo AM, López-Sobaler AM et al. Smoking and passive smoking as conditioners of folate status in young women. *J Am Coll Nutr* 2004; 23: 365-71.
42. Nishino Y, Fukao A, Tsubono Y et al. Relation between passive smoking at home and dietary intake. *Nihon Koshu Eisei Zasshi* 1998; 45: 619-24.
43. Hampl JS, Taylor CA, Booth CL. Differences in dietary patterns of nonsmoking adults married to smokers vs. nonsmokers. *Am J Health Promot* 2001; 16: 1-6.
44. Rogers I, Emmett P. The effect of maternal smoking status, educational level and age on food and nutrient intakes in preschool children: results from the Avon Longitudinal Study of Parents and Children. *Eur J Clin Nutr* 2003; 57: 854-64.
45. González-Rodríguez LG, Rodríguez-Rodríguez E, Perea JM et al. Folate status in Spanish schoolchildren and its association with parental smoking habits. *Nutr Hosp* 2012; 27: 1092-8.
46. De Coen V, Vansteelandt S, Maes L et al. Parental socioeconomic status and soft drink consumption of the child The mediating proportion of parenting practices. *Appetite* 2012; 59: 76-80.
47. Bjelland M, Brantsaeter AL, Haugen M et al. (2013) Changes and tracking of fruit, vegetables and sugar-sweetened beverages intake from 18 months to 7 years in the Norwegian mother and child cohort study. BMC Public Health 13.
48. Sobal J. Obesity and socioeconomic status: a framework for examining relationships between physical and social variables. *Med Anthropol* 1991; 13: 231-47.
49. Andrieu E, Darmon N, Drewnowski A. Low-cost diets: more energy, fewer nutrients. *Eur J Clin Nutr* 2006; 60: 434-6.
50. Maillot M, Darmon N, Vieux F et al. Low energy density and high nutritional quality are each associated with higher diet costs in French adults. *American Journal of Clinical Nutrition* 2007; 86: 690-6.
51. Naska A, Bountziouka V, Trichopoulou A. Soft drinks: time trends and correlates in twenty-four European countries. A cross-national study using the DAFNE (Data Food Networking) databank. *Public Health Nutrition* 2010; 13: 1346-55.
52. Verloigne M, Van Lippevelde W, Maes L et al. Family- and school-based predictors of energy balance-related behaviours in children: a 6-year longitudinal study. *Public Health Nutrition* 2013; 16: 202-11.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):34-40
ISSN 1135-3074

Characterization of bioimpedance measures in overweight and obese hemodialyzed patients[1-3]

Mar Ruperto[1,4], Guillermina Barril[2] and Francisco J. Sánchez-Muniz[3]

[1]*From Departamento de Nutrición Humana y Dietética. Facultad de Ciencias de la Salud. Universidad Alfonso X el Sabio. Villanueva de la Cañada. Madrid (Spain).* [2]*Servicio de Nefrología. Hospital Universitario La Princesa. Madrid (Spain).* [3]*Departamento de Nutrición y Bromatología I (Nutrición). Facultad de Farmacia. Universidad Complutense de Madrid. Madrid (Spain).*

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.*

Correspondence: Mar Ruperto.
Departamento de Nutrición Humana y Dietética.
Facultad de Ciencias de la Salud.
Avenida de la Universidad, 1.
Universidad Alfonso X el Sabio.
28691 Villanueva de la Cañada. Madrid.
E-mail: marruperto@yahoo.com

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 population[1]. 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 Study[4] 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/m^2, but no increase in mortality risk in those with a BMI higher than 25 kg/m^2. 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 patients[6]. 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 patients[11-13]. 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 markers[15]. 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 overhydration markers as a risk factors of morbidity and mortality in HD population[16]. 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/m^2; overweight, 25-29.9 kg/m^2 and obese, ≥ 30 kg/m^2).

Assessment of Nutritional status

Nutritional-inflammatory status was assessed by the malnutrition-inflammation score (MIS) questionnaire[17] 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 (%) = (actual weight / SBW) × 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 range[20]. TSF was measured with a Lange Skin Calipers (Cambridge Instruments) using standard techniques. MAMC was estimated as follows: MAMC (cm) = Mid-arm circumference (cm) - 0.314 × TSF (mm). Waist circumference (WC) was measured according to WHO guidelines[21] 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 patients[6]. 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 ± SD, and PA < 4 were indicators of volume overload in dialysis patients[24].

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 ± 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/m²*	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 *n = 38*	*Overweight* *n = 23*	*Obesity* *n = 12*	*p-value**
BMI, *kg/m²*	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 (sp)*	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† *n,(%)*	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

	Total body water (%)			
Variable	*Coefficient*	*SEM*	*p-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 patients[28].

BMI appears to misclassify alterations of body composition in our study. LBM%, and exchange Na/K were lower in overweigh/obese HD patients. These findings are somewhat similar to some previous study[15] 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 markers[30-32]. 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 adipocitokynes 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 infiltration[35] and that weight loss is associated with a reduction in circulating concentrations of inflammatory biomarkers[36] such as IL-6 and CRP[37]. 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 LBM[42]. 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 patients[44], 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 potentials 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.

References

1. Flegal KM, Graubard BI, Williamson DF, Gail MH. Excess deaths associated with underweight, overweight, and obesity. *JAMA* 2005; 293: 1861-7.
2. Kalantar-Zadeh K, Anker SD, Coats AJ, Horwich TB, Fonarow GC. Obesity paradox as a component of reverse epidemiology in heart failure. *Arch Intern Med* 2005; 165: 1797-8.
3. Kovesdy CP, Anderson JE, Kalantar-Zadeh K. Paradoxical association between body mass index and mortality in men with CKD not yet on dialysis. *Am J Kidney Dis* 2007; 49: 581-91.
4. Degoulet P, Legrain M, Reach I et al. Mortality risk factors in patients treated by chronic hemodialysis. Report of the Diaphane collaborative study. *Nephron* 1982; 31: 103-10.
5. Leavey SF, McCullough K, Hecking E, Goodkin D, Port FK, Young EW. Body mass index and mortality in 'healthier' as compared with 'sicker' haemodialysis patients: results from the Dialysis Outcomes and Practice Patterns Study (DOPPS). *Nephrol Dial Transplant* 2001; 16: 2386-94.
6. Chertow GM, Lazarus JM, Lew NL, Ma L, Lowrie EG. Bioimpedance norms for the hemodialysis population. *Kidney Int* 1997; 52: 1617-21.
7. K/DOQI. Clinical practice guidelines for nutrition in chronic renal failure. K/DOQI, National Kidney Foundation. *Am J Kidney Dis* 2000; 35: S1-140.
8. Fouque D, Vennegoor M, ter WP et al. EBPG guideline on nutrition. *Nephrol Dial Transplant* 2007; 22 (Supl. 2): ii45-ii87.

9. De Fijter WM, De Fijter CW, Oe PL, ter Wee PM, Donker AJ. Assessment of total body water and lean body mass from anthropometry, Watson formula, creatinine kinetics, and body electrical impedance compared with antipyrine kinetics in peritoneal dialysis patients. *Nephrol Dial Transplant* 1997; 12: 151-6.
10. Donadio C, Consani C, Ardini M et al. Estimate of body water compartments and of body composition in maintenance hemodialysis patients: comparison of single and multifrequency bioimpedance analysis. *J Ren Nutr* 2005; 15: 332-44.
11. Lowrie EG, Li Z, Ofsthun N, Lazarus JM. Body size, dialysis dose and death risk relationships among hemodialysis patients. *Kidney Int* 2002; 62: 1891-7.
12. Kalantar-Zadeh K, Kuwae N, Wu DY et al. Associations of body fat and its changes over time with quality of life and prospective mortality in hemodialysis patients. *Am J Clin Nutr* 2006; 83: 202-10.
13. Noori N, Kopple JD, Kovesdy CP et al. Mid-arm muscle circumference and quality of life and survival in maintenance hemodialysis patients. *Clin J Am Soc Nephrol* 2010; 5: 2258-68.
14. Chertow GM, Jacobs C, Lazarus JM, Lew N, Lowrie EG. Phase angle predicts survival in hemodialysis patients. *J Ren Nutr* 1997; 7: 204-7.
15. Antlanger M, Hecking M, Haidinger M et al. Fluid overload in hemodialysis patients: a cross-sectional study to determine its association with cardiac biomarkers and nutritional status. *BMC Nephrol* 2013; 14: 266.
16. De MR, Grootendorst DC, Axelsson J, Boeschoten EW, Krediet RT, Dekker FW. Excess mortality due to interaction between protein-energy wasting, inflammation and cardiovascular disease in chronic dialysis patients. *Nephrol Dial Transplant* 2008; 23: 2957-64.
17. Kalantar-Zadeh K, Kopple JD, Block G, Humphreys MH. A malnutrition-inflammation score is correlated with morbidity and mortality in maintenance hemodialysis patients. *Am J Kidney Dis* 2001; 38: 1251-63.
18. Rambod M, Kovesdy CP, Kalantar-Zadeh K. Malnutrition-Inflammation Score for risk stratification of patients with CKD: is it the promised gold standard? *Nat Clin Pract Nephrol* 2008; 4: 354-5.
19. Rambod M, Bross R, Zitterkoph J et al. Association of Malnutrition-Inflammation Score with quality of life and mortality in hemodialysis patients: a 5-year prospective cohort study. *Am J Kidney Dis* 2009; 53: 298-309.
20. Alastrue A. Valoración de los parámetros antropométricosen nuestra población. *Med Clin (Barc)* 1982; 78: 407-15.
21. World Health Organisation. Waist circumference and Waist-Hip Ratio: report of a WHO expert consultation. 2011.
22. Di IB, Bellizzi V. Association of mortality and morbidity with bioimpedance analysis. *Kidney Int* 2000; 58: 464-5.
23. Di Iorio BR, Scalfi L, Terracciano V, Bellizzi V. A systematic evaluation of bioelectrical impedance measurement after hemodialysis session. *Kidney Int* 2004; 65: 2435-40.
24. Cigarran S, Barril G, Cirugeda A et al. Hypoalbuminemia is also a marker of fluid excess determined by bioelectrical impedance parameters in dialysis patients. *Ther Apher Dial* 2007; 11: 114-20.
25. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity-related health risk. *Am J Clin Nutr* 2004; 79: 379-84.
26. Kalantar-Zadeh K, Block G, Humphreys MH, Kopple JD. Reverse epidemiology of cardiovascular risk factors in maintenance dialysis patients. *Kidney Int* 2003; 63: 793-808.
27. Kalantar-Zadeh K, Kopple JD. Obesity paradox in patients on maintenance dialysis. *Contrib Nephrol* 2006; 151: 57-69.
28. Noori N. et al. Survival predictability of lean and fat mass in men and women undergoing maintenance hemodialysis. *Am J Clin Nutr* 2010; 92: 1060-70.
29. Jones CH. Serum albumin—a marker of fluid overload in dialysis patients? *J Ren Nutr* 2001; 11: 59-61.
30. Kalantar-Zadeh K, Kopple JD. Relative contributions of nutrition and inflammation to clinical outcome in dialysis patients. *Am J Kidney Dis* 2001; 38: 1343-50.
31. Kalantar-Zadeh K, Kopple JD, Humphreys MH, Block G. Comparing outcome predictability of markers of malnutrition-inflammation complex syndrome in haemodialysis patients. *Nephrol Dial Transplant* 2004; 19: 1507-19.
32. Kalantar-Zadeh K, Kuwae N, Wu DY et al. Associations of body fat and its changes over time with quality of life and prospective mortality in hemodialysis patients. *Am J Clin Nutr* 2006; 83: 202-10.
33. Morley JE, Abbatecola AM, Argiles JM et al. Sarcopenia with limited mobility: an international consensus. *J Am Med Dir Assoc* 2011; 12: 403-9.
34. Honda H, Qureshi AR, Axelsson J et al. Obese sarcopenia in patients with end-stage renal disease is associated with inflammation and increased mortality. *Am J Clin Nutr* 2007; 86: 633-8.
35. Harman-Boehm I, Bluher M, Redel H et al. Macrophage infiltration into omental versus subcutaneous fat across different populations: effect of regional adiposity and the comorbidities of obesity. *J Clin Endocrinol Metab* 2007; 92: 2240-7.
36. Ziccardi P, Nappo F, Giugliano G et al. Reduction of inflammatory cytokine concentrations and improvement of endothelial functions in obese women after weight loss over one year. *Circulation* 2002; 105: 804-9.
37. Tchernof A, Nolan A, Sites CK, Ades PA, Poehlman ET. Weight loss reduces C-reactive protein levels in obese postmenopausal women. *Circulation* 2002; 105: 564-9.
38. Machek P, Jirka T, Moissl U, Chamney P, Wabel P. Guided optimization of fluid status in haemodialysis patients. *Nephrol Dial Transplant* 2010; 25: 538-44.
39. Nescolarde L, Piccoli A, Roman A et al. Bioelectrical impedance vector analysis in haemodialysis patients: relation between oedema and mortality. *Physiol Meas* 2004; 25: 1271-80.
40. Chazot C, Wabel P, Chamney P, Moissl U, Wieskotten S, Wizemann V. Importance of normohydration for the long-term survival of haemodialysis patients. *Nephrol Dial Transplant* 2012; 27: 2404-10.
41. Wizemann V, Wabel P, Chamney P et al. The mortality risk of overhydration in haemodialysis patients. *Nephrol Dial Transplant* 2009; 24: 1574-9.
42. Oliveira CM, Kubrusly M, Mota RS, Silva CA, Choukroun G, Oliveira VN. The phase angle and mass body cell as markers of nutritional status in hemodialysis patients. *J Ren Nutr* 2010; 20: 314-20.
43. Jones CH, Akbani H, Croft DC, Worth DP. The relationship between serum albumin and hydration status in hemodialysis patients. *J Ren Nutr* 2002; 12: 209-12.
44. Guida B, De NL, Pecoraro P et al. Abnormalities of bioimpedance measures in overweight and obese hemodialyzed patients. *Int J Obes Relat Metab Disord* 2001; 25: 265-72.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):41-48
ISSN 1135-3074

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

Liliana Guadalupe González-Rodríguez[1,3], Ana María López Sobaler[2,3], Aránzazu Aparicio Vizuete[2,3] and Rosa María Ortega Anta[2,3]

[1]Faculty of Health Sciences. Alfonso X El Sabio University. Villanueva de la Cañada. Madrid. [2]Department of Nutrition, Faculty of Pharmacy, Complutense University of Madrid. [3]UCM Research Group VALORNUT (920030). Department of Nutrition. Faculty of Pharmacy. Complutense University of Madrid. Spain.

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 ± 329.35 mL/day (S: 1,526.3 ± 386.05 mL/day, LA: 1,504.8 ± 326.17 s and A: 1,499.3 ± 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.*

Correspondence: Liliana Guadalupe González Rodríguez.
Faculty of Health Sciences.
Alfonso X El Sabio University.
Ave. Universidad, 1.
28691 Villanueva de la Cañada. Madrid.
E-mail: liligoro@uax.es

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 ± 329,35 mL/día (S: 1.526,3 ± 386,05 mL/día, PA: 1.504,8 ± 326,17 mL/día y A: 1.499,3 ± 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.*

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 conditions[1].

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 memory[2-4]. Decrements in physical performance in children athletes have been observed under conditions of as little as 2% dehydration, measured acutely as percent body weight loss[3-5]. Even mild to moderate dehydration can therefore persist for some hours after the conclusion of physical activity[2]. 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 children[2]. 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 adults[6].

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 were 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 height^2 (m^2). Normal weight, overweight and obesity were defined according to BMI specific percentiles for age and sex in the reference population[8]. The cut-off for overweight was the 85th percentile and for obesity the 97th percentile[9].

Dietary data

Participants recorded their dietary intake using a "3-day food intake record" from Sunday to Tuesday[10]. 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 data[11]. Energy and water intake were calculated using food composition tables[12]. 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 IOM[13]. 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 persons[15].

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:

(Theoretical energy expenditure – energy intake) × 100/ 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 questionnaire[19], 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 24[20]. The physical activity coefficient was used to classify schoolchildren by PAL using the criteria of the IOM (sedentary: ≥ 1.0 - < 1.4, low active: ≥ 1.4 - < 1.6, active: ≥ 1.6 - < 1.9 and very active: ≥ 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 (%)[1]	75.59 ± 19.28	74.77 ± 19.85	76.28 ± 18.8
% total water intake < AI[1]	91%	90.7%	91.2%
Water intake from beverages (mL/day)ǂ†	603.11 ± 295.08	627.46 ± 323.45	582.58 ± 267.67*
Water intake from beverages adequacy (%)[1]	43.24 ± 21.72	43.71 ± 22.64	42.85 ± 20.94
% water intake from beverages < AI[1]	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.
ǂBeverages not include milk or dairy drinks.
†Data adjusted for total energy intake.
[1] Adequate intake (AI) for children by EFSA[14].

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

	Sedentary (n = 20)	*Low active (n = 438)*	*Active (n = 106)*
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 (%)[1]	74.03 ± 25.94	75.53 ± 19.28	76.11 ± 17.99
% total water intake < AI[1]	90.0	91.1	90.6
Water intake from beverages (mL/day)ǂ†	741.99 ± 371.79	602.66 ± 292.84	578.80 ± 284.06
Water intake from beverages adequacy (%)[1]	51.80 ± 30.21	43.16 ± 21.50	41.96 ± 20.59
% water intake from beverages < AI[1]	95.0	97.9	98.1

Values are expressed as mean and SD or %. Differences by physical activity level: [a]sedentary *vs* low active, [b]sedentary *vs* active, [c]low active *vs* active. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$.
ǂ Beverages not include milk or dairy drinks.
† Data adjusted for total energy intake.
[1] Adequate intake (AI) for children by EFSA[14].

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

	Total	*Sedentary (n = 20)*	*Low active (n = 438)*	*Active (n = 106)*
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 activity[13]. 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 schoolchildren[29]. 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 boys[30].

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 boys[13]. 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 ± 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 ± 21.08 %), while boys underestimated (6.20 ± 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 literature[27] 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 semiquantitative 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 ± 29.6 mL/day vs. 1,504.6 ± 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/day[3], 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 NHANES[35].

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 females[37].

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 countries[14]. 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 literature[1]. 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 water[38]. Also, the report pointed out that although low water intake has been associated with some chronic diseases, evidence was insufficient[38]. Therefore, an adequate intake was set up to prevent deleterious, primarily acute, effects of dehydration, which include metabolic and functional abnormalities[38]. 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 EFSA[14], since they are recent and set for European population. In this regard, mean adequacy percentage of total water intake (75.59 ± 19.28%) and of water from beverages (43.24 ± 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.

Acknowledgements

This work was funded by Health Research Fund of Social Security project PI060318 and the "Creation and Consolidation Program Research Group at the Complutense University of Madrid, Madrid" (Ref: GR58/08; Code: 4120787).

Conflict of interest statement

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

References

1. Kalman DS, Lepeley A. A Review of Hydration. *Strenght Cond J* 2010; 32 (2): 56-63.
2. D'Anci KE, Constant F, Rosenberg IH. Hydration and Cognitive Function in Children. *Nutr Rev* 2006; 64 (10): 457-64.
3. Bellisle F, Thornton SN, Hébel P, Denizeau M, Tahiri M. A study of fluid intake from beverages in a sample of healthy French children, adolescents and adults. *Eur J Clin Nutr* 2010; 64 (4): 350-5.
4. Lieberman HR. Hydration and cognition: a critical review and recommendations for future research. *J Am Coll Nutr* 2007; 26 (Supl. 5): 555S–561S.
5. Grandjean AC, Reimers KJ, Buyckx ME. Hydration: issues for the 21st century. *Nutrition Reviews* 2003; 61 (8): 261-71.
6. Popkin BM, D'Anci KE, Rosenberg IH. Water, Hydration and Health. *Nutr Rev* 2010; 68 (8): 439–58.
7. World Health Organization. Physical status: use and interpretation of anthropometric. Report of a Joint FAO/WHO/UNU Expert Consultation. Technical Report Series 854. Geneva, World Health Organization, 1995.
8. Hernández M, Castellet J, Narvaiza JL, et al. Curvas y tablas de crecimiento (Growth Charts and Tables). Instituto de Investigación sobre crecimiento y desarrollo. Faustino Orbegozo Eizaguirre. Madrid: Editorial Garsi, 1988.
9. SEEDO. Consenso SEEDO 2007 para la evaluación del sobrepeso y la obesidad y el establecimiento de criterios de intervención terapéutica. *Rev Esp Obes* 2007. pp. 7-48.
10. Ortega RM, Requejo AM, López-Sobaler AM. Questionnaires for dietetic studies and the assessment of nutritional status. In: Ortega RM, Requejo AM (eds). Nutriguía. Manual of Clinical Nutrition in Primary Care. Madrid, Editorial Complutense, 2009. pp. 456-467.
11. Ortega RM, López-Sobaler AM, Andrés P, Requejo AM, Aparicio A, Molinero LM. DIAL Software for assessing diets and food calculations. Department of Nutrition (UCM) and Alce Ingeniería, S.A, Madrid. Versión 2.3, March 2012. http://www.alceingenieria.net/nutricion.htm (Accessed on January 2014).
12. Ortega RM, López-Sobaler AM, Requejo AM and Andrés P. Food composition tables. A basic tool for assessing nutritional status. Madrid, Editorial Complutense, 2010. pp. 15-81.
13. Institute of Medicine. Dietary reference intakes: energy, carbohydrate, fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC: Institute of Medicine of the National Academies Press, 2005.
14. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary reference values for water. *EFSA Journal* 2010; 8 (3): 1-48.
15. Krebs-Smith SM, Kott PS, Guenther PM. Mean proportion and population proportion: two answers to the same question? *J Am Diet Assoc* 1989; 89 (5): 671-6.
16. Ortega RM, Quintas ME, Sánchez-Quiles MB, Andrés P, Requejo AM, Encinas-Sotillos A. Underestimation of energy intake in a group of young female university students of Madrid. *Rev Clin Esp* 1997; 197 (8): 545-9.
17. Ortega RM, Requejo AM, Andrés P, López-Sobaler AM, Redondo MR, González-Fernández M. Relationship between diet composition and body mass index in a group of Spanish adolescents. *Br J Nutr* 1995; 74 (6): 765-73.
18. Black AE, Goldberg GR, Jebb SA, Livingstone MB, Cole TJ, Prentice AM. Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluation the results of published surveys. *Eur J Clin Nutr* 1991; 45: 583-99.
19. Ortega RM, Requejo AM, López-Sobaler AM. Activity questionnaire. In: Ortega RM, Requejo AM (eds). Nutriguía. Manual of Clinical Nutrition in Primary Care. Madrid, Editorial Complutense, 2009. pp. 468.
20. World Health Organization. Energy and protein requirements. Reports of a Joint FAO/WHO/UNU Expert consultation. Technical report series 724. World Health Organization, Geneva, World Health Organization, 1985.
21. Willett W. Stampfer MJ. Total energy intake: implications for epidemiologic analyses. *Am J Epidemiol* 1986; 124 (1): 17-27.
22. Willett WC, Sampson L, Stampfer MJ, Rosner B, Bain C, Witschi J et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol* 1985; 122 (1): 51-65.
23. Sichert-Hellert W, Kersting M. Home-made carbonated water and the consumption of water and other beverages in German children and adolescents: results of the DONALD study. *Acta Paediatr* 2004; 93: 1583-7.
24. Savanovitch C, Sauvant-Rochat MP. An educational resource based on water and health as a teaching aid in French primary schools Part I: Identification of Needs and Content. *Educ Sci* 2013; 3: 300-13.
25. Gelbrich G, Blüher S, Reich A, Müller G, Kiess W. Prevalence of obesity and elevated blood pressure as well as onset of puberty in German school attending different educational tracks. *Horm Res* 2008; 70 (6): 340-8.
26. Moreno LA, Fleta J, Sarría A, Rodríguez G, Gil C, Bueno M. Secular changes in body fat patterning in children and adolescents of Zaragoza (Spain), 1980-1995. *Int J Obes Relat Metab Disord* 2001; 25 (11): 1656-60.
27. Ortega RM, López-Sobaler AM, Navia B, Perea JM, Aparicio A, Rodríguez-Rodríguez E. Hábitos alimentarios, ingesta de energía y nutrientes y padecimiento de sobrepeso/obesidad en escolares españoles. Diferencias en función de su consumo de pan. [Eating habits patterns, energy and nutrient intake and overweight/obesity in Spanish school children. Differences according to their bread consumption]. Madrid: Secretaría técnica y de comunicación. Campaña pan cada día, 2010.
28. Marrodán MD, Mesa MS, Díaz A, Soblechero A, Barrio PA, Drak, L et al. Diagnosis de la obesidad: actualización de criterios y su validez clínica y poblacional. [Obesity screening, Updated criteria and their clinical and populational validity]. *An Pediatr* (Barc). 2006; 65 (1): 5-14.
29. Telford RM, Telford RD, Cunningham RB, Cochrane T, Davey R, Waddington G. Longitudinal patterns of physical activity in chil-

dren aged 8 to 12 years: the LOOK study. *Int J Behav Nutr Phys Act* 2013; 10 (1): 81.
30. Klinker CD, Schipperijn J, Christian H, Kerr J, Ersbøll AK, Troelsen J. Using accelerometers and global positioning system devices to assess gender and age differences in children's school, transport, leisure and home based physical activity. *Int J Behav Nutr Phys Act* 2014; 11 (1): 8.
31. Velasco J, Mariscal-Arcas M, Rivas A, Caballero L, Hernández-Elizondo J, Olea-Serrano F. Valoración de la dieta de escolares granadinos e influencia de factores sociales. [Assessment of the diet of school children from Granada and influence of social factors]. *Nutr Hosp* 2009; 24 (2): 193-9.
32. Capdevila F, Llop D, Guillén N, Luque V, Pérez S, Sellés V, et al. Consumo, hábitos alimentarios y estado nutricional de la población de Reus (X): evolución de la ingestión alimentaria y de la contribución de los macronutrientes al aporte energético (1983-1993) según edad y sexo. [Food intake, dietary habits and nutritional status of the population of Reus (Catalonia, Spain) (X): evolution of the diet and macronutrients contribution to energy intake (1983–1999), by age and sex] *Med Clín* (Barc). 2000; 1 (115): 7-14.
33. Ballew C, Kuester S, Serdula M, Bowman B, Dietz W. Nutrients intakes and dietary pattern of young children by dietary intakes. *J Pediatr* 2000; 136 (2): 181-7.
34. Drewnowski A, Rehm CD, Constant F. Water and beverage consumption among children age 4-13 y in the United States: analyses of 2005–2010 NHANES data. *Nutr J* 2013; 12 (1): 85.
35. Kant AK, Graubard BI. Contributors of water intake in US children and adolescents: associations with dietary and meal characteristics-National Health and Nutrition Examination Survey 2005-2006. *Am J Clin Nutr* 2010; 92 (4): 887-96.
36. Feferbaum R, de Abreu LC, Leone C. Fluid intake patterns: an epidemiological study among children and adolescents in Brazil. *BMC Public Health* 2012; 12: 1005.
37. Ottevaere C, Huybrechts I, Béghin L, Cuenca-Garcia M, De Bourdeaudhuij I, Gottrand F, et al. Relationship between self-reported dietary intake and physical activity levels among adolescents: the HELENA study. *Int J Behav Nutr Phys Act* 2011; 6 (8): 8.
38. Institute of Medicine. Panel on dietary reference intakes for electrolytes and water. Dietary reference intakes for water, potassium, sodium, chloride, and sulfate. Washington, D.C., National Academies Press, 2005.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):49-55
ISSN 1135-3074

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

Carmen Gómez-Candela[1], Jersy Jair Cárdenas Salas[2], Natalia García Vázquez[3], Thabata Koester Weber[2], Teresa Alarcón-Alarcón[4], Luis Suarez Gonzalo[5], Juan Pedro Pérez Robledo[5] y otros miembros de la Comisión de Nutrición*

*[1]Unidad de Nutrición Clínica y Dietética. Presidenta de la Comisión de Nutrición. [2]Unidad de Nutrición Clínica y Dietética. [3]Servicio de Farmacia. Secretaria de la Comisión de Nutrición. [4]Servicio de Geriatría. [5]Servicio de Anestesia y Reanimación. [6]Servicio de Cirugía General. Comisión de Nutrición. Hospital Universitario La Paz. IdiPAZ. Universidad Autónoma de Madrid. España. *Otros miembros de la Comisión de Nutrición: M. Calso González, D. del Gallo Errea, A. García de Lorenzo, C. Grande Aragón, M. A. Gomez Mendieta, P. González Sanz-Agero, A. López Carrasco, J. Nieto López-Guerrero, M. A. Rico Hernández, J. Ríos Blanco, M. Ruiz Garrido, E. Sánchez Santos, J. M. Sarriá Osés y Z. Ros Mar.*

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.*

Correspondence: Carmen Gómez Candela.
Hospital Universitario La Paz.
Unidad de Nutrición Clínica y Dietética.
Paseo de la Castellana, 241.
28046 Madrid.
E-mail: cgcandela@salud.madrid.org

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.*

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 plasma[1]. 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 rate[4]; 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 wass less than with PSS[5]. 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 alkalosis[6]. Some studies suggest the superiority of LR as a resuscitation therapy in hypovolemic hemorrhagic shock, producing less pulmonary edema than PSS[7]. 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 level[8]. As mentioned above, lactate metabolism generates glucose and it is not surprising that the intraoperative administration of LR doubles concentrations of glucose in diabetic patients[9]. 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

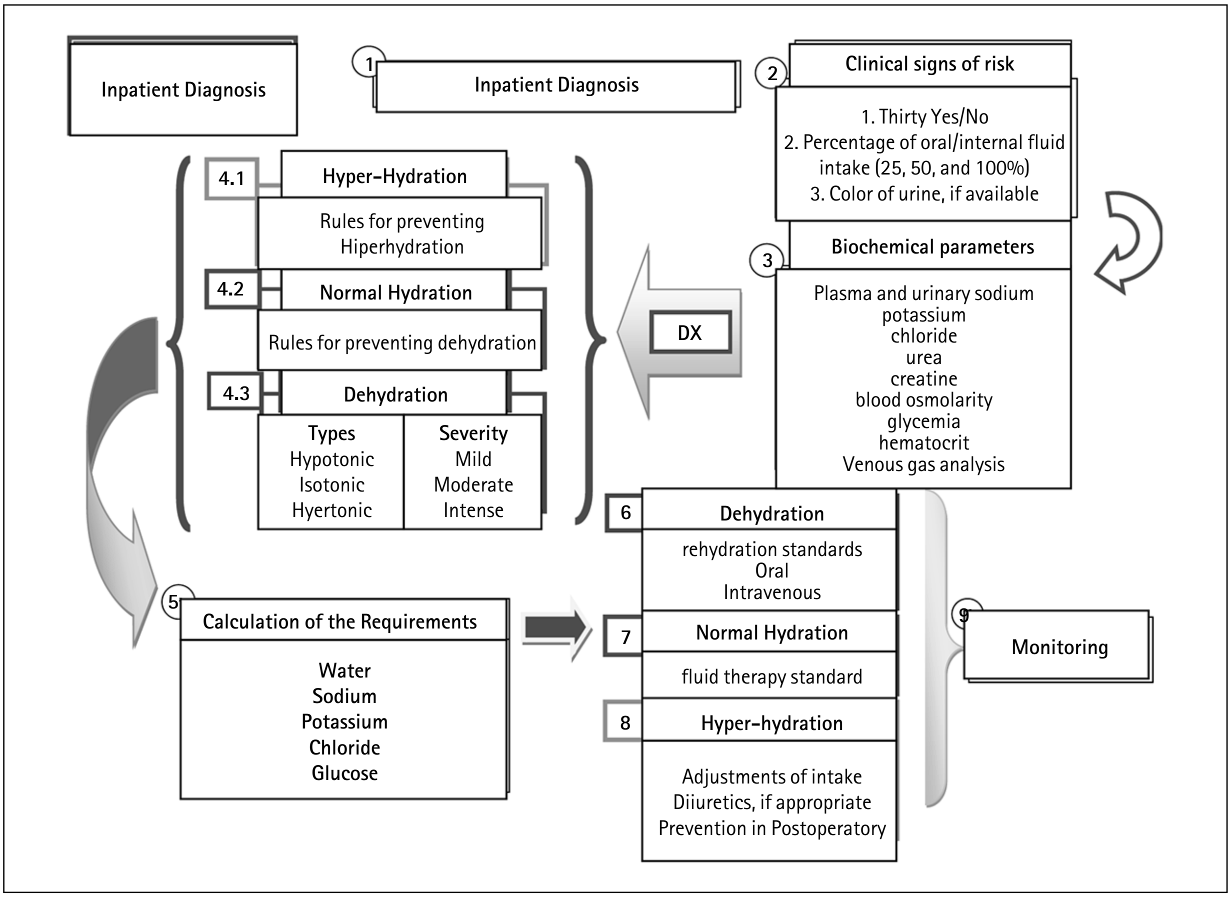


Fig. 1.—Algorithm for Hospital Hidration.

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-hydration[13].

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 °C[14].

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 consciousness[15]. 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 edema[16] 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	• Ascites • Diuretics • Gastrointestinal losses (diarrhea,...) • Pleural aspiration • Inadequate intake of water and minerals • Burns • Fistulas • Bleeding	• **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	• Profuse sweating • Loss of gastrointestinal fluid • Use of thiazides • Replacement of H_2O without supplying Na^+ and K^+	• **Mild:** Nausea, upset stomach • **Moderate:** Headache, lethargy, confusion, and dullness • **Severe(Na^+<120 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	• Vomiting • Sweating • Osmotic Diuresis • Osmotic Diarrhea • Inadequate water intake	• **Mild:** Thirst and oliguria • **Moderate:** Weakness, neuromuscular irritability, neurological focal deficiencies • **Severe (Na^+>180 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 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 (1mEq = 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^+ plasmatic in 1 mEq/L. The maximum infusion rate is 20 mEq/hour[19].

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 any[15].
- 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 (HCO3-less than 10 mEq/L) add HCO3- 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:

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

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 osmolarity 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.

References

1. Wakim KG. "Normal" 0.9 per cent salt solution is neither "normal" nor physiological. *JAMA* 1970; 214: 1710.
2. Williams EL, Hildebrand KL, McCormick SA, Bedel MJ. The effect of intravenous lactated Ringer's solution versus 0.9% sodium chloride solution on serum osmolality in human volunteers. *Anesth Analg* 1999; 88: 999–1003.
3. Fiona R, Dileep NL, Williams R, Rowlands B, Allison S. (Ab) normal saline and physiological Hartmann's solution: a randomized double-blind crossover study. *Clinical Science* 2003; M 104; 17-24.
4. Wilcox CS. Regulation of renal blood flow by plasma chloride. *J Clin Invest* 1983; 71: 726–35.
5. Yunos NM, Bellomo R, Hegarty C et al. Association between a chloride-liberal vs chloride-restrictive intravenous fluid administration strategy and kidney injury in critically ill adults. *JAMA* 2012; 308: 1566-72.
6. Cohen RD, Simpson R. Lactate metabolism. *Anesthesiology* 1975; 43 (6): 661-73.
7. Phillips CR, Vinecore K, Hagg DS, Sawai RS, Differding JA, Watters JM, Schreiber MA. Resuscitation of haemorrhagic shock with normal saline *vs* lactated Ringer's: Effects on oxygenation, extravascular lung water and haemodynamics. *Crit Care* 2009; 13 (2): R30.
8. Tommasino C, Moore S, Todd MM. Cerebral effects of isovolemic hemodilution with crystalloid or colloid solutions. *Crit Care Med* 1988; 16 (9): 862-8.
9. Thomas DJ, Alberti KG. Hyperglycaemic effects of Hartmann's solution during surgery in patients with maturity onset diabetes. *Br J Anaesth* 1978; 50 (2): 185-8.
10. Shaw AD, Bagshaw SM, Goldstein SL et al. Major complications, mortality, and resource utilization after open abdominal surgery: 0.9% saline compared to Plasma-Lyte. *Ann Surg* 2012; 255: 821-9.
11. Lobo SM, Ronchi LS, Oliveira NE, Brand o PG, Froes A, Cunrath GS, Nishiyama KG, Netinho JG, Lobo FR. Restrictive strategy of intra-operative fluid maintenance during optimization of oxygen delivery decreases major complications after high-risk surgery. *Crit Care* 2011; 15: R226.
12. Lobo DN, Bostock KA, Neal KR, Perkins AC, Rowlands BJ, Allison SP. Effect of salt and water balance on recovery of gastrointestinal function after elective colonic resection: a randomised controlled trial. *Lancet* 2002; 359: 1812–8.
13. Schols JM, De Groot CP, van der Cammen TJ, Olde Rikkert MG. Preventing and treating dehydration in the elderly during periods of illness and warm weather. *J Nutr Health Aging* 2009; 13 (2): 150-7.
14. Schneider AG, Baldwin I, Freitag E, Glassford N, Bellomo R: Estimation of fluid status changes in critically ill patients: fluid balance chart or electronic bed weight. *J Crit Care* 2012; 27: 745.
15. Rose BD and Post TW. Clinical Physiology of Acid-Base and Electrolyte Disorders, 5th ed, McGraw-Hill, New York 2001. Page 441.
16. Twigley AJ, Hillman KM. The end of the crystalloid era? A new approach to peri-operative fluid administration. *Anaesthesia* 1985; 40 (9): 860-71.
17. Annemieke Smorenberg, Can Ince and AB Johan Groeneveld. Dose and type of crystalloid fluid therapy in adult hospitalized patients. *Perioperative Medicine* 2013; 2: 17.
18. Sterns Richard H, MD. Maintenance and replacement fluid therapy in adults. UpToDate 2013.
19. Van De Vreede M, Wilson SG, Dooley MJ: Intravenous potassium chloride use in hospitals: current practice. *J Pharm Pract Res* 2008; 38: 19-22.
20. Adrogué HJ, Madias NE: The challenge of hyponatremia. *J Am Soc Nephrol* 2012; 23: 1140–8.
21. Runkle I, Villabona C, Navarro A, Pose A, Formiga F, Tejedor A, Poch E. The treament of hyponatremia secundary to the syndrome of inappropriate antidiuretic hormone secretion. *Med Clin* 2013; 141: 507-10.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):56-62
ISSN 1135-3074

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

Aurora Hernández[1], Ligia Esperanza Díaz[1], Oscar Daniel Rangel[2], Katherine Flores[3], Raúl Hoyos[4], Mercedes Gil-Campos[3], Concepción M. Aguilera[2] and Ascensión Marcos[1]

[1]Immunonutrition research group. ICTAN. CSIC. Madrid. Spain. [2]Department of Biochemistry and Molecular Biology. Institute of Nutrition and Food Technology. University of Granada. Granada. Spain. [3]Reina Sofía Hospital. University of Córdoba. Granada. Spain. [4]Virgen de las Nieves Clinic Hospital. University of Granada. Granada. Spain.

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.*

Correspondence: Aurora Hernández González.
Department of Immunonutrition Research Group.
Institute of Food Science and Technology and Nutrition (ICTAN).
Spanish National Research Council (CSIC).
José Antonio Novais, 10.
28040 Madrid.
E-mail: aurora.hernandez@ictan.csic.es

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) solo 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.*

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 population[1]. Both childhood and adolescence are critical periods for the onset of obesity and for obesity associated morbidity in later life[2]. Obesity is often associated with metabolic complications, reduced capacity for physiological activity[3] and increased development of chronic and degenerative diseases through adulthood[4]. The metabolic modifications by the energy imbalance in young obese subjects is associated with modifications in the body features[5] 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 filtration[8]. Values of TBW volumes, proportions of body constituents and their associations with age and fatness are considered as interesting biomarkers to assess adiposity[8]. 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 obesity[8]. Under this situation, as body fatness increases, TBW volume also increases, but it declines as a percentage of body weight[8]. 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 TBW[9]. 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 disease[11], cerebral palsy patients[12], patients with short bowel[13] and newborns with parenteral nutrition[14] 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 adulthood[15]. 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 adolescents[17-20]. CRP has also shown significant associations with CVD, and this inflammatory protein is well recognized as a potent predictor CVD risk factor[21].

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 molecules[22].

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

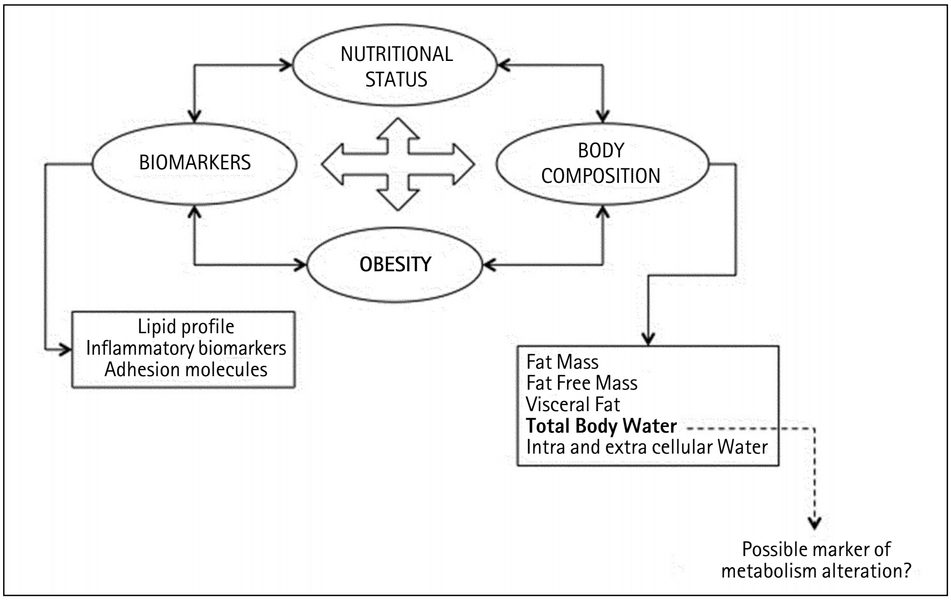


Fig. 1.—Interaction among nutritional status, body composition and biomarkers in obese subjects.

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 al[23]. 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 al[24], 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 thermoregulation[25]. 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 cases[26-28].

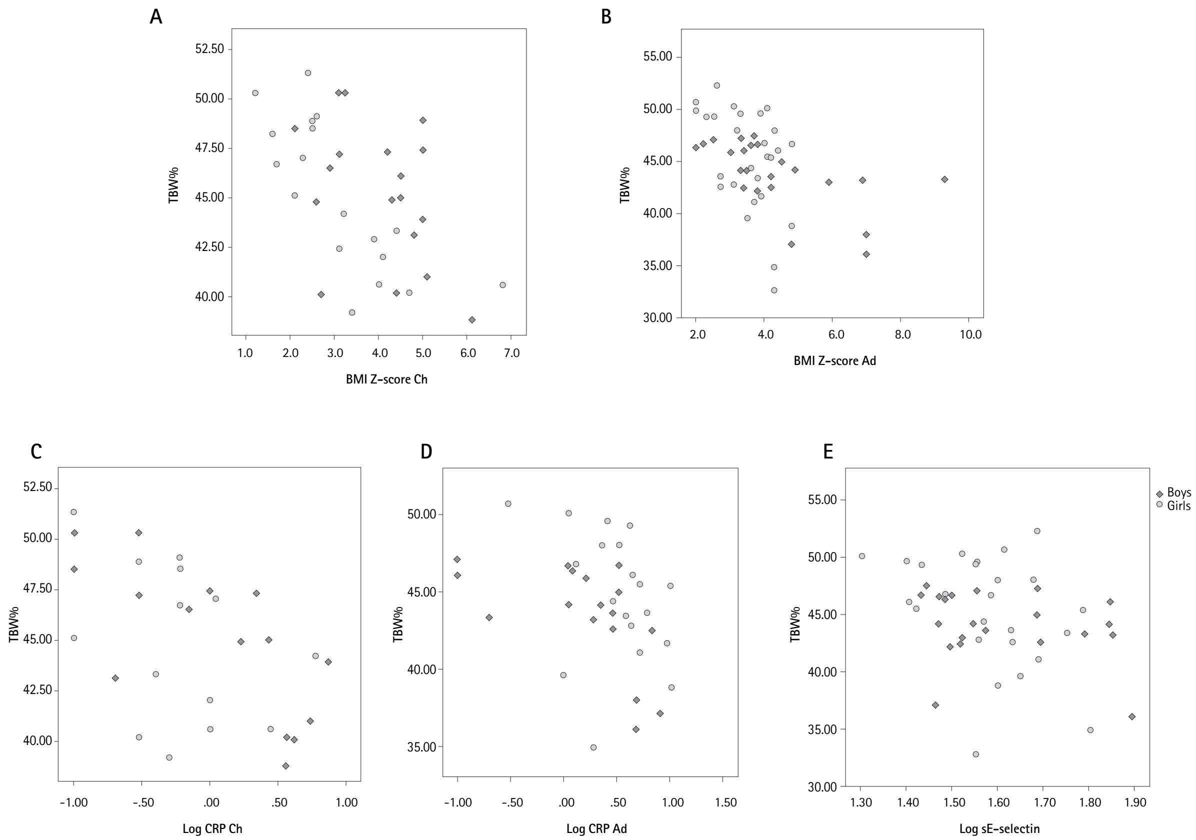
In the current study a significant negative correlation between TBW and BMI Z-score was found, both in children and in adolescents. This association was adjusted for age and sex. This finding could be of public health interest because of the increasing prevalence of childhood obesity, a significant determinant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

	(7-16 yrs)		*(7.0-10.9 yrs)*		*(11.0-16.0 yrs)*	
Parameters	*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.



Bilateral partial correlation plot between Total Body Water (TBW) (%) and (A) BMI Z-score in children (Ch); (B) BMI Z-score in adolescents (Ad); (C, D) C-Reactive Protein (CRP) (mg/dL) in children (Ch) and adolescent (Ad) boys, respectively; (E) sE-selectin (ng/mL) in adolescent girls.

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 atherosclerosis[32]. 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 women[32]. 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 adolescents[22], 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 levels[22].

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 growth[33]. Therefore, age was used as an adjustment factor in the analysis[34]. 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 described[35], 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

Esther Nova[1], José Maldonado[4]

[1]*Immunonutrition Research Group, ICTAN, CSIC. Madrid. Spain.*

[4]*Virgen de las Nieves Clinic Hospital, University of Granada. Granada. Spain.*

Acknowledgments

This research has been supported by the PRONAOS Study CDTI-2008 1114 and Biosearch. We would like to thank Ms. Laura Barrios for her excellent technical assistance in performing the statistical analysis, and also Ms. Mª José Valdemoro and Ms. Mª Soledad González for their reference contribution.

Conflict of interest

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

References

1. Txakartegi Etxebarria X, López Mateo M, Aurrekoetxea JJ. [Obesity and overweight. An assessment of the effectiveness of a public health intervention.] *An Pediatr* (Barc). 2013 Oct 15. pii: S1695-4033(13)00376-7. doi: 10.1016/j.anpedi.2013.08.008. [Epub ahead of print]
2. Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS. Inter-relationships among childhood BMI, childhood height, and adult obesity: the Bogalusa Heart Study. *Int J Obes Relat Metab Disord* 2004 Jan; 28 (1): 10-6.
3. Deforche B, Lefevre J, De Bourdeaudhuij I, Hills AP, Duquet W, Bouckaert J. Physical fitness and physical activity in obese and nonobese Flemish youth. *Obes Res* 2003 Mar; 11 (3): 434-41.
4. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002; 360 (9331): 473-82.
5. Oria E, Lafita J, Petrina E, Arguelles I. Composicion corporal y obesidad. *An Sist Sanit Navar* 2002; 25 (Supl. 1): 91-102.
6. Desideri G, De Simone M, Iughetti L, Rosato T, Iezzi ML, Marinucci MC et al. Early activation of vascular endothelial cells and platelets in obese children. *J Clin Endocrinol Metab* 2005; 90 (6): 3145-52.
7. Suheyl Ezgu F, Hasanoglu A, Tumer L, Ozbay F, Aybay C, Gunduz M. Endothelial activation and inflammation in prepubertal obese Turkish children. *Metabolism* 2005; 54 (10): 1384-9.
8. Chumlea WC, Schubert CM, Sun SS, Demerath E, Towne B, Siervogel RM. A review of body water status and the effects of age and body fatness in children and adults. *J Nutr Health Aging* 2007; 11 (2): 111-8.
9. De Beer M, Weijs P, Gemke R. Validation of total body water analysis by bioelectrical impedance analysis with deuterium dilution in (pre)school children. *Eur J Clin Nutr* 2011. p. 223-6.22.
10. Haroun D, Croker H, Viner RM, Williams JE, Darch TS, Fewtrell MS et al. Validation of BIA in obese children and adolescents and re-evaluation in a longitudinal study. *Obesity* (Silver Spring). 2009; 17 (12): 2245-50.
11. Donadio C, Consani C, Ardini M, Bernabini G, Caprio F, Grassi G et al. Estimate of body water compartments and of body composition in maintenance hemodialysis patients: comparison of single and multifrequency bioimpedance analysis. *J Ren Nutr* 2005; 15 (3): 332-44.
12. Bell KL, Boyd RN, Walker JL, Stevenson RD, Davies PS. The use of bioelectrical impedance analysis to estimate total body water in young children with cerebral palsy. *Clin Nutr* 2013; 32 (4): 579-84.
13. Chambrier C, Normand S, Ecochard R, Pachiaudi C, Laville M, Bouletreau P. Total-body-water measurement with (18)O-labeled water in short-bowel patients with an ileostomy. *Nutrition* 2001; 17 (4): 287-91.
14. Coran AG, Drongowski RA, Wesley JR. Changes in total body water and extracellular fluid volume in infants receiving total parenteral nutrition. *J Pediatr Surg* 1984; 19 (6): 771-6.
15. Srinivasan SR, Myers L, Berenson GS. Predictability of childhood adiposity and insulin for developing insulin resistance syndrome (syndrome X) in young adulthood: the Bogalusa Heart Study. *Diabetes* 2002; 51 (1): 204-9.
16. Zimmet P, Magliano D, Matsuzawa Y, Alberti G, Shaw J. The metabolic syndrome: a global public health problem and a new definition. *J Atheroscler Thromb* 2005; 12 (6): 295-300.
17. Warnberg J, Marcos A. Low-grade inflammation and the metabolic syndrome in children and adolescents. *Curr Opin Lipidol* 2008; 19 (1): 11-5.
18. Martos R, Valle M, Morales RM, Canete R, Gascon F, Urbano MM. Changes in body mass index are associated with changes in inflammatory and endothelial dysfunction biomarkers in obese prepubertal children after 9 months of body mass index SD score loss. *Metabolism* 2009; 58 (8): 1153-60.
19. De Heredia FP, Gomez-Martinez S, Marcos A. Obesity, inflammation and the immune system. *Proc Nutr Soc* 2012; 71 (2): 332-8.
20. Wärnberg J. Inflammatory status in adolescents; the impact of health determinants such as overweight and fitness. [Thesis for doctoral degree]. Stockholm: Karolinska Institutet; 2006.
21. Hansson GK. Inflammation, atherosclerosis, and coronary artery disease. *N Engl J Med* 2005 Apr 21; 352 (16): 1685-95.
22. Glowinska B, Urban M, Peczynska J, Florys B.Soluble adhesion molecules (sICAM-1, sVCAM-1) and selectins (sE selectin, sP selectin, sL selectin) levels in children and adolescents with obesity, hypertension, and diabetes. *Metabolism* 2005 Aug; 54 (8): 1020-6.

23. Sobradillo B, Aguirre A, Aresti U, Bilbao A, Fernández-Ramos C, Lizagarra A, et al. Curvas y tablas de crecimiento (estudios longitudinal y transversal). Bilbao: Fundación Faustino Orbegozo Eizaguirre; 2004.
24. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; 320: 1240-3.
25. Guzmán F. Líquido y Electrolitos en Cirugía. En: Fisiopatología celular y bioquímica. Vergara. Ed. *Médica Panamericana* 2004. p. 172.
26. Morgensterrn B, Mahoney D, Warady B. Estimating Total Body Water in Children on the Basis of Height: A Reevaluation of the Formulas Mellits and Cheek. *J Am Soc Nephrol* 2002; 13: 1884-8.
27. Azócar P, Cano Sch, Marín B, Díaz B, Salazar R, Vásquez F. (Estimación del agua corporal total por deuterio en diálisis peritoneal pediátrica). *Rev Chil Pediatr* 2003; 74 (5): 504-10.
28. Berardesca E, Maibach HI. Transepidermal water loss and skin surface hydration in the non-invasive assessment of stratum corneum function. *Derm Beruf Umwelt* 1990; 38: 50-3.
29. Heilbronn LK, Noakes M, Clifton PM. Energy restriction and weight loss on very-low-fat diets reduce C-reactive protein concentrations in obese, healthy women. *Arterioscler Thromb Vasc Bio* 200; (21): 968-70.
30. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet* 2002 (360): 473-82.
31. Aronson D, Bartha P, Zinder O, Kerner A, Markiewicz W, Avizohar O, Brook GJ, Levy Y. Obesity is the major determinant of elevated C-reactive protein in subjects with the metabolic syndrome. *IJO* 2004; 28: 674–9.
32. Aydin M, Dumlu T, Alemdar R, Kayapinar O, Celbek G, Karabacak A, Turker Y, Kaya H, Ertas F, Atilgan Z. Correlation between the body fat composition and high sensitive C-reactive protein in Turkish adults. *Endocr Regul* 2012; 46 (3): 147-52.
33. Tratado de nutrición. Capítulo 40. Evaluación de la composición corporal. En: El contenido de agua corporal total aumenta con la edad, la relación entre el espacio extracelular y el intracelular disminuye durante el crecimiento. Ed Díaz de Santos. p. 633.
34. Jurimae T, Hills A.P. Body composition assessment in children and adolescents. En: Medicine and sport science. *KARGER* 2001; Vol. 44.
35. Malina RM, Bouchard C, Bar-Or O. Growth, Maturation, and Physical Activity. *Human Kinetics* 2004. p. 112-113.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):63-67
ISSN 1135-3074

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

Joana Silva[1,2], Patrícia Padrão[2,3,4], Carla Gonçalves[1,2], Raquel Esteves[1,2], Susana Carrapatoso[5], Joana Carvalho[5], Milton Severo[4], Carla Lopes[4,6] and Pedro Moreira[2,4,5]

[1]Faculty of Sciences of University of Porto. Porto. Portugal. [2]Faculty of Nutrition and Food Sciences of University of Porto. Porto. Portugal. [3]Hydration and Health Institute. Porto. Portugal. [4]Institute of Public Health of University of Porto. Porto. Portugal. [5]Centre of Physical Activity, Health and Leisure. Faculty of Sports. University of Porto. Porto. Portugal. [6]Faculty of Medicine of University of Porto. Porto. Portugal.

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 ± 654.5 mL *vs* 1,832.0 ± 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 (β = 0.314, 95%CI: 0.095,0.562 and β = 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.*

Correspondence: Joana Silva.
E-mail: joanafcosta.silva@gmail.com

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 socio 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 ± 654,5 mL vs 1.832,0 ± 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 (β = 0,314, 95% CI: 0,095, 0,562 y β = 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 forms[1], 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 hypertension[2].

Hydration status can be assessed through subjective observations and by objective noninvasive measurements[3]. 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 measurements[3]. Current evidence select urine indices, as more sensitive than other methods[3], 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 osmolality[5], although this is yet a controversial topic.

The identification of the determinants of hydration status is crucial, although data on this topic is scares, namely regarding the impact of dietary intake on hydration physiology[6]. The hydration status is mainly influenced by water[4], 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 status[7]. 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 the113 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 adults[11], 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 1983[12], 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 procedures[14]. Body mass index (BMI) was calculated as weight (kg) divided by square height (m^2), and participants were classified according to WHO BMI reference values[15], 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 (creatinine 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 analyses[16].

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 ± SD*	70.0 ± 4.9	70.3 ± 6.6	0.960*
Education level, *n (%)*			
Illiterate	3 (10.7%)	11 (23.9%)	0.555ǂ
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 ± SD*	27.5 ± 3.3	26.9 ± 4.0	0.499†
BMI (kg/m^2), *n (%)*			
Underweight	0 (0.0%)	2 (4.3%)	0.667ǂ
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%)	0.427ǂ
Dyslipidemias	14 (51.9%)	23 (51.1%)	0.951ǂ
Diabetes mellitus	4 (14.8%)	6 (13.3%)	0.861ǂ
Renal Impairment	1 (3.6%)	4 (8.7%)	0.116ǂ
Depression status, *n (%)*			
Absence	24 (88.9%)	27 (60.0%)	0.009ǂ
Presence	3 (11.1%)	18 (40.0%)	
Physical activity, *n (%)*			
Low	6 (21.4%)	7 (15.2%)	0.450ǂ
Moderate	11 (39.3%)	14 (30.4%)	
High	11 (39.3%)	25 (54.3%)	
Urinary parameters, *mean ± SD*;			
24-h urine volume, mL	1982.5 ± 654.2	1832.0 ± 655.8	0.341†
24-h UOSM, mOsm/kg	454.0 ± 158.5	402.7 ± 149.4	0.204*
24-h USG	1.015 ± 0.006	1.013 ± 0.005	0.131*
24-h sodium excretion, mg/day	4492.4 ± 1485.3	3495.0 ± 1084.9	0.003†

*Mann-Whitney U test; † T-test for independent samples; ǂ 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 urine[7]. 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 sample[17].

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 gravity[6]. 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 volume[7]. 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 ± 1,485.3 mg/day and 3,495.0 ± 1,084.9 mg/day, p = 0.003), a value above the WHO maximum level of 2,000 mg/day[21]. 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 1ǂ		*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

ǂCrude 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 population[6], three urinary parameters were used in the present study. The 24-h urine indices reflect recent volume of fluid consumed[25], although some authors indicate a lower intraindividual variance in 24-h urine volume[26]. 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 exclude 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 suggest 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.

Acknowledgments

This research was supported by a grant (code PP-IJUP2011-302) from the Young Research Group from the University of Porto – Investigação Jovem da Universidade do Porto. The participation of all elderly individuals in study is gratefully acknowledged. This elderly community project belongs to CIAFEL (PEst-OE/SAU/UI0617/2011). We thank the following individuals for their assistance with data collection: Cláudia Ferreira, Isabel Vaz, Filipa Graça, Inês Pádua e Rita Sousa.

There is no conflict of interest between the authors and the funding source.

References

1. Vivanti A et al. Clinical assessment of dehydration in older people admitted to hospital: What are the strongest indicators? *Archives of Gerontology and Geriatrics* 2008; 47 (3): 340-55.
2. Maughan RJ. Hydration, morbidity, and mortality in vulnerable populations. *Nutrition Reviews* 2012; 70 (s2); S152-S155.
3. Shirreffs S. Markers of hydration status. *European Journal of Clinical Nutrition* 2003; 57: S6-S9.
4. Manz F, Wentz A. 24-h hydration status: parameters, epidemiology and recommendations. *European Journal of Clinical Nutrition* 2003; 57: S10-S18.
5. Armstrong L et al. Urinary indices of hydration status. *International Journal of Sport Nutrition* 1994; 4 (3): 265.
6. Perrier E et al. Hydration biomarkers in free-living adults with different levels of habitual fluid consumption. *British Journal of Nutrition* 2012; 1 (1): 1-10.
7. Alexy U et al. 24h-Sodium excretion and hydration status in children and adolescents-Results of the DONALD Study. *Clinical Nutrition* 2012; 31 (1): 78-84.
8. Stahl A et al. Relation between hydration status in children and their dietary profile–results from the DONALD study. *European Journal of Clinical Nutrition* 2007; 61 (12): 1386-92.
9. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research* 1975; 12 (3): 189-98.
10. Guerreiro M et al. Adaptação à população portuguesa da tradução do "Mini Mental State Examination"(MMSE). *Revista Portuguesa de Neurologia* 1994; 1 (9): 9-10.
11. Craig CL et al. International physical activity questionnaire: 12-Country reliability and validity. *Medicine and Science in Sports and Exercise* 2003; 35 (8): 1381-95.
12. Yesavage JA et al. Development and validation of a geriatric depression screening scale: a preliminary report. *Journal of Psychiatric Research* 1983; 17 (1): 37-49.
13. Pocinho MT et al. Clinical and psychometric validation of the geriatric depression scale (GDS) for portuguese elders. *Clinical Gerontologist* 2009; 32 (2): 223-36.
14. Sánchez-García S et al. Anthropometric measures and nutritional status in a healthy elderly population. *BMC Public Health* 2007; 7 (1): 2.
15. World Health Organization, Obesity: preventing and managing the global epidemic. *World Health Organization Technical Report Series* 2000. 894.
16. Liu L, Ikeda K, Yamori Y. Inverse relationship between urinary markers of animal protein intake and blood pressure in Chinese: results from the WHO Cardiovascular Diseases and Alimentary Comparison (CARDIAC) Study. *International Journal of Epidemiology* 2002; 31 (1): 227-33.
17. He FJ et al. Effect of salt intake on renal excretion of water in humans. *Hypertension* 2001; 38 (3): 317-20.
18. Phillips PA et al. Reduced thirst after water deprivation in healthy elderly men. *New England Journal of Medicine* 1984; 311 (12): 753-9.
19. Kriemler S et al. Preventing dehydration in children with cystic fibrosis who exercise in the heat. *Medicine and Science in Sports and Exercise* 1999; 31 (6): 774-9.
20. Millard Stafford M et al. Thirst and hydration status in everyday life. *Nutrition Reviews* 2012; 70 (s2): S147-S151.
21. World Health Organization. Diet, nutrition and the prevention of chronic diseases Joint WHO/FAO expert consultation 2003 03-Junho-2012]; Available from: http://whqlibdoc.who.int/trs/who_trs_916.pdf.
22. Brown IJ et al. Salt intakes around the world: implications for public health. *International Journal of Epidemiology* 2009; 38 (3): 791-813.
23. Ortega RM et al. Estimation of salt intake by 24 h urinary sodium excretion in a representative sample of Spanish adults. *British Journal of Nutrition* 2011; 105 (5). p. 787.
24. Ribic CH et al. Salt intake of the Slovene population assessed by 24 h urinary sodium excretion. *Public Health Nutr* 2010; 13 (11): 1-7.
25. Popkin BM, D'Anci KE, Rosenberg IH. Water, hydration, and health. *Nutrition Reviews* 2010; 68 (8): 439-58.
26. Dyer AR, Shipley M, Elliott P. Urinary Electrolyte Excretion in 24 Hours and Blood Pressure in the INTERSALT Study I. Estimates of Reliability. *American journal of epidemiology* 1994; 139 (9): 927-39.

Revista Española de Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):68-74
ISSN 1135-3074

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

Emma Ruiz Moreno[1], Susana del Pozo de la Calle[1], Teresa Valero Gaspar[1], Paula Rodríguez Alonso[1], José Manuel Ávila Torres[1] and Gregorio Varela-Moreiras[1,2]

[1]Spanish Nutrition Foundation (FEN), Madrid. Spain. [2]University CEU San Pablo. Madrid. Spain.

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 a 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 conotros países europeos, se puede considerar todavía como relativamente bajo o moderad, 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 cobre consumo de alimentos. Calidad de la dieta. Hidratación.*

Correspondence: Gregorio Varela-Moreiras
E-mail: gvarela@ceu.es - gvarela@fen.org.es

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 meals[1]. An increasing number of people using catering services, restaurants and vending machines[2], 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 observed[3]. 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 population[4].

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, etc[7]. 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 diet[9].

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

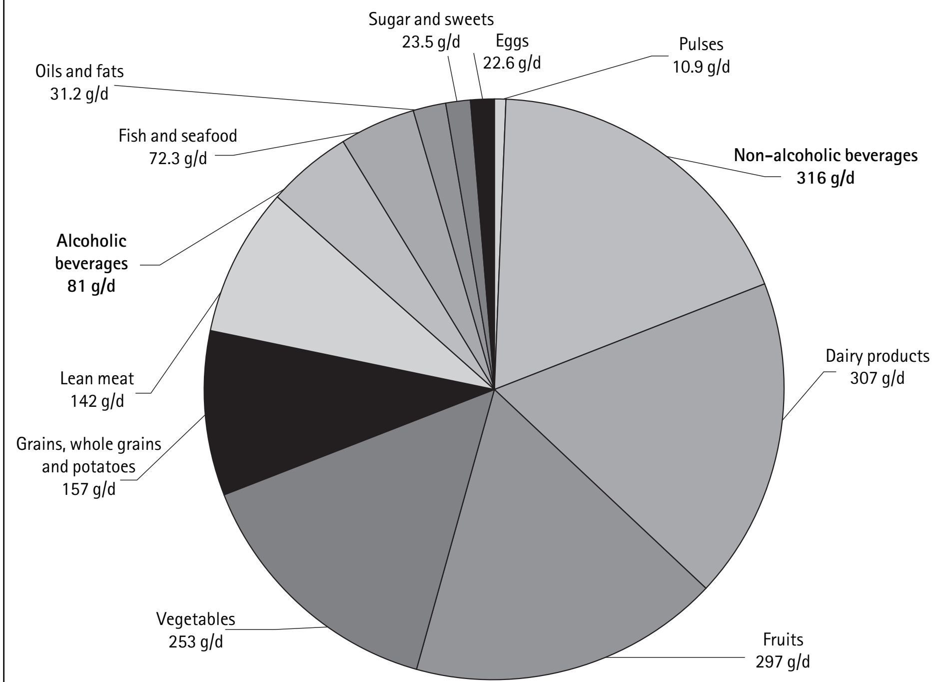


Fig. 1.—Distribution of the different food and beverages groups at Spanish households in 2012 (g/person per day).

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 tenfold 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 nowdays an 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 represented 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)

	Alcoholic beverages		*Non-alcoholic beverages*	
	2011	*2012*	*2011*	*2012*
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)

	Low		*Medium-low*		*Medium*		*High/Medium high*	
	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
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%), alcoholic 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 en energy; carbohydrates (50-60% of the total energy), whereas for alcohol in case of, it should contribute less than 10% of the total en 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 foos 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 1991[10-13]. 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.

Acknowledgements

The authors are grateful to those responsible for the Food Consumption Survey data (Ministry of Agriculture, Food and Environment, MAGRAMA, Spain) and the sponsorship from the Ministry for the present study.

References

1. Cruz Cantera P. Percepción social de la Familia en España. CIS 1995. p. 1-79.

2. Varela G, Ávila J, Cuadrado C, del Pozo S, Ruiz E, Moreiras O. Valoración de la Dieta Española de acuerdo al Panel de Consumo Alimentario. Fundación Española de la Nutrición (FEN). Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino; 2008.
3. Varela-Moreiras G, del Pozo S, Cuadrado C, Ruiz-Moreno E, Ávila J, Moreiras O. Evaluación de patrones de consumo alimentario y factores realacionados en grupos de población emergentes:INMIGRANTES. : Ministerio de Medio Ambiente y Medio Rural y Marino; 2009.
4. Instituto Nacional de Estadística (INE). Encuesta Nacional de Salud 2011-2012. Available at: www.ine.es, 2013.
5. Varela-Moreiras G, Avila J, Cuadrado C, del Pozo S, Ruiz E, Moreiras O. Evaluation of food consumption and dietary patterns in Spain by the Food Consumption Survey: updated information. *Eur J Clin Nutr* 2010; 64: S37-S43.
6. Varela-Moreiras G, Ruiz-Moreno E, Valero T, Avila J, Del Pozo S. The Spanish diet: an update. *Nutr Hosp* 2013; 28 (Supl. 5): 13-20.
7. Ministerio de Agricultura, Alimentación y Medio Ambiente (MAGRAMA). La Alimentación en España. Madrid, España: Ministerio de Agricultura, Alimentación y Medio Ambiente; 1987-2012.
8. Del Pozo S, García V, Cuadrado C, Ruiz E, Valero T, Ávila J, et al. Valoración Nutricional de la Dieta Española de acuerdo al Panel de Consumo Alimentario. Madrid: Fundación Española de la Nutrición (FEN); 2012.
9. Moreiras O, Carbajal Á, Cabrera L, Cuadrado C. Tablas de composición de alimentos. 15.ª ed. Madrid: Pirámide; 2011.
10. Varela G, García D and Moreiras-Varela O. La Nutrición de los Españoles. Diagnóstico y Recomendaciones. Madrid: Escuela Nacional de Administración Pública, 1971.
11. Varela G, Moreiras O, Carbajal A and Campo M. Encuesta de presupuestos familiares 1990-91. Volume I. Spanish National Statistical Institute, 1991.
12. Varela G, Moreiras O, Carbajal A and Campo M. Encuesta de Presupuestos Familiares 1990-91. Estudio Nacional de Nutrición y Alimentación 1991. Vol I. Madrid: INE, 1995.
13. Instituto Nacional de Estadística (INE). Encuesta de Presupuestos Familiares 1980-81 (1985). Estudio sobre Nutrición Vol V, 2nd ed. Madrid: INE.
14. Aranceta J, Pérez C, Amela C, García R. Encuesta de Nutrición de la Comunidad de Madrid. Documentos Técnicos de Salud Pública No. 18. Madrid: Dirección General de Prevención y Promoción de la Salud, Comunidad de Madrid, 1994.
15. Aranceta J, Pérez C, Marzana I, Eguileor I, González de Galdeano L and Saenz de Buruaga J. Food consumption patterns in the Basque Country: the EINUT-I study. *Public Health Nutr* 1998; 1: 185-92.

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition

Rev Esp Nutr Comunitaria 2014;20(Supl. 1):75-80
ISSN 1135-3074

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

Lourdes Ribas-Barba[1,2], Blanca Román-Viñas[1,2], Joy Ngo de la Cruz[1], Carmen Pérez-Rodrigo[3], Javier Aranceta-Bartrina[3] and Lluís Serra-Majem[1,2,4]

[1]Nutrition Research Foundation-FIN. Barcelona Science Park. Barcelona. Spain. [2]Ciber Obn Physiopathology of Obesity and Nutrition. Institute of Health "Carlos III". Madrid. [3]Unit of Community Nutrition. Local Subdivision of Public Health. Bilbao. [4]Department of Clinical Sciences. University of Las Palmas de Gran Canaria. Spain.

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 moment[3]. 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 intake[4]. 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,

Correspondence: Lluis Serra-Majem.
Departamento de Ciencias Clínicas.
Universidad de Las Palmas de Gran Canaria.
Apdo. de Correos 550.
35080 Las Palmas de Gran Canaria.
E-mail: lserra@dcc.ulpgc.es

and those engaging in vigorous exercise[2]. Mild dehydration causes alterations in a variety of critical cognitive functions such as concentration, alertness and short-term memory in children[5] young adults[6-8] and in the elderly[9].

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 status[10-12]. 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 population[13].

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 intake[14]. 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 activity[17].

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 lifestyle[18].

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 elsewhere[19]. 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 Questionnaire[21]. 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 gender[22].

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 recommendations[18], 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 SENC[18], 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 active[23]. 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 sports[24].

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 individuals[25]. 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-

Table I

Beverages consumption (ml/day) by tertiles of total energy expenditure (MET) and age group, and beverage consumption grouped according to the SENC hydration pyramid (ml/day and number of servings/day). Children and adolescents, Spain (2000)

	Age group, years																	
	2-5			6-9			10-13			14-17			18-24			Total		
	Tertiles METS Totals			Tertiles METS Totals			Tertiles METS Totals			Tertiles METS Totals			Tertiles METS Totals			Tertiles METS Totals		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Coffee	.3	.2	.3	.9	.5	1.1	3.8	4.6	2.1	17.9	17.4	16.4	47.7	52.7	59.7	24.6	26.4	29.6
Tea	.0	.0	.6	.9	1.3	.2	3.2	.7	3.0	7.5	4.8	6.9	8.2	12.1	12.3	5.6	6.3	7.2
Sugar sweetened soft drinks	52.6	35.6	28.9	94.3	50.5	60.2	122.1	117.1	115.0	167.6	168.4	175.7	179.3	165.9	166.5	145.1	131.8	134.2
Sugar-free soft drinks	1.1	.3	3.8	.5	1.7	4.1	5.6	6.3	17.6	10.3	11.5	12.4	14.7	15.2	17.5	9.4	9.9	13.6
Water	522.7	682.1	785.3	656.7	808.7	857.5	755.3	910.1	959.9	830.9	1019.8	1017.0	874.3	1035.8	1124.9	785.8	949.6	1013.5
Non alcoholic beverages	576.6	718.2	819.0	753.2	862.7	923.1	890.1	1038.9	1097.6	1034.2	1221.8	1228.4	1124.1	1281.6	1380.9	970.5	1124.0	1198.2
Total Milk	442.3	382.5	450.0	412.8	387.0	422.4	390.5	379.2	405.3	354.7	384.0	360.8	309.7	322.7	348.8	356.9	357.7	378.6
Whole milk	395.2	284.6	350.5	318.7	298.1	322.6	292.4	269.8	273.2	256.8	250.0	231.4	189.6	186.9	225.4	255.1	235.9	257.7
Semi skimmed milk	8.6	17.1	11.2	17.2	12.2	16.5	9.5	25.0	31.2	35.0	50.3	24.1	37.8	52.2	47.7	27.4	39.1	33.4
Skimmed milk	18.2	56.5	55.9	48.4	44.4	48.7	57.5	53.0	72.3	38.6	59.7	76.6	66.5	68.1	56.9	52.6	60.0	62.1
Fresh juice	84.0	62.7	56.8	74.4	75.7	79.8	75.2	65.7	83.5	56.0	67.3	73.8	64.8	67.3	70.0	67.8	67.5	72.7
Packaged juice	89.4	68.0	78.1	62.4	56.2	59.3	54.6	58.2	68.2	64.4	61.0	62.7	56.1	61.9	65.8	61.6	61.1	66.1
Non alcoholic beer	.0	.0	.0	.0	.0	.0	.1	.1	.2	2.2	1.8	1.1	1.3	1.6	1.3	1.0	1.0	.8
Low alcohol drinks: beer, cider alcohol, wine	.0	.0	.0	.0	.0	.1	6.9	2.9	2.1	22.8	23.7	32.4	78.2	88.6	83.9	38.9	42.3	43.0
High alcohol drinks; vermouth, sweet wine, rum, whisky, cognac	.0	.0	.0	.0	.0	.0	1.4	.4	.7	4.8	8.3	10.2	18.4	15.9	20.4	9.0	8.4	10.9
SENC COMPARISON																		
SENC level 1: water	522.7	682.1	785.3	656.7	808.7	857.5	755.3	910.1	959.9	830.9	1019.8	1017.0	874.3	1035.8	1124.9	785.8	949.6	1013.5
SENC level 2: Coffee, tea, sugar-free-soft drinks	1.4	.5	4.7	2.2	3.6	5.4	12.6	11.6	22.7	35.7	33.7	35.7	70.6	80.0	89.5	39.5	42.6	50.5
SENC level 3: Milk, fresh juice, non alcoholic beer	526.2	445.2	506.8	487.2	462.7	502.2	465.8	445.0	488.9	412.9	453.0	435.7	375.8	391.6	420.1	425.7	426.3	452.1
SENC level 4:Sugar sweetened soft drinks, packaged juice	142.0	103.5	107.0	156.7	106.7	119.5	176.8	175.3	183.1	232.0	229.4	238.4	235.3	227.8	232.3	206.7	192.9	200.3
Number of servings level 1 SENC	2.6	3.4	3.9	3.3	4.0	4.3	3.8	4.6	4.8	4.2	5.1	5.1	4.4	5.2	5.6	3.9	4.7	5.1
Number of servings level 2 SENC	.0	.0	.0	.0	.0	.0	.1	.1	.1	.2	.2	.2	.4	.4	.4	.2	.2	.3
Number of servings level 3 SENC	2.6	2.2	2.5	2.4	2.3	2.5	2.3	2.2	2.4	2.1	2.3	2.2	1.9	2.0	2.1	2.1	2.1	2.3
Number of servings level 4 SENC	.7	.5	.5	.8	.5	.6	.9	.9	.9	1.2	1.1	1.2	1.2	1.1	1.2	1.0	1.0	1.0
Number of servings levels 1 to 3 SENC	5.3	5.6	6.5	5.7	6.4	6.8	6.2	6.8	7.4	6.4	7.5	7.4	6.6	7.5	8.2	6.3	7.1	7.6

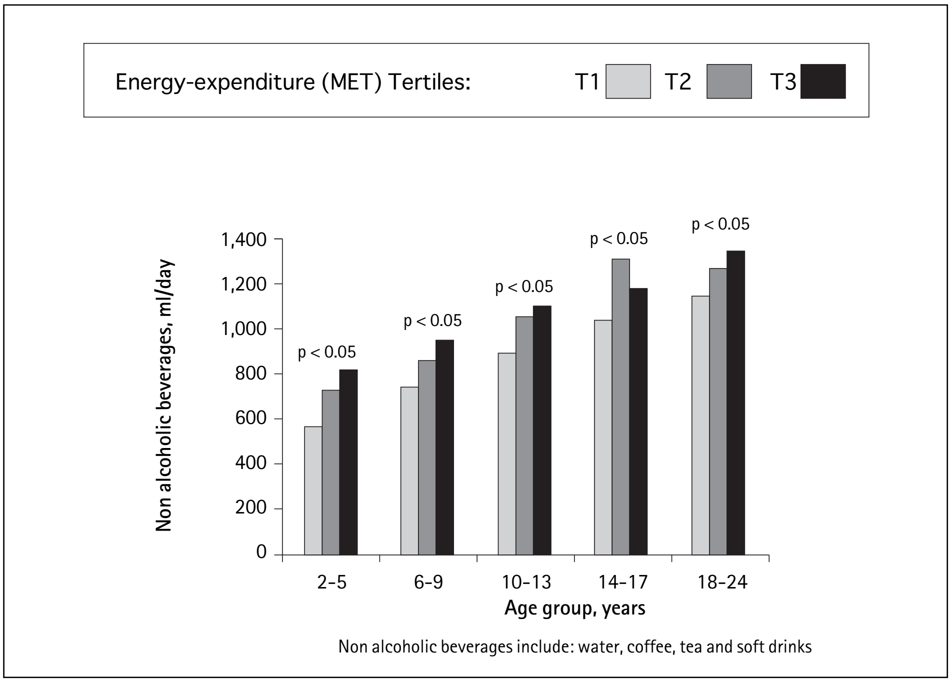


Fig. 1.—Non alcoholic beverage intake in children and adolescents and level of physical activity performed at school/work.

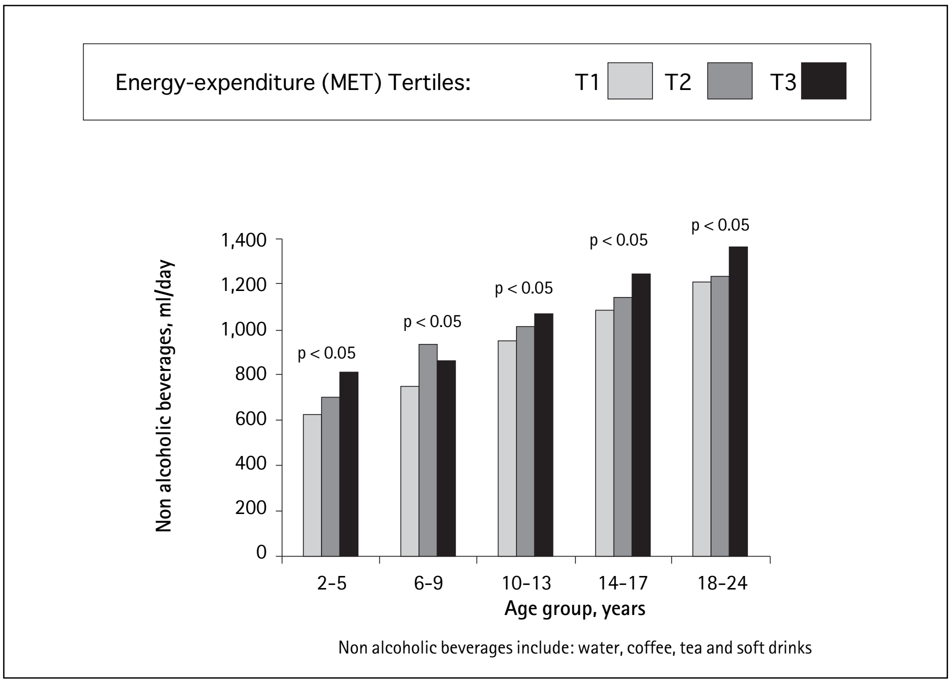


Fig. 2.—Non alcoholic beverage intake in children and adolescents and level of physical activity performed during leisure time.

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 boys[26].

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, Kant[15] 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 day[18]. 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.

References

1. European Food Safety Authority (EFSA), Scientific Opinion on Dietary Reference Values for water. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). *EFSA Journal* 2010; 8 (3): 1459. pp. 1-47
2. Popkin BM, D'Anci KE, Rosenberg IH. Water, Hydration and Health. *Nutr Rev* 2010 August; 68 (8): 439–58.
3. Gibson S, Shirreffs SM. Beverage consumption habits "24/7" among British adults: association with total water intake and energy intake. *Nutr J* 2013 Jan 10; 12: 9.
4. American Academy of Pediatrics Committee on Sports Medicine and Fitness. Climatic heat stress and the exercising child and adolescent. *Pediatrics* 2000; 106: 158–9.
5. Bar-Or O, Dotan R, Inbar O, Rotshtein A, Zonder H. Voluntary hypohydration in 10- to 12-yearold boys. *J Appl Physiol* 1980; 48: 104–8.
6. Cian C, Barraud PA, Melin B, Raphel C. Effects of fluid ingestion on cognitive function after heat stress or exercise-induced dehydration. *Int J Psychophysiol* 2001; 42: 243–51.
7. Cian C, Koulmann PA, Barraud PA, Raphel C, Jimenez C, Melin B. Influence of variations of body hydration on cognitive performance. *J Psychophysiol* 2000; 14: 29–36.
8. D'Anci KE, Vibhakar A, Kanter JH, Mahoney CR, Taylor HA. Voluntary dehydration and cognitive performance in trained college athletes. *Percept Mot Skills* 2009; 109: 251–69.
9. Suhr JA, Hall J, Patterson SM, Niinisto RT. The relation of hydration status to cognitive performance in healthy older adults. *Int J Psychophysiol* 2004; 53: 121–5.
10. Hu FB. Resolved: there is sufficient scientific evidence that decreasing sugar-sweetened beverage consumption will reduce the prevalence of obesity and obesity-related diseases. *Obes Rev* 2013 Aug;14 (8): 606-19.
11. Kaiser KA, Shikany JM, Keating KD, Allison DB. Will reducing sugar-sweetened beverage consumption reduce obesity? Evidence supporting conjecture is strong, but evidence when testing effect is weak. *Obes Rev* 2013 Aug; 14 (8): 620-33.
12. Kosova EC, Auinger P, Bremer AA. The relationships between sugar-sweetened beverage intake and cardiometabolic markers in young children. *J Acad Nutr Diet* 2013 Feb; 113 (2): 219-27.
13. Duffey KJ, Huybrechts I, Mouratidou T, Libuda L, Kersting M, De Vriendt T, et al.; HELENA Study group. Beverage consumption among European adolescents in the HELENA study. *Eur J Clin Nutr* 2012 Feb; 66 (2): 244-52.
14. Drewnowski A, Rehm CD, Constant F. Water and beverage consumption among children age 4-13 y in the United States: analyses of 2005—2010 NHANES data. *Nutr J* 2013 Jun 19; 12 (1): 85.
15. Kant AK, Graubard BI. Contributors of water intake in US children and adolescents: associations with dietary and meal characteristics—National Health and Nutrition Examination Survey 2005-2006. *Am J Clin Nutr* 2010 Oct; 92 (4): 887-96.
16. Bellisle F, Thornton SN, Hébel P, Denizeau M, Tahiri M. A study of fluid intake from beverages in a sample of healthy French children, adolescents and adults. *Eur J Clin Nutr* 2010; 64 (4): 350-5.
17. De Francisco ALM, Martínez Castelao A, en representación del Grupo Investigador Bahía 2008*. Bahía Study 2008: a hydration barometer of the Spanish population. *Nefrologia* 2010; 30 (2): 220-6.
18. Sociedad Española de Nutrición Comunitaria Grupo de expertos. Guía para una hidratación saludable. La Declaración de Zaragoza. SENC, 2008. *Rev Esp Nut Comunitaria* 2009; 15: 45-7.
19. Serra Majem L, Garcia-Closas R, Ribas L, Perez Rodrigo C, Aranceta J. Food patterns of Spanish schoolchildren and adolescents. The enKid study. *Public Health Nutr* 2001; 4: 1433–8.
20. Countrywide Integrated Noncommunicable Diseases Intervention (CINDI) Programme. Protocol and Guidelines. Copenhagen: WHO Regional Office for Europe; 1991.
21. Elosua R, Marrugat J, Molina L, Pons S, Pujol E and the MARATHOM Investigators. Validation of the Minnesota Leisure Time Physical Activity Questionnaire in Spanish men. *Am J Epidemiol* 1994; 139: 1197–209.
22. Roman B, Serra-Majem L, Pérez-Rodrigo C, Drobnic F, Segura R. Physical activity in children and youth in Spain: future actions for obesity prevention. *Nutr Rev* 2009 May; 67 (Supl. 1): S94-S98.
23. Ottevaere C, Huybrechts I, Béghin L, Cuenca-Garcia M, De Bourdeaudhuij I, Gottrand F, et al. HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study Group. Relationship between self-reported dietary intake and physical activity levels among adolescents: the HELENA study. *Int J Behav Nutr Phys Act* 2011 Feb 6;8:8. doi: 10.1186/1479-5868-8-8.
24. Tomlin DL, Clarke SK, Day M, McKay HA, Naylor PJ. Sports drink consumption and diet of children involved in organized sport. *J Int Soc Sports Nutr* 2013 Aug 19;10(1):38. doi: 10.1186/1550-2783-10-38.
25. Cavadini C, Decarli B, Grin J, Narring F, Michaud PA. Food habits and sport activity during adolescence: differences between athletic and non-athletic teenagers in Switzerland. *Eur J Clin Nutr* 2000 Mar; 54 (Supl. 1): S16-20.
26. Ranjit N, Evans MH, Byrd-Williams C, Evans AE, Hoelscher DM. Dietary and activity correlates of sugar-sweetened beverage consumption among adolescents. *Pediatrics* 2010 Oct; 126 (4): e754-761.
27. Park S, Sherry B, O'Toole T, Huang Y. Factors associated with low drinking water intake among adolescents: the Florida Youth Physical Activity and Nutrition Survey, 2007. *J Am Diet Assoc* 2011 Aug; 111 (8): 1211-7.

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).

1. REMISIÓN Y PRESENTACIÓN DE MANUSCRITOS

Los trabajos se remitirán por vía electrónica a través del correo electrónico: redacción@renc.es

Cada parte del manuscrito empezará una página, respetando siempre el siguiente orden:

1.1 Carta de presentación

Deberá indicar el Tipo de Artículo que se remite a consideración y contendrá:

- Una breve explicación de cuál es su aportación así como su relevancia dentro del campo de la nutrición.
- Declaración de que es un texto original y no se encuentra en proceso de evaluación por otra revista, que no se trata de publicación redundante, así como declaración de cualquier tipo de conflicto de intereses o la existencia de cualquier tipo de relación económica.
- Conformidad de los criterios de autoría de todos los firmantes y su filiación profesional.
- Cesión a la revista **Revista Española de Nutrición Comunitaria** de los derechos exclusivos para editar, publicar, reproducir, distribuir copias, preparar trabajos derivados en papel, electrónicos o multimedia e incluir el artículo en índices nacionales e internacionales o bases de datos.
- Nombre completo, dirección postal y electrónica, teléfono e institución del autor principal o responsable de la correspondencia.
- Cuando se presenten estudios realizados en seres humanos, debe enunciarse el cumplimiento de las normas éticas del Comité de Investigación o de Ensayos Clínicos correspondiente y de la Declaración de Helsinki vigente, disponible en: http://www.wma.net/s/index.htm.

1.2 Página de título

Se indicarán, en el orden que aquí se cita, los siguientes datos: título del artículo (en castellano y en inglés); se evitarán símbolos y acrónimos que no sean de uso común.

Nombre completo y apellido de todos los autores, separados entre sí por una coma. Se aconseja que figure un máximo de ocho autores, figurando el resto en un anexo al final del texto.

Mediante números arábigos, en superíndice, se relacionará a cada autor, si procede, con el nombre de la institución a la que pertenecen.

Podrá volverse a enunciar los datos del autor responsable de la correspondencia que ya se deben haber incluido en la carta de presentación.

En la parte inferior se especificará el número total de palabras del cuerpo del artículo (excluyendo la carta de presentación, el resumen, agradecimientos, referencias bibliográficas, tablas y figuras).

1.3 Resumen

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.

Encabezando nueva página se incluirá la traducción al inglés del resumen y las palabras clave, con idéntica estructuración.

1.4 Palabras clave

Debe incluirse al final de resumen un máximo de 5 palabras clave que coincidirán con los Descriptores del Medical Subjects Headings (MeSH): http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=mesh

1.5 Abreviaturas

Se incluirá un listado de las abreviaturas presentes en el cuerpo del trabajo con su correspondiente explicación. Asimismo, se indicarán la primera vez que aparezcan en el texto del artículo.

1.6 Texto

Estructurado en el caso de originales, originales breves y revisiones, cumplimentando los apartados de Introducción, Objetivos, Métodos, Resultados y Discusión (Conclusiones, en su caso).

Se deben citar aquellas referencias bibliográficas estrictamente necesarias teniendo en cuenta criterios de pertinencia y relevancia.

En la metodología, se especificará el diseño, la población a estudio, los métodos estadísticos empleados, los procedimientos y las normas éticas seguidas en caso de ser necesarias.

1.7 Anexos

Material suplementario que sea necesario para el entendimiento del trabajo a publicar.

1.8 Agradecimientos

Esta sección debe reconocer las ayudas materiales y económicas, de cualquier índole, recibidas. Se indicará el organismo, institución o empresa que las otorga y, en su caso, el número de proyecto que se le asigna. Se valorará positivamente haber contado con ayudas.

Toda persona física o jurídica mencionada debe conocer y consentir su inclusión en este apartado.

1.9 Bibliografía

Las citas bibliográficas deben verificarse mediante los originales y deberán cumplir los Requisitos de Uniformidad del Comité Internacional de Directores de Revistas Médicas, como se ha indicado anteriormente.

Las referencias bibliográficas se ordenarán y numerarán por orden de aparición en el texto, identificándose mediante números arábigos en superíndice.

Las referencias a textos no publicados ni pendiente de ello, se deberán citar entre paréntesis en el cuerpo del texto.

Para citar las revistas médicas se utilizarán las abreviaturas incluidas en el *Journals Database,* disponible en: http://www. ncbi.nlm.nih.gov/entrez/query.fcgi?db=journals.

En su defecto en el catálogo de publicaciones periódicas en bibliotecas de ciencias de la salud españolas: http://www.c17.net/c17/.

▶▶▶

1.10 Tablas y Figuras

El contenido será autoexplicativo y los datos no deberán ser redundantes con lo escrito. Las leyendas deberán incluir suficiente información para poder interpretarse sin recurrir al texto y deberán estar escritas en el mismo formato que el resto del manuscrito.

Se clasificarán con números arábigos, de acuerdo con su orden de aparición, siendo esta numeración independiente según sea tabla o figura. Llevarán un título informativo en la parte superior y en caso de necesitar alguna explicación se situará en la parte inferior. En ambos casos como parte integrante de la tabla o de la figura.

Se remitirán en fichero aparte, preferiblemente en formato JPEG, GIFF, TIFF o PowerPoint, o bien al final del texto incluyéndose cada tabla o figura en una hoja independiente.

1.11 Autorizaciones y declaración de conflictos de intereses

Si se aporta material sujeto a copyright o que necesite de previa autorización para su publicación, se deberá acompañar, al manuscrito, las autorizaciones correspondientes.

Se incluirá, al final de cada trabajo y previa a la bibliografía la declaración de intereses del autor/autores del trabajo.

2. TIPOS Y ESTRUCTURA DE LOS TRABAJOS

2.1 Original: Trabajo de investigación cuantitativa o cualitativa relacionado con cualquier aspecto de la investigación en el campo de la nutrición.

2.2 Original breve: Trabajo de la misma característica que el original, que por sus condiciones especiales y concreción, puede ser publicado de manera más abreviada.

2.3 Revisión: Trabajo de revisión, preferiblemente sistemática, sobre temas relevantes y de actualidad para la nutrición.

2.4 Notas Clínicas: Descripción de uno o más casos, de excepcional interés que supongan una aportación al conocimiento clínico.

2.5 Perspectiva: Artículo que desarrolla nuevos aspectos, tendencias y opiniones. Sirviendo como enlace entre la investigación y la sociedad.

2.6 Editorial: Artículo sobre temas de interés y actualidad. Se escribirán a petición del Comité Editorial.

2.7 Carta al Director: Observación científica y de opinión sobre trabajos publicados recientemente en la revista, así como otros temas de relevante actualidad.

2.8 Carta Científica: La multiplicación de los trabajos originales que se reciben nos obligan a administrar el espacio físico de la revisa. Por ello en ocasiones pediremos que algunos originales se reconviertan en carta científica cuyas características son:

- Título
- Autor (es)
- Filiación
- Dirección para correspondencia
- Texto máximo 400 palabras
- Una figura o una tabla
- Máximo cinco citas

La publicación de una Carta Científica no es impedimento para que el artículo *in extenso* pueda ser publicado posteriormente en otra revista.

2.9 Artículo de Recensión: Comentarios sobre libros de interés o reciente publicación. Generalmente a solicitud del Comité editorial aunque también se considerarán aquellos enviados espontáneamente.

2.10 Artículo Especial: El Comité Editorial podrá encargar, para esta sección, otros trabajos de investigación u opinión que considere de especial relevancia. Aquellos autores que de forma voluntaria deseen colaborar en esta sección, deberán contactar previamente con el Director de la revista.

2.11 Artículo Preferente: Artículo de revisión y publicación preferente de aquellos trabajos de una importancia excepcional. Deben cumplir los requisitos señalados en este apartado, según el tipo de trabajo. En la carta de presentación se indicará de forma notoria la solicitud de Artículo Preferente. Se publicarán en el primer número de la revista posible.

EXTENSIÓN ORIENTATIVA DE LOS MANUSCRITOS

Tipo de artículo	Resumen	Texto	Tablas y figuras	Referencias
Original	Estructurado 250 palabras	Estructurado 4.000 palabras	5	35
Original breve	Estructurado 150 palabras	Estructurado 2.000 palabras	2	15
Revisión	Estructurado 250 palabras	Estructurado 6.000 palabras	6	150
Notas clínicas	150 palabras	1.500 palabras	2	10
Perspectiva	150 palabras	1.200 palabras	2	10
Editorial	—	2.000 palabras	2	10 a 15
Carta al Director	—	400 palabras	1	5

Eventualmente se podrá incluir, en la edición electrónica, una versión más extensa o información adicional.

3. PROCESO EDITORIAL

El Comité de Redacción acusará recibo de los trabajos recibidos en la revista e informará, en el plazo más breve posible, de su recepción.

Todos los trabajos recibidos, se someten a evaluación por el Comité Editorial y por al menos dos revisores expertos.

Los autores puden sugerir revisores que a su juicio sean expertos sobre el tema. Lógicamente, por motivos éticos obvios, estos revisores propuestos deben ser ajenos al trabajo que se envía. Se deberá incluir en el envío del original nombre y apellidos, cargo que ocupan y email de los revisores que se proponen.

Previamente a la publicación de los manuscritos, se enviará una prueba al autor responsable de la correspondencia utilizando el correo electrónico. Esta se debe revisar detenidamente, señalar posibles erratas y devolverla corregida a su procedencia en el plazo máximo de 48 horas. Revista Española de Nutrición Comunitaria no acepta la responsabilidad de afirmaciones realizadas por los autores

Revista Española de
Nutrición Comunitaria
Spanish Journal of Community Nutrition