Available Research on:
Hydration and Electrolyte Replacement

Drinking water is associated with weight loss in overweight dieting women independent of diet and activity.

OBESITY: (Silver Spring). 2008 Nov; 16(11): 2481-8. Epub 2008 Sep 11. Stookey JD, Constant F, Popkin BM,
Gardner CD. Children's Hospital Oakland Research Institute, Oakland, California, USA.

BACKGROUND: Data from short-term experiments suggest that drinking water may promote weight loss by lowering total energy intake and/or altering metabolism. The long-term effects of drinking water on change in body weight and composition are unknown, however.

OBJECTIVE: This study tested for associations between absolute and relative increases in drinking water and weight loss over 12 months.

METHODS AND PROCEDURES: Secondary analyses were conducted on data from the Stanford A TO Z weight loss intervention on 173 premenopausal overweight women (aged 25-50 years) who reported <1 l/day drinking water at baseline. Diet, physical activity, body weight, percent body fat (dual-energy X-ray absorptiometry), and waist circumference were assessed at baseline, 2, 6, and 12 months. At each time point, mean daily intakes of drinking water, noncaloric, unsweetened caloric (e.g., 100% fruit juice, milk) and sweetened caloric beverages, and food energy and nutrients were estimated using three unannounced 24-h diet recalls. Beverage intake was expressed in absolute (g) and relative terms (% of beverages). Mixed models were used to test for effects of absolute and relative increases in drinking water on changes in weight and body composition, controlling for baseline status, diet group, and changes in other beverage intake, the amount and composition of foods consumed and physical activity. RESULTS: Absolute and relative increases in drinking water were associated with significant loss of body weight and fat over time, independent of covariates.

DISCUSSION: The results suggest that drinking water may promote weight loss in overweight dieting women.

Water as an essential nutrient: the physiological basis of hydration.

Jéquier E, **Constant F**.

Department of Physiology, University of Lausanne, Pully, Switzerland.

How much water we really need depends on water functions and the mechanisms of daily water balance regulation. The aim of this review is to describe the physiology of water balance and consequently to highlight the new recommendations with regard to water requirements. Water has numerous roles in the human body. It acts as a building material; as a solvent, reaction medium and reactant; as a carrier for nutrients and waste products; in thermoregulation; and as a lubricant and shock absorber. The regulation of

water balance is very precise, as a loss of 1% of body water is usually compensated within 24 h. Both water intake and water losses are controlled to reach water balance. Minute changes in plasma osmolarity are the main factors that trigger these homeostatic mechanisms. Healthy adults regulate water balance with precision, but young infants and elderly people are at greater risk of dehydration. Dehydration can affect consciousness and can induce speech incoherence, extremity weakness, hypotonia of ocular globes, orthostatic hypotension and tachycardia. Human water requirements are not based on a minimal intake because it might lead to a water deficit due to numerous factors that modify water needs (climate, physical activity, diet and so on). Water needs are based on experimentally derived intake levels that are expected to meet the nutritional adequacy of a healthy population. The regulation of water balance is essential for the maintenance of health and life. On an average, a sedentary adult should drink 1.5 l of water per day, as water is the only liquid nutrient that is really essential for body hydration.European Journal of Clinical Nutrition advance online publication, 2 September 2009; doi:10.1038/ejcn.2009.111.

J Occup Health. 2006 Jul;48(4):284-9.

Using urine specific gravity to evaluate the hydration status of workers working in an ultra-low humidity environment.

Su SB, **Lin KH**, **Chang HY**, **Lee CW**, **Lu CW**, **Guo HR**.

Department of Environmental and Occupational Health, Medical College, National Cheng Kung University, Taiwan.

--- USG (urine specific gravity) is a good biomarker for evaluating the hydration status of workers working in ultra-low humidity environments, who need proper protection and adequate fluid supply to prevent excess water loss and its adverse health effects.

J R Coll Physicians Lond. 1998 Jul-Aug;32(4):328-32. Links

Community acquired pneumonia.

Finch R.

City Hospital, Nottingham.

CAP affects all ages but predominantly the elderly. The microbial aetiology is diverse and rarely established at the time of admission. Initial management includes assessment of severity, correction of dehydration and imbalances of gas exchange, and prompt administration of antibiotic. The regimens will vary by risk factor and severity assessment. Mortality remains high, especially in those requiring intensive care. Prevention includes control of underlying disease, smoking and ethanol abuse, and the appropriate use of influenza and pneumococcal vaccines.

Br J Nutr. 2004 Jun;91(6):951-8.

The effects of fluid restriction on hydration status and subjective feelings in man.

Shirreffs SM, **Merson SJ**, **Fraser SM**, **Archer DT**.

The subjects reported feelings of headache during the FR trial and also that their ability to concentrate and their alertness were reduced.

Occup Environ Med. 2003 Feb;60(2):90-6

Fluid losses and hydration status of industrial workers under thermal stress working extended shifts.

CONCLUSIONS: This study found that "involuntary dehydration" did not occur in **well informed workers**, which has implications for heat stress standards that do not make provision for full fluid replacement during heat exposure. Fluid replacement during meal breaks was not significantly increased above fluid replacement rates during work time, with implications for the duration and spacing of meal breaks on long shifts. Testing of urinary specific gravity was found to be a good indication of hydration status and a practical method of improving workforce awareness and understanding of this important risk factor. Approximately 10 000 dehydration tests have been conducted under the dehydration protocol in a workforce of 2000 persons exposed to thermal stress and has proved practical and reliable.

J Strength Cond Res. 2008 Mar;22(2):455-63. Links

Active dehydration impairs upper and lower body anaerobic muscular power.

Jones LC, **Cleary MA**, **Lopez RM**, **Zuri RE**, **Lopez R**.

Athletics Department, Chicago State University, Chicago, Illinois, USA.

Our findings suggest that dehydration of 2.9% body mass decreases the ability to generate upper and lower body anaerobic power. Coaches and athletes must understand that sports performance requiring anaerobic strength and power can be impaired by inadequate hydration and may contribute to increased susceptibility to musculoskeletal injury.

Should children drink more water?: the effects of drinking water on cognition in children.

Edmonds CJ, **Burford D**.

School of Psychology, University of East London, Stratford Campus, University House, London, UK. c.edmonds@uel.ac.uk

… Results showed that children who drank additional water rated themselves as significantly less thirsty than the comparison group (p=0.002), and they performed better on visual attention tasks (letter cancellation, p=0.02; spot the difference memory tasks, ps=0.

Nutr Rev. 2006 Oct;64(10 Pt 1):457-64.

Hydration and cognitive function in children.

D'Anci KE, **Constant F**, **Rosenberg IH**.

Research in young adults shows that mild dehydration corresponding to only 1% to 2% of body weight loss can lead to significant impairment in cognitive function. Dehydration in infants is associated with confusion, irritability, and lethargy; in children, it may produce decrements in cognitive performance.

Nurs Times. 2003 Jan 7-13;99(1):50-1.

Drinking water in schools.

Brander N.

Children do not drink enough during the school day--and the resulting dehydration contributes to continence problems (Box 1). One important part of treating these problems is an adequate and regular fluid intake during the day (Haines et al, 2000). However, it is not uncommon for pupils to go six or seven hours without a single drink, and those who do drink usually drink less than they need (Almond, 1993; Haines et al, 2000).

Child Care Health Dev. 2007 Jul;33(4):409-15.

A study of the association between children's access to drinking water in primary schools and their fluid intake: can water be 'cool' in school?

Kaushik A, **Mullee MA**, **Bryant TN**, **Hill CM**.

CONCLUSION: Most children have an inadequate fluid intake in school. Free access to drinking water in class is associated with improved total fluid intake. Primary schools should promote water drinking in class.

(Note: See my marketing strategy for "hydr8" baseball caps and t-shirts…this is a strategy taken right out of Pepsi/Cok, to address the "cool" factor)

Adolesc Med Clin. 2005 Jun;16(2):447-61, x.

School commercialism and adolescent health.

Molnar A.

Education Policy Studies Laboratory, College of Education, Arizona State University, Box 872411, Tempe, AZ 85287-2411, USA. alex.molnar@asu.edu

Commercial activities in public schools are examined in light of growing concern over increasing rates of childhood obesity. The work and findings of the Education Policy Studies Laboratory, which documents school commercialism through media references, is detailed. Alongside evidence of increased commercialism, including activities that promote the consumption of unhealthful beverages and foods by students, growing public opposition to such activities also is documented. The argument is made that schoolhouse commercialism is not in the best interests of the health or the education of students.

Int J Paediatr Dent. 2004 Jul;14(4):267-71.

Fluid for thought: availability of drinks in primary and secondary schools in Cardiff, UK.

Hunter ML, **Chestnutt IG**, **Evans SM**, **Withecombe AC**.

Department of Dental Health and Biological Sciences, UWCM Dental School, Cardiff, UK. hunterml@cf.ac.uk

CONCLUSIONS: While primary schools appear largely to restrict the availability of drinks to those conducive to the maintenance of good general and dental health, secondary schools appear to foster the use of vending machines. Guidelines should be developed on the use and content of vending machines in schools in order to both meet school objectives and promote healthy choices.

J Hum Nutr Diet. 2005 Aug;18(4):281-6.

Does the provision of cooled filtered water in secondary school cafeterias increase water drinking and decrease the purchase of soft drinks?

Loughridge JL, **Barratt J**.

Community Dietitian for Schools, North Tyneside, Wallsend, Tyne and Wear, UK. jane.loughridge@northyneside.gov.uk

CONCLUSIONS: This pilot study indicates that active promotion of water drinking increased consumption of water by secondary school students. Further developments of the project are suggested.

J Athl Train. 2007 Jan-Mar;42(1):66-75.

Two percent dehydration impairs and six percent carbohydrate drink improves boys basketball skills.

Dougherty KA, **Baker LB**, **Chow M**, **Kenney WL**.

CONCLUSION: Deterioration in basketball skill performance accompanies two percent dehydration in skilled 12- to 15-yr-old basketball players. Additionally, EUH with a 6% CES significantly improves shooting performance and on-court sprinting over EUH with water.

Neuropsychological performance, postural stability, and symptoms after dehydration.

Patel AV, **Mihalik JP**, **Notebaert AJ**, **Guskiewicz KM**, **Prentice WE**.

University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, USA.

CONCLUSIONS: Our results suggest that moderate dehydration (-2.5 +/- 0.63%) significantly influenced the self-report of symptoms commonly associated with concussion. Dehydration resulted in a deterioration of visual memory and increases in the self-report of fatigue. Despite these findings, dehydration did not affect other neuropsychological and postural stability objective testing measures for concussion.

Increasing the daily water intake for the prophylactic treatment of headache: a pilot trial.

Spigt MG, **Kuijper EC**, **Schayck CP**, **Troost J**, **Knipschild PG**, **Linssen VM**, **Knottnerus JA**.

Our results seem to justify larger scaled research on the effectiveness of increased water intake in headache patients.

J Am Coll Nutr. 2007 Oct;26(5 Suppl):575S-584S.

Assessing hydration status: the elusive gold standard.

Armstrong LE.

Human Performance Laboratory, Department of Kinesiology, University of Connecticut, Storrs, CT 06269-1110, USA. lawrence.armstrong@uconn.edu

…one blood or urine sample cannot validly represent fluctuating TBW and fluid compartments. Future research should (a) evaluate novel techniques that assess hydration in real time and are precise, accurate, reliable, non-invasive, portable, inexpensive, safe, and simple; and (b) clarify the relationship between P(osm) and TBW oscillations in various scenarios.

(Note: This is why I recommend avg 3-4 hydrometer readings per day in the training – there is room on the assessment sheet for up to 5 readings/day).

J Am Coll Nutr. 2007 Oct;26(5 Suppl):597S-603S.

Hydration at the work site.

Kenefick RW, **Sawka MN**.

United States Army Research Institute of Environmental Medicine, 42 Kansas Street, Natick, MA 01760, USA. Robert.Kenefick@us.army.mil

… the majority of legislative guidelines provide vague guidance and none take into account the effects of work intensity, specific environments, or protective clothing. Improved occupational guidelines for fluid and electrolyte replacement during hot weather occupational activities should be developed to include recommendations for fluid consumption before, during, and after work.

Fluid replacement following dehydration reduces oxidative stress during recovery.

Paik IY, **Jeong MH**, **Jin HE**, **Kim YI**, **Suh AR**, **Cho SY**, **Roh HT**, **Jin CH**, **Suh SH**.

Department of Physical Education, Yonsei University, Shinchon-Dong, Seodaemun-Gu, Seoul, South Korea.

…results suggest that (1) dehydration impairs exercise performance and increases DNA damage during exercise to exhaustion; and (2) fluid replacement prolongs exercise endurance and attenuates DNA damage.

Pre-exercise hyperhydration delays dehydration and improves endurance capacity during 2 h of cycling in a temperate climate.

Goulet ED, **Rousseau SF**, **Lamboley CR**, **Plante GE**, **Dionne IJ**.

Research Centre on Aging, University of Sherbrooke, Sherbrooke, P.Q., Canada.

…pre-exercise hyperhydration improves endurance capacity and peak power output and decreases heart rate and thirst sensation, but does not reduce rectal temperature during 2 h of moderate to intense cycling in a moderate environment when fluid consumption is 33% of sweat losses.

The use of body mass changes as a practical measure of dehydration in team sports.

Harvey G, **Meir R**, **Brooks L**, **Holloway K**.

Department of Exercise Science and Sport Management, Australia.

…. a change in body mass during a game of soccer is an effective method of monitoring dehydration due to sweat loss when compared to other known methods that may be invasive and inappropriate in the field.

Voluntary dehydration among elementary school children residing in a hot arid environment.

Bar-David Y, **Urkin J**, **Landau D**, **Bar-David Z**, **Pilpel D**.

Division of Pediatrics, Soroka University Medical Center and Primary Pediatric Care Unit, Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel.

Conclusions: A high proportion of children who reside in a hot and arid environment were found to be in a state of moderate to severe dehydration. Bedouin ethnicity was associated with better hydration, whereas Israeli-born Jews were most severely dehydrated. Educational intervention programmes promoting water intake should start in early childhood and continue throughout life.

Strategies for ensuring good hydration in the elderly.

Ferry M.

Centre Hospitalier Universitaire, Service de Gériatrie, 179 Blvd. du Maréchal Juin, F-26953 Valence 9, France. mferry@ch-valence.fr

The prevention of dehydration must be multidisciplinary. Caregivers and health care professionals should be constantly aware of the risk factors and signs of dehydration in elderly patients. Strategies to maintain normal hydration should comprise practical approaches to induce the elderly to drink enough. This can be accomplished by frequent encouragement to drink, by offering a

wide variety of beverages, by advising to drink often rather than large amounts, and by adaptation of the environment and medications as necessary.

Int J Sports Physiol Perform. 2008 Sep;3(3):262-78. Links

Hydration status, knowledge, and behavior in youths at summer sports camps.

Decher NR, **Casa DJ**, **Yeargin SW**, **Ganio MS**, **Levreault ML**, **Dann CL**, **James CT**, **McCaffrey MA**, **Oconnor CB**, **Brown SW**.

Department of Kinesiology, University of Connecticut, USA.

CONCLUSION: Hydration at summer sports camp is a concern and special efforts need to be made to help youths develop hydration strategies.

Wilderness Environ Med. 2008 Fall;19(3):172-80. Links

Effects of an electrolyte additive on hydration and drinking behavior during wildfire suppression.

Cuddy JS, **Ham JA**, **Harger SG**, **Slivka DR**, **Ruby BC**.

Human Performance Laboratory, University of Montana, Missoula, MT 59812, USA.

CONCLUSION: The addition of an electrolyte mixture to plain water decreased the overall fluid consumption of the water + electrolyte group by 220 mL.h(-1) (3.3 L.d(-1)). Supplementing water with electrolytes can reduce the amount of fluid necessary to consume and transport during extended activity. This can minimize carrying excessive weight, possibly reducing fatigue during extended exercise.

Int J Sports Med. 2006 Apr;27(4):330-5.

Consistently high urine specific gravity in adolescent American football players and the impact of an acute drinking strategy.

Stover EA, **Zachwieja J**, **Stofan J**, **Murray R**, **Horswill CA**.

Gatorade Sports Science Institute, Barrington, IL 60010, USA.

The slight decline in body weight and consistently high USG (Part 1) suggested that standard fluid replacement strategies were less than optimal for a majority of the players. Implementing a drinking strategy appeared to improve hydration status based on changes in body weight and USG (Part 2).

J Sports Med Phys Fitness. 1999 Mar;39(1):47-53. Links

Urine color, osmolality and specific electrical conductance are not accurate measures of hydration status during postexercise rehydration.

Kovacs EM, **Senden JM**, **Brouns F**.

Department of Human Biology, Maastricht University, The Netherlands.

Urine color, SEC (specific electrical conductance) and osmolality are poor indicators of hydration status measured from the balance between fluid intake and urine output up to 6 hrs postexercise.

(Note…I recommend hydrometer SG readings rather than these other indicators, which are more secondary in nature…)

AIHA J (Fairfax, Va). 2002 Mar-Apr;63(2):190-8. Links

A review of fluid replacement for workers in hot jobs.

Clap AJ, **Bishop PA**, **Smith JF**, **Lloyd LK**, **Wright KE**.

Department of HPER, South Dakota State University, Brookings 57007, USA.

Although water is a very common beverage, some previous research has reported that drinks containing low to moderate levels of electrolytes and carbohydrates may provide some significant advantages in industrial situations. In general these studies seem to support the use of electrolyte-carbohydrate beverages as a supplement to water or as a replacement for water.

(Note: I recommend training in adding unrefined sea salt to the water...)

J Appl Physiol. 1998 Oct;85(4):1329-36.

Effect of sodium in a rehydration beverage when consumed as a fluid or meal.

Ray ML, **Bryan MW**, **Ruden TM**, **Baier SM**, **Sharp RL**, **King DS**.

Exercise Biochemistry Laboratory, Department of Health and Human Performance, Iowa State University, Ames, Iowa 50011, USA.

…results provide evidence that the inclusion of sodium in rehydration beverages, as well as consumption of a sodium-containing liquid meal, increases fluid retention and improves plasma volume restoration.

Drinking salt water enhances rehydration in horses dehydrated by frusemide administration and endurance exercise.

Butudom P, **Schott HC 2nd**, **Davis MW**, **Kobe CA**, **Nielsen BD**, **Eberhart SW**.

Department of Large Animal Clinical Sciences, Michigan State University, East Lansing 48824-1314, USA.

…providing salt water as the initial rehydration fluid maintained an elevated [Na+] and resulted in greater total FI and recovery of bwt loss during the first hour of recovery, in comparison to offering only plain water.

Fluid and electrolyte balance in elite gaelic football players.

Newell M, **Newell J**, **Grant S**.

Institute of Biomedical and Life Sciences, University of Glasgow, Scotland.

A single hydration strategy based on published guidelines may not be suitable for an entire team due to variations in individual sweat rates. Maximising player performance could be better achieved by accurate quantification of individual fluid and electrolyte losses.

(Note: Recommend drinking half body weight in ounces per day minimum, plus unrefined sea salt additive…)

Clin Sports Med. 1999 Jul;18(3):513-24. Links

Water and electrolyte requirements for exercise.

Latzka WA, **Montain SJ**.

Thermal and Mountain Medicine Division, US Army Research Institute of Environmental Medicine, Natick, Massachusetts, USA. wlatzka@natick-ccmail.army.mil

Electrolyte supplementation is generally not necessary because dietary intake is adequate to offset electrolytes lost in sweat and urine; however, during initial days of hot-weather training or when meals are not calorically adequate, supplemental salt intake may be indicated to sustain sodium balance.

Can J Appl Physiol. 1999 Apr;24(2):188-200. Links

Dehydration, rehydration, and exercise in the heat: rehydration strategies for athletic competition.

Galloway SD.

Department of Sports Studies, University of Stirling, Stirling FK9 4LA Scotland.

The best postexercise rehydration strategy would be to ingest a large volume of a beverage that contains a CHO source and a high sodium content.

Voluntary fluid intake and core temperature responses in adolescent tennis players: sports beverage versus water.

Bergeron MF, **Waller JL**, **Marinik EL**.

Department of Physical Therapy, Medical College of Georgia, Augusta, GA 30912-0800, USA. mbergero@mcg.edu

CONCLUSION: Ad libitum consumption of a CHO-E (carbohydrate/electrolyte drink) may be more effective than water in minimising fluid deficits and mean core temperature responses during tennis and other similar training in adolescent athletes.

Sports drinks, exercise training, and competition.

von Duvillard SP, **Arciero PJ**, **Tietjen-Smith T**, **Alford K**.

Human Performance Laboratory, Department of Health and Human Performance, Texas A&M University-Commerce, Commerce, Texas 75429-3011, USA. serge_vonduvillard@tamu-commerce.edu

However, overdrinking may cause Na+ depletion and in some cases lead to hyponatremia. Maintaining proper hydration before, during, and after training and competition will help reduce fluid loss, maintain performance, lower submaximal exercise heart rate, maintain plasma volume, and reduce heat stress, heat exhaustion, and possibly heat stroke.

(Note: Na+ depletion indicates lack of sea salt in water…)

Rehydration with drinks differing in sodium concentration and recovery from moderate exercise-induced hypohydration in man.

Merson SJ, **Maughan RJ**, **Shirreffs SM**.

School of Sport and Exercise Sciences, Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK.

…the addition of 40 or 50 mmol/l of sodium chloride to a rehydration beverage reduced subsequent urine output, thereby providing more effective rehydration than a sodium-free drink. This did not, however, result in improved performance 4 h after the end of the rehydration period.

Dehydration rates and rehydration efficacy of water and sports drink during one hour of moderate intensity exercise in well-trained flatwater kayakers.

Sun JM, **Chia JK**, **Aziz AR**, **Tan B**.

Changi Sports Medicine Centre, Changi General Hospital, Singapore.
jermie@singnet.com.sg

Although the hydration efficacy of Gatorade proved superior to that of water, the athletes' hydration habits with either fluids did not provide adequate hydration. It is recommended that specific strategies be developed to address dehydration and rehydration issues of kayakers in Singapore.

(Note: Gatorade is less welcome in society's with lower sugar intake…better to use water + sea salt)

Water balance and salt losses in competitive football.

Maughan RJ, **Watson P**, **Evans GH**, **Broad N**, **Shirreffs SM**.

School of Sport and Exercise Sciences, Longborough University, Longborough, Leicestershire, LE11 3TU England.

…descriptive data show a large individual variability in hydration status, sweat losses, and drinking behaviors in a competitive football match played in a cool environment, highlighting the need for *individualized assessment of hydration status to optimize fluid-replacement strategies.*

Dehydration Studies in Older Adults

Dehydration—a fluid imbalance caused by too little fluid taken in or too much fluid lost or both—can occur quickly in all older adults, and the effects can be harmful.
Weinberg AD, Minaker KL. Dehydration. Evaluation and management in older adults. *Council on Scientific Affairs, American Medical Association. JAMA 1995; 274(19):1552–6.*

Hospitalizations for dehydration in older adults increased by 40% from 1990 to 2000. Xiao H, et al. Economic burden of dehydration among hospitalized elderly patients.
Am J Health Syst Pharm 2004; 61(23):2534–40.

Adequate fluid consumption has been associated with fewer falls, lower rates of constipation, and lower rates of laxative use, as well as better rehabilitation outcomes in orthopedic patients and reduced risk of bladder cancer in men. Robinson SB, Rosher RB. Can a beverage cart help improve hydration? *Geriatr Nurs 2002;23(4):208–11.* Mukand JA, et al. The effects of dehydration on rehabilitation outcomes of elderly orthopedic patients. *Arch Phys Med Rehabil 2003;84(1):58–61.* Michaud DS, et al. Fluid intake and the risk of bladder cancer in men. *N Engl J Med 1999;340(18):1390–7.*

Drinking five or more 8-oz. glasses of water (but not other liquids) per day has been associated with lower rates of fatal coronary heart disease in middle-age and older adults than drinking two or fewer glasses. Chan J, et al. Water, other fluids, and fatal coronary heart disease: the Adventist Health Study. *Am J Epidemiol 2002;155(9):827–33.*

Drinking 16 oz. of room-temperature water before a meal resulted in significantly lower rates of postprandial orthostatic hypotension in older adults who had autonomic failure. Shannon JR, et al. Water drinking as a treatment for orthostatic syndromes. *Am J Med 2002;112(5):355–60.*

Potential consequences of dehydration include constipation, falls, medication toxicity, urinary-tract and respiratory infections, delirium, renal failure, seizure, electrolyte imbalance, hyperthermia, and longer time to wound healing (especially pressure ulcers). Mentes JC, Culp K. Reducing hydration-linked events in nursing home residents. *Clin Nurs Res 2003;12(3):210–25.* Bennett JA, et al. Unrecognized chronic dehydration in older adults: examining prevalence rate and risk factors. *J Gerontol Nurs 2004;30(11):22–8.*

In older adults with many comorbidities, dehydration can precipitate emergency hospitalization and increase the risk of repeated hospitalizations. Gordon JA, et al. Initial emergency department diagnosis and return visits: risk versus perception. Ann *Emerg Med 1998;32(5):569–73.*

Dehydration has been associated with increased mortality rates among hospitalized older adults. Warren JL, et al. The burden and outcomes associated with dehydration among US elderly, 1991. *Am J Public Health 1994;84(8):1265–9.*

Healthy, community-dwelling older adults have no differences from younger adults in “water consumption, total water intake, water output through urine, total water output, and net water balance.” In this comparison of older and younger adults using a controlled diet, the researchers found “markers of hydration status were within the range of clinical normalcy for all groups.” Bossingham MJ, et al. Water balance, hydration status, and fat-free mass hydration in younger and older adults. *Am J Clin Nutr 2005;81(6):1342–50.*

48% of older adults admitted had laboratory values indicative of dehydration; 80% of them lived in the community. Bennett JA, et al. Unrecognized chronic dehydration in older adults: examining prevalence rate and risk factors. *J Gerontol Nurs 2004;30(11):22–8.*

Dehydration is not solely a function of the aging process but may be more related to concomitant medical conditions or dependent living. Morgan AL, et al. Hydration status of community-dwelling seniors. *Aging Clin Exp Res 2003;15(4):301–4.*

Physical or emotional illness, surgery, trauma, or higher physiologic demands (as occurs in exercise) increase risk of dehydration. Luckey AE, Parsa CJ. Fluid and electrolytes in the aged. *Arch Surg 2003;138(10):1055–60.*

Dehydration in nursing homes has been linked to inadequately trained nurses and insufficiently supervised certified nursing assistants. Specifically, Kayser-Jones and colleagues found that residents were not positioned appropriately for drinking (for example, some were lying on their sides in bed) and that they were rushed when given food and drink. In addition, liquids were often inaccessible to residents who could drink without assistance, leading to extremely low daily intake of fluids. Kayser-Jones J, et al. Factors contributing to dehydration in nursing homes: inadequate staffing and lack of professional supervision. *J Am Geriatr Soc 1999;47(10):1187–94.*

AGE-RELATED CHANGES THAT PROMOTE DEHYDRATION

The thirst response, which is the body's primary mechanism of signaling the need for fluid, becomes blunted with age. This was apparent in a 2002 trial that compared men 51 to 60 years of age with those 20 to 28 years of age. During a strenuous 10-day hill-walking excursion, the older men had less thirst and became progressively dehydrated; younger participants had no dehydration. Ainslie PN, et al. Energy balance, metabolism, hydration, and performance during strenuous hill walking: the effect of age. *J Appl Physiol 2002;93(2):714–23.*

In older men, the serum markers of dehydration (serum osmolality and sodium level) took longer to return to normal after an episode of dehydration than they did in younger men. Miescher E, Fortney SM. Responses to dehydration and rehydration during heat exposure in young and older men. *Am J Physiol 1989;257(5 Pt 2):R1050–6.*

Total body fluid.

From puberty to 39 years of age, total body fluid is about 60% of body weight in men and 52% in women; after age 60, total body fluid decreases to about 52% of body weight in men and 46% in women. In addition, muscle mass is lost with age, increasing the proportion of fat cells, which contain less water than muscle cells do, resulting in a decrease in intracellular fluid volume. Metheny NM. Fluid and electrolyte balance: nursing considerations *4th ed. Philadelphia: Lippincott; 2000*.

Decline in kidney function.

Creatinine clearance, an indicator of the kidney's efficiency in filtering toxins from the blood, can decline with age. Lindeman and colleagues found that in "normal" patients, the "mean decrease in [creatinine clearance] was 0.75 mL/min/year" after age 40. "Normal" patients were those who didn't have renal or urinary tract disease or use diuretics or anti-hypertensives. Lindeman RD, et al. Longitudinal studies on the rate of decline in renal function with age. *J Am Geriatr Soc 1985;33(4):278–85.*

RISK FACTORS

Older age and black race have both been associated with an increased likelihood of dehydration. Lavizzo-Mourey R, et al. Risk factors for dehydration among elderly nursing home residents. *J Am Geriatr Soc 1988;36(3):213–8.*

Upon admission to an ED, adults 85 years of age and older were three times more likely to have a diagnosis of dehydration than were adults 65 to 74 years of age. Ciccone A, et al. Age-related differences in diagnoses within the elderly population. *Am J Emerg Med 1998;16(1):43–8.*

Older black adults have higher prevalence rates of dehydration at the time of hospitalization than do older white adults. Lancaster KJ, et al. Dehydration in black and white older adults using diuretics. *Ann Epidemiol 2003;13(7):525–9.*

Personal Characteristics	
❑ Age > 85 years ❑ Female sex	❑ Body-mass index < 21 or > 27
Significant Health Conditions	
❑ Dementia or positive screening for cognitive impairment ❑ Depression or positive screening for depression ❑ Cerebrovascular accident ❑ Diabetes	❑ Urinary incontinence ❑ Renal disease ❑ Cardiac arrhythmia ❑ Malnutrition ❑ History of dehydration ❑ History of repeated infections
Medications	
❑ > 4 medications ❑ Laxatives ❑ Angiotensin-converting enzyme inhibitors	❑ Steroids ❑ Diuretics ❑ Psychotropics: antipsychotics, antidepressants, anxiolytics
Intake	
❑ Requires assistance to drink ❑ Has dysphagia or chokes ❑ Can drink independently but forgets ❑ Semidependent, regarding feeding	❑ Poor eater (eats < 50% of food given) ❑ Fluid intake of < 1,500 mL/day ❑ Spills while drinking ❑ Receives tube feedings
Laboratory Abnormalities	
❑ Urine specific gravity > 1.020 ❑ Urine is dark yellow	❑ Serum sodium > 150 mEq/L ❑ Blood urea nitrogen–creatinine ratio > 20 mg/dL
The Dehydration Risk Appraisal Checklist was designed to evaluate dehydration risk in nursing home residents. It is currently being evaluated for reliability and scalability.	

Reprinted with permission from Mentes JC and the Iowa Veterans Affairs Nursing Research Consortium. Evidence-based protocol: hydration management. In Titler MG, series editor. *Series on evidence-based practice for older adults.* Iowa City, IA: the University of Iowa College of Nursing Gerontological Nursing Interventions Research Center, Research Translation and Dissemination Core; 2004.

Table 1. Dehydration Risk Appraisal Checklist

Medications that directly affect renal function and interfere with fluid balance include diuretics, laxatives, and angiotensin-converting enzyme inhibitors. Psychotropic medications, such as antipsychotics and anxiolytics, have anticholinergic effects that cause dryness of the mouth, constipation, or urinary retention—effects that can alter hydration status. Polypharmacy has also been shown to heighten risk:

Lavizzo-Mourey and colleagues found a significant bivariate relationship between the use of more than four medications and severe dehydration in nursing home residents. Lavizzo-Mourey R, et al. Risk factors for dehydration among elderly nursing home residents. *J Am Geriatr Soc 1988;36(3):213–8.*

Level of physical dependency, one's ability to perform activities of daily living, has also been examined as a risk factor. Results from three studies, all carried out in nursing homes, are contradictory. In a 1988 study, those who required assistance with transfer and ambulation were found to be at higher risk for dehydration. Lavizzo-Mourey R, et al. Risk factors for dehydration among elderly nursing home residents. *J Am Geriatr Soc 1988;36(3):213–8.*

However, two more recent studies found that those with better physical function were at greater risk for dehydration. Gaspar PM. Water intake of nursing home residents. *J Gerontol Nurs*

1999;25(4):23–9. Mentes JC, Culp K. Reducing hydration-linked events in nursing home residents. *Clin Nurs Res 2003;12(3):210–25.* This somewhat counterintuitive finding may reflect environmental factors in nursing homes, where caregivers may be more attuned to highly dependent residents who cannot drink independently, leaving those who are able to care for themselves to do so. Such an approach may not work with residents who are physically functional but cognitively impaired.

Functionally limited but independent community-dwelling older adults had normal hydration status after a 12-hour fast, leading the researchers to conclude that dehydration may have greater associations to having many comorbid conditions or dependent living. Morgan AL, et al. Hydration status of community-dwelling seniors. *Aging Clin Exp Res 2003;15(4):301–4.*

Cognitive impairment has been associated with dehydration in older adults.

Dementia.

Many people in early stages of dementia are undiagnosed, as they are still able to converse in a conventional manner and can usually accomplish self-care activities. The Hartford Geriatric Institute's series Try this includes a protocol entitled, "Recognition of dementia in hospitalized adults," for assessing older patients for cognitive impairment in acute care settings. Mezey M, Maslow K. Try this: recognition of dementia in hospitalized older adults. *New York: Hartford Institute for Geriatric Nursing; 2004.*

Because people with dementia often forget to drink, their actual intake should be assessed; to do so, watch the patient eat, check to see if his water pitcher is empty or full, and ask him how he would get a drink of water if he were thirsty. Nursing interventions include prompts to drink at regular intervals to ensure an adequate intake.

Delirium.

Studies have shown that dehydration is often a cause of delirium. Inouye SK, Charpentier PA. Precipitating factors for delirium in hospitalized elderly persons. Predictive model and interrelationship with baseline vulnerability. JAMA 1996; 275(11):852–7. Mentes J, et al. Acute confusion indicators: risk factors and prevalence using MDS data. *Res Nurs Health 1999;22(2): 95–105.*

Concomitant conditions.

Dehydration occurs more frequently in older adults who are frail and in those with diabetes, cancer, cardiac disease, or acute infections (such as urinary tract infections, upper respiratory infections, pneumonia, gastroenteritis, or skin infections). Xiao H, et al. Economic burden of dehydration among hospitalized elderly patients. *Am J Health Syst Pharm 2004; 61(23):2534–40.* Warren JL, et al. The burden and outcomes associated with dehydration among US elderly, 1991. *Am J Public Health 1994;84(8):1265–9.*

Having multiple comorbidities has been associated with dehydration. Bennett JA, et al. Unrecognized chronic dehydration in older adults: examining prevalence rate and risk factors. *J Gerontol Nurs 2004;30(11):22–8.* Lavizzo-Mourey R, et al. Risk factors for dehydration among elderly nursing home residents. *J Am Geriatr Soc 1988;36(3):213–8.*

INDICATORS OF HYDRATION STATUS

Urine color chart.

The use of urine color, as measured using a urine color chart, can be helpful in monitoring hydration status. Armstrong LE, et al. Urinary indices of hydration status. *Int J Sport Nutr 1994;4(3):265–79.* Mentes JC. Hydration management. In: Titler M, editor. Series on evidence-based practice for older adults. Iowa City, IA: *University of Iowa Gerontological Nursing Interventions Research Center; 2004.*

The urine color chart has eight standardized colors, ranging from pale straw (number 1) to greenish brown (number 8). Armstrong LE, et al. Urinary indices of hydration status. *Int J Sport Nutr 1994;4(3):265–79.*

Urine that is the color of pale straw usually indicates a normal hydration status; as urine darkens, poorer hydration may be indicated (after the effect of discoloration by food or medications has been ruled out). A reading of less than 4 on the color chart is preferred. Mentes JC, et al. Use of a urine color chart to monitor hydration status in nursing home residents. *Biol Res Nurs 2006;7(3):197–203.*

The color chart is most effective when a person's average urine color is calculated over several days to establish an individual baseline color. If urine becomes darker, further assessment can be conducted and fluids adjusted to prevent dehydration. Certain medications (such as aspirin, warfarin, and multi-vitamins) and foods (such as fresh fruits and vegetables) can discolor urine; the best results have been obtained in older adults with adequate renal function. Mentes JC, et al. Use of a urine color chart to monitor hydration status in nursing home residents. *Biol Res Nurs 2006;7(3):197–203.*

Serum markers.

The most reliable indicators of dehydration include elevated serum sodium, elevated serum osmolality, and the ratio of blood urea nitrogen–creatinine. (See University of Iowa Chart College of Nursing Gerontology Nursing Interventions Research Center, Table 2). Unfortunately, as is true of other standard tests, serum markers confirm a diagnosis of dehydration once it is too late to prevent it from occurring.

Test	Ranges for	
	Impending dehydration	Dehydration
Blood urea nitrogen–creatinine ratio	20:1–24:1 mg/dL	≥ 25:1 mg/dL
Serum osmolality	290–300 mmol/kg	> 300 mmol/kg
Serum sodium		> 150 mEq/L
Urine osmolality		> 1,050 mmol/kg
Urine specific gravity	1.020–1.029	> 1.029
Urine color	dark yellow	greenish brown
Amount of urine	800–1,200 mL/day	< 800 mL/day

Adapted with permission from Mentes JC and the Iowa Veterans Affairs Nursing Research Consortium. Evidence-based protocol: hydration management. In Titler MG, series editor. *Series on evidence-based practice for older adults.* Iowa City, IA: the University of Iowa College of Nursing Gerontological Nursing Interventions Research Center, Research Translation and Dissemination Core; 2004.

Table 2. Ranges of Laboratory Test Results for Determining Hydration Status

Clinical assessments.

Dry oral mucosa, a furrowed tongue, decreased salivation, sunken eyes, decreased urine output, upper-body weakness, and a rapid pulse may indicate dehydration. Gross CR, et al. Clinical indicators of dehydration severity in elderly patients. *J Emerg Med 1992;10(3):267–74.*

Although assessment of skin turgor on the sternum is a mainstay in the assessment of hydration level in younger adults, it's not a reliable indicator in older adults because of changes in skin elasticity that occur with age. A reduction in axillary sweat production is another unreliable indicator. Gross CR, et al. Clinical indicators of dehydration severity in elderly patients. *J Emerg Med 1992;10(3):267–74.* Eaton D, et al. Axillary sweating in clinical assessment of dehydration in ill elderly patients. *BMJ 1994;308(6939): 1271.*

NURSING IMPLICATIONS

Older adults should not consume large amounts of fluid at one time; although the definition of "large amounts" varies from person to person, some older adults may have diminished renal function, which may result in overhydration. Luckey AE, Parsa CJ. Fluid and electrolytes in the aged. *Arch Surg 2003;138(10):1055–60.*

It's therefore essential that frail elderly patients with multiple comorbidities and several limitations in the ability to perform activities of daily living drink small amounts consistently throughout the day.

Calculating a fluid goal in hospitalized patients can help nurses to monitor fluid intake before difficulties arise. Results from a study comparing three well-known calculations showed the most effective standard to be the following: 100 mL/kg for the first 10 kg of weight, 50 mL/kg for the next 10 kg of weight, and 15 mL/kg for the remaining weight. Chidester JC, Spangler AA. Fluid intake in the institutionalized elderly. *J Am Diet Assoc 1997;97(1):23–8*. This option was considered "reasonable for patients whether they are of normal weight, underweight, or overweight."

Except those who may require fluid restrictions to prevent overhydration—those with severe congestive heart failure, renal failure, or certain severe mental disorders in which polydipsia is a feature—most older adults should have a fluid goal of at least 1,500 mL per day. Careful monitoring is required for symptoms that suggest congestive heart failure: new weight gain, pedal edema, neck vein distension, or shortness of breath. Finding the right amount an older adult should drink per day can be difficult, but it's important.

Fluid preferences.

Simmons and colleagues found that fluid intake increased in nursing home residents who were given the beverages they requested. Water is often considered the best beverage. Simmons SF, et al. An intervention to increase fluid intake in nursing home residents: prompting and preference compliance. *J Am Geriatr Soc 2001;49(7):926–33.*

"Hydration habits."

Four categories of nursing home residents. Mentes J. A typology of oral hydration problems exhibited by nursing home residents. *J Gerontol Nurs 2006;23(1): 13–21.*

* Can drink. Functionally capable of accessing and consuming fluids, these residents may not understand the importance of drinking sufficient amounts, may not feel thirsty, or may forget to drink because of cognitive impairment. Those who can understand should receive education, a

graduated cup, and their preferred beverages. Residents with cognitive impairment should receive frequent offers of drinks and invitations to social events that encourage drinking

* Can't drink. Frailty or dysphagia makes these residents incapable of accessing or consuming fluids safely. Those who are physically dependent should receive assistance and a sports cup with a straw. Swallowing exercises, fluid-rich foods such as melons and pureed foods, oral care, and family education may help those with dysphagia.

* Won't drink. Although some residents can drink safely, they don't. They may fear incontinence or may never have consumed many fluids. Educate those with incontinence concerns, suggesting Kegel exercises; medication should be provided when necessary. For those who have never enjoyed drinking, encourage frequent small amounts of fluid and provide preferred beverages during activities.
* End of life. Hydration at the end of life should be based on advanced directives or the preferences of the patient or family.

Dehydration Versus Volume Depletion

Dehydration and volume depletion are terms often used synonymously. But they describe different syndromes with differing symptoms and management. Extracellular volume depletion is the result of a net loss of total-body sodium with a reduction in intravascular volume. Major causes of volume depletion include blood loss, diarrhea, and vomiting; people experience light-headedness and orthostatic hypotension. In nonemergency situations, such as diarrhea with a bacterial cause, fluids containing some sodium, such as ginger ale and clear broths, are best used for fluid replacement. Emergency fluid resuscitation in dehydration and volume depletion, which is beyond the scope of this article, differs significantly in terms of type of fluid used and the timing of the treatment. For more information, see "Language Guiding Therapy: The Case of Dehydration Versus Volume Depletion," by Marge and colleagues, in the November 1, 1997, issue of Annals of Internal Medicine.

SSRIs and Hyponatremia

Selective serotonin reuptake inhibiters (SSRIs) have become first-line treatment for depression in older adults. However, Dutch scientists found that people taking SSRIs had four times the risk of developing hyponatremia than those not taking the medications. The risk of developing hyponatremia was greatest in the first two weeks of treatment. 1 Therefore, it's essential to monitor serum sodium levels in older adults who have recently been prescribed SSRIs. Monitoring fluid intake is also important, because changes in fluid and sodium intake can intensify a developing hyponatremia. Changes in mental status, including lethargy or acute confusion, should be investigated immediately. *Movig KL, et al. Eur J Clin Pharmacol 2002;58(2):143–8.*

Tips for Nurses by Health Care Setting

Hospital

Ensure that the hospitalized older adult has access to something to drink at all times. Offer fluids regularly, as the older adult may not experience thirst and therefore may not help himself. A water pitcher that is untouched at the end of the shift tells you much about the hydration habits of the older person in your care. Minimizing fasting times for surgery and diagnostic procedures is also important. In the ED, when appropriate, provide food and fluids to older adults who must wait longer than two hours.

Nursing home

Educate certified nursing assistants on the importance of consistent oral hydration and supervise their care of patients. Kayser-Jones J, et al. Factors contributing to dehydration in nursing homes: inadequate staffing and lack of professional supervision. *J Am Geriatr Soc 1999;47(10):1187–94.*

Provide preferred beverages during group activities or at teatime or nonalcoholic "happy hour," and use a beverage cart, which can create a social environment that encourages fluid intake. Robinson SB, Rosher RB. Can a beverage cart help improve hydration?*Geriatr Nurs 2002;23(4):208–11.*

For those with difficulty drinking, the use of positioning strategies, swallowing exercises, cuing, and good oral care should be tried before fluids are thickened for safe consumption. Family members can provide important information about hydration habits and fluid preferences and make offering fluids (the most successful strategy to increase consumption) a regular part of their visits. Robinson SB, Rosher RB. Can a beverage cart help improve hydration? *Geriatr Nurs 2002;23(4):208–11.* Mentes JC, Culp K. Reducing hydration-linked events in nursing home residents. *Clin Nurs Res 2003;12(3):210–25.* Simmons SF, et al. An intervention to increase fluid intake in nursing home residents: prompting and preference compliance. *J Am Geriatr Soc 2001;49(7):926–33.*

Ambulatory care

Ask older adults about their daily fluid intake and discuss how much fluid to drink on a daily basis, pointing out the need for increased amounts of fluid during exercise, in hot weather, and during illness. Review medications that affect fluid balance and increase or decrease dosages as needed. Recommend to healthy older adults with adequate renal function that they monitor their urine color. Mentes JC, et al. Use of a urine color chart to monitor hydration status in nursing home residents. *Biol Res Nurs 2006;7(3):197–203.*

Remind older adults who have urinary incontinence that they shouldn't impose restrictions on their fluid intake to prevent incontinence episodes. Regardless of the type of incontinence, adequate intake of fluid, approximately 1,500 to 2,000 mL per day, is indicated to maintain hydration. Burke MM, Laramie JA. Primary care of the older adult: a multidisciplinary approach. *2nd ed. St. Louis: Mosby; 2004*.

Home care

Assess the types and amounts of fluid the home care patient is consuming. Educate the patient on the best fluids to consume. Educate the family on the importance of hydration and the risk factors for dehydration and ask them to report any instance in which the patient is not eating or drinking as he normally does, as an older person can become dehydrated even after a day of reduced intake.

Vocational Hydration Study - Firefighting

Hydration study alters firefighters' approach to safety, recovery

By KIMBERLY EDDS
2008-02-17 03:00:00

IRVINE - A pioneering study into how dehydration and innate physical demands of firefighting affect performance is radically changing the way the Orange County Fire Authority operates, setting aside long-held firehouse traditions in the interest of science to maximize the efficiency of its workforce and keep firefighters from dying prematurely.

Hundreds of local firefighters are now rethinking their shift-change coffee klatch and soda habits in the wake of the OCFA study, which laid out significant lapses in understanding the damaging effects of dehydration and a lack of effective rehabilitation practices to protect firefighters' health.

Nearly half the firefighters who die from duty-related deaths die not in fiery infernos or dramatic building collapses, but from heart attacks and coronary events, most within 24 hours of the time the fire alarm sounds. A total of 440 firefighters, or 43.7percent of those who died on the job, had sudden cardiac death, a National Fire Protection Association study from 1995 to 2004 said.

Scientists have long had elite athletes in their cross hairs, testing and tinkering with the human body in an attempt to stretch physical ability to the outer limits. Playing with fire for a living is inherently dangerous, but little research had been done on the intrinsic physical demands and stress of firefighting and on what can be done to create a safer and more efficient workforce, until the OCFA launched its hydration study in August.

Conducted by the fire authority's Wellness and Fitness Program (WeFit), financed by federal funds and backed by the Orange County Professional Firefighters Association, the results have altered the way local firefighters recover from fires. Swigs of water and a few minutes' rest are being swapped for some quality time under an ice-cold towel - a now-proven way to quickly bring racing heart rates back to normal. Firefighters are being made aware of the damage their job does to their bodies and ways to train to prevent heart attacks and strokes on and off the job.

Temperatures hovered around the 80s when 126 local firefighters and paramedics, from 23 to 60 years old, suited up and marched through the 30-minute drill mimicking an apartment fire. From newbie firefighter to battalion chief, they arrived in a variety of sizes, ages and physical ability. They swallowed tiny transmitters embedded in a large, white pill and strapped on wristband computers that recorded heart rate five times a second.

For 15 minutes, they fought the blaze, dragging heavy hoses and pulling weighted dummies to safety. Flames reaching hundreds of degrees licked the ceiling above as firefighters crawled through the apartment, battling the blaze with shots of water. Their hearts pounded at nearly 200 beats a minute - about triple their resting rate.

Their internal temperatures rose to a high of 106 degrees. They were cooking themselves.

For 15 minutes, they marched up and down the six flights of stairs. Their heart rates stayed near their maximums, pumping as they marched up and down.

Four percent of the study participants threw in the towel before the 30-minute physical test was complete, unable to keep up with the demands of pulling 100 pounds of hose and marching up and down flights of stairs, weighed down by 60 pounds of protective clothing and gear.

Those numbers, which came from an army of volunteers from the OCFA's 850 firefighters and chiefs, were disturbing, said Nancy Espinoza, the fire authority's exercise physiologist.

Even more startling was the revelation that 90 percent of the participants were dehydrated before the drill began, setting up themselves for even more of a strain on their bodies, said Dennis Ratcliffe, 33, of OCFA Station 21.

"Everyone knows we should drink more water, but we are all still fairly bad at that," Ratcliffe said.

When the 30 minutes were up, the firefighters rested, randomly assigned to four different rehab methods. Some gathered around a misting fan. Others covered their heads with iced towels. Others sat in KoreKoolers - sideline chairs that allow their elbows to be submerged in ice and water.

Even sitting still, their core body temperatures continued to shoot upward for five more minutes. Firefighters dropped an average of 3 pounds during the 30-minute drill. One firefighter lost 8 pounds, a loss so severe it could significantly affect decision-making ability.

The maximum heart rate averaged 180 beats per minute, with the highest hitting 214 beats per minute.

KoreKoolers proved as nearly effective as cooling down with wet towels over firefighters' heads and necks. The fire authority is now packing towels in coolers rather than investing in the more expensive, unwieldy chairs, Espinoza said.

With more people jam-packing cities, firefighters are being forced to be experts in everything from swift-water rescue to high-rise fires and everything in between. More demands mean more stress on firefighters, said Joe Kerr, president of the Orange County Professional Firefighters Association. People are working too hard to meet not only the demands of the public, but also the demands firefighters place on themselves, he said.

Meeting some of those demands could be as simple as a few more glasses of water throughout the day - and a few more hours a week in the gym, going through exercise routines tailored to mimic firefighting tasks, said Capt. Mike Contreras, who commands the fire authority's WeFit program.

"Firefighters are generally in good shape," said Dr. Orr Limpisvasti of Anaheim's Kerlan-Jobe Orthopaedic Center. "But if you're going to ask your body to do something very stressful, it is critical to be hydrated - and stay hydrated."

Firefighters cannot be required to down certain amounts of water, but hydrating will be encouraged, Espinoza said. The fire authority is also looking at different electrolyte-replacement drinks to rehydrate crews during longer firefights.

The benefits go beyond saving human lives. The culture shift is also saving dollars - lowering workers' compensation costs, health care bills and reducing overtime to backfill for injured firefighters.

Since the inception of the WeFit program, which provides employees an hour during their shifts to work out and the gyms to do it, the fire authority has seen workers' compensation costs for its top four injuries - back, shoulder, heart and knee - drop from $5.8million to $1.8million.

The authority is not only looking to save lives and money now; officials are also looking to the future, hoping to create a firefighting force specifically trained to combat not only fires, but also the inherent physical stresses and demands that firefighting brings. And with the graying firefighting force, aimed at drawing on experienced firefighters who can meet all of the demands of modern firefighting, fire departments across the country are preparing their troops for the stress of the jobs into their 40s and 50s - well past the prime of many elite athletes.

"Knocking on a door to tell a family member their loved one is dead or injured is the last thing you want to do," said OCFA Chief Chip Prather, who has had to make that long trip to the door. "We're hoping to prevent that from happening."

The need for proper hydration and elite fitness is being drilled into the OCFA troops with signs posted in restrooms and common areas, and the message will be repeated during mandatory meetings. Hydrating is no longer an option; it's a survival tool.

"When you show up to work, you expect the person next to you to be able to do the job," Ratcliffe said. "And if something happens to you, you expect them to be able to help you."

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World Health Organization
Geneva, 2004

World Health Organization:
Health Risks From Drinking Demineralised Water

Conclusion from extensive studies:

Drinking water should contain minimum levels of certain essential minerals (and other components such as carbonates). Unfortunately, over the two past decades, little research attention has been given to the beneficial or protective effects of drinking water substances.

The main focus was on contaminants and their toxicological properties. Nevertheless, some studies have attempted to define the minimum content of essential elements or TDS in drinking water, and some countries have included requirements or guidelines for selected substances in their drinking water regulations. Although these are exceptional cases, the issue is relevant not only where drinking water is obtained by desalination (if not adequately re-mineralised) but also where home treatment or central water treatment reduces the content of important minerals and low-mineral bottled water is consumed.

Although drinking water manufactured by desalination is stabilized with some minerals, this is usually not the case for water demineralised as a result of household treatment. Even when stablized, the final composition of some waters may not be adequate in terms of providing health benefits. Although desalinated waters are supplemented mainly with calcium (lime) or other carbonates, they may be deficient in magnesium and other microelements such as fluorides and potassium, as are most natural waters. Furthermore, the quantity of calcium that is supplemented is based on technical considerations (i.e., reducing the aggressiveness) rather than on health concerns. Possibly none of the commonly used ways of re-mineralization could be considered optimum, since the water does not contain all of its beneficial components. Current methods of stabilization are primarily intended to decrease the corrosive effects of demineralised water.

Demineralised water that has not been remineralized , or low-mineral content water – in the light of the absence or substantial lack of essential minerals in it – is not considered ideal drinking water, and therefore, its regular consumption may not be providing adequate levels of some beneficial nutrients. This chapter provides a rationale for this conclusion.

The evidence in terms of experimental effects and findings in human volunteers related to highly demineralised water is mostly found in older studies, some of which may not meet current methodological criteria. However, these findings and conclusions should not be dismissed. Some of these studies were unique, and the intervention studies, although undirected, would hardly be scientifically, financially, or ethically feasible to the same extent today. The methods, however, are not so questionable as to necessarily invalidate their results. The older animal and clinical studies on health risks from drinking

demineralised or low-mineral water yielded consistent results both with each other and with more recent research, and recent research has tended to be supportive.

Sufficient evidence is now available to confirm the health risk from drinking water deficient in calcium or magnesium. Many studies show that higher water magnesium is related to decreased risks for CVD and especially for sudden death from CVD. This relationship has been independently described in epidemiological studies with different study designs, performed in different areas (with different populations), and at different times. The consistent epidemiological observations are supported by the data from autopsy, clinical, and animal studies. Biological plausibility for a protective effect of magnesium is substantial, but the specificity is less evident due to the multifactorial aetiology of CVD. In addition to an increased risk of sudden death, it has been suggested that intake of water low in magnesium may be associated with a higher risk of motor neuronal disease, pregnancy disorders (so-called preeclampsia, and sudden death in infants) and some types of cancer. Recent studies suggest that the intake of soft water, i.e. water low in calcium, is associated with higher risk of fracture in children, certain neurodegenerative diseases, pre-term birth and low weight at birth and some types of cancer. Furthermore, the possible role of water calcium in the development of CVD cannot be excluded.

International and national authorities responsible for drinking water quality should consider guidelines for desalination water treatment, specifying the minimum content of the relevant elements such as calcium and magnesium and TDS. If additional research is required to establish guidelines, these authorities should promote targeted research in this field to elaborate the health benefits. If guidelines are established for substances that should be in deminerialized water, authorities should ensure that the guidelines also apply to uses of certain home treatment devices and bottled waters.