Water: An essential but overlooked nutrient

SUSAN M. KLEINER, PhD, RD

ABSTRACT

Water is an essential nutrient required for life. To be well hydrated, the average sedentary adult man must consume at least 2,900 mL (12 c) fluid per day, and the average sedentary adult woman at least 2,200 mL (9 c) fluid per day, in the form of noncaffeinated, nonalcoholic beverages, soups, and foods. Solid foods contribute approximately 1,000 mL (4 c) water, with an additional 250 mL (1 c) coming from the water of oxidation. The Nationwide Food Consumption Surveys indicate that a portion of the population may be chronically mildly dehydrated. Several factors may increase the likelihood of chronic, mild dehydration, including a poor thirst mechanism, dissatisfaction with the taste of water, common consumption of the natural diuretics caffeine and alcohol, participation in exercise, and environmental conditions. Dehydration of as little as 2% loss of body weight results in impaired physiological and performance responses. New research indicates that fluid consumption in general and water consumption in particular can have an effect on the risk of urinary stone disease; cancers of the breast, colon, and urinary tract; childhood and adolescent obesity; mitral valve prolapse; salivary gland function; and overall health in the elderly. Dietitians should be encouraged to promote and monitor fluid and water intake among all of their clients and patients through education and to help them design a fluid intake plan. The influence of chronic mild dehydration on health and disease merits further research. *J Am Diet Assoc. 1999;99:200-206.*

Water is the most abundant compound in the human body. All biochemical reactions occur in water, and water is an active participant in those reactions. There is no life (as we know it) without water. It is also well known that severe dehydration acutely affects health. Does chronic mild dehydration take its toll as well?

This review addresses the current knowledge of the effects of chronic mild dehydration on human performance and health, and calls for a revival of patient/client education regarding water intake as well as future research directions.

PHYSIOLOGICAL ASPECTS

The Functions of Water in the Body

Fluids fill virtually every space in cells and between them. Water molecules not only fill space, but they also help form the structures of macromolecules such as proteins and glycogen. As the primary fluid in the body, water serves as a solvent for minerals, vitamins, amino acids, glucose, and many other nutrients. Water also plays a key role in the digestion, absorption, transportation, and use of nutrients. Water is the medium for the safe elimination of toxins and waste products and whole-body thermoregulation is critically dependent on it. From energy production to joint lubrication to reproduction, there is no system in the body that does not depend on water.

Definition of Dehydration

Dehydration can be acute, as from a bout of intense exercise, or chronic, resulting from less than adequate rehydration of daily water losses over a period of time. Both types of dehydration are defined as a 1% or greater loss of body weight as a result of fluid loss (1,2). For the purpose of this article, mild dehydration is defined as a 1% to 2% loss of body weight caused by fluid losses.

Metabolic and Physiologic Effects of Dehydration

In rats, water deprivation over a period of 48 hours resulted in an increase of plasma osmolality and hematocrit level and a decrease of plasma volume, all in the range of ±10% (3). Water-deprived rats predominantly used fat as a metabolic fuel, but total energy turnover measured by oxygen consumption was not altered. Plasma triacylglycerol was decreased, likely because of the elevation of plasma free fatty acids, the reduction of hepatic fatty acid synthesis, and reduced triacylglycerol secretion into the blood. Hohenneger et al (3) speculated that enhanced plasma levels of corticosterone (about 100%) and glucagon (about 50%) may contribute to the metabolic situation observed in water deprivation.

S. M. Kleiner is the owner of High Performance Nutrition, 7683 SE 27th St, No. 167, Mercer Island, WA 98040. She is also an affiliate assistant professor with the Nutritional Sciences Program at the University of Washington, Seattle.

Dehydration of as little as 1% decrease in body weight results in impaired physiological and performance responses (4-6), and is discussed in more detail below. It affects a wide range of cardiovascular and thermoregulatory responses (7-14). Dehydration in excess of 3% to 5% of body weight decreases endurance and strength (6,15) and is the primary cause of heat exhaustion (16).

Practical Indexes of Hydration Status

There is no universally accepted laboratory method for determining whether a patient is well hydrated, euhydrated, or hypohydrated. Frequently used measures are urine specific gravity, urine osmolality, plasma osmolality, plasma sodium, or hematocrit level. As field tests, these methods are rather impractical. Armstrong and coworkers (17) have shown that urine color, using a standardized color reference chart, is interchangeable with urine specific gravity and urine osmolality in determining whether a subject is well hydrated, euhydrated, or hypohydrated. Furthermore, hematologic measures were not as sensitive to mild hypohydration as the urinary indexes selected. These authors concluded that "...urine color may be used in athletic/industrial settings or field studies, where close estimates of urine specific gravity or urine osmolality are acceptable, but should not be utilized in laboratories where greater precision and accuracy are required...." (17, p 265). Although recognizing the limitations of color names, Armstrong et al recommend that athletes and other persons seek to produce urine that is "very pale yellow," "pale yellow," or "straw colored," to indicate that they are well hydrated.

Another crude yet relatively accurate method of evaluating hydration status in the field is body weight measurement—2.2 kg (1 lb) is equivalent to 470 mL (2 c) fluid. Once baseline body weight is established, weight lost that is not attributable to tissue losses, as in before and after exercise for instance, is fluid loss.

Symptoms of Dehydration

Early signs of dehydration include headache, fatigue, loss of appetite, flushed skin, heat intolerance, light-headedness, dry mouth and eyes, burning sensation in the stomach, and dark urine with a strong odor. Signs of more advanced, severe dehydration include difficulty swallowing, clumsiness, shriveled skin, sunken eyes and dim vision, painful urination, numb skin, muscle spasms, and delirium (18).

Stamford (19) postulated that muscle cramps may be related to hydration status because muscles cramp more frequently when the body is dehydrated. Heat cramps, the least serious of the 3 heat-related disorders (ie, heat cramps, heat exhaustion, heat stroke), is characterized by severe cramping of the skeletal muscles that are used most heavily during exercise. High sweat rates and dehydration likely disrupt the balance between the electrolytes potassium and sodium, leading to cramps. However, a cause-and-effect relationship has not been established. Recovery from muscle cramps requires moving the affected person to a cool location (in the case of heat cramps), fluid replacement, and restoration of electrolyte balance (20). Others, however, postulate a new hypothesis unrelated to hydration status (21). This hypothesis states that exercise-associated muscle cramping is caused by sustained abnormal spinal reflex activity secondary to muscle fatigue. In this case, passive stretching relieves the cramping.

Influencers of Hydration Status

The primary controller of hydration status in human beings is thirst. Unfortunately, the threshold for the induction of thirst occurs at a point where a person is already dehydrated to a level of 0.8% to 2% loss of body weight (22,23). If the level of hypohydration is greater than 3% of body weight loss, complete rehydration requires more than just fluid replacement from simple beverages. Food or other osmolar intake is often necessary for complete rehydration, which may require 18 to 24 hours (23).

Environment can alter the thirst mechanism. Water immersion induces shifts in vascular volume and in the concentration and activity of vasopressin, renin-angiotensin II, and atrial natriuretic polypeptide, the hormones and enzyme associated with thirst and drinking (23). Thus, in addition to the blunted thirst response associated with exercise (24), it is likely that swimmers may have virtually no thirst response during immersion.

Taste influences hydration and beverage choice in adults and children (25,26). A survey conducted in 1994 at 2 community health centers in Rhode Island (25) showed that of the 124 respondents, 55% used only bottled water for drinking. Among the reasons cited for choosing bottled water, 43% of the respondents said taste was their reason. In children, the magnitude of rehydration is significantly affected by the flavor of the available beverage (26).

Factors that influence urinary excretion rates and volume influence hydration status. The diuretic effects of caffeine were recently demonstrated in a study of 12 healthy German men and women (mean age=27 years) who were usual coffee drinkers, but abstained from drinking or eating anything containing caffeine for 5 days before the study. Six cups of coffee (642 mg caffeine per day) led to an increase in 24-hour urine excretion of 753±532 mL ($P<.001$), a negative fluid balance, and a decrease in body weight of 0.77±0.4 kg ($P<.001$). Total body water decreased by 1.1±1.2 kg or 2.7% ($P<.01$). Sodium and potassium losses also increased. Despite this level of dehydration, only 2 subjects experienced thirst.

Alcohol is another natural diuretic. It depresses production of antidiuretic hormone (ADH, also known as vasopressin) by the pituitary gland in the brain. The kidney responds to ADH by reabsorbing water, and preventing water loss. When ADH secretion is depressed, water losses increase.

Environmental factors such as increases in temperature and altitude and decreases in relative humidity increase water loss through perspiration and respiration (8,11-13,28,29). As environmental temperatures rise, the requirements of thermoregulation increase sweat losses to maintain normal body core temperatures through evaporation. At high altitude, decreases in relative humidity increase respiratory fluid losses through maintenance of fluid balance in respiratory tissues.

Requirements

Water accounts for one half to four fifths of body weight, depending on level of lean body mass. On average, men have a higher level of lean body mass than women. As a percentage of body mass, body water is higher in men than in women, and falls in both with age (30).

Water is an essential nutrient because it is required in amounts that exceed the body's ability to produce it. Even without perspiration (sensible losses) the normal daily turnover of water is approximately 4% of total body weight in adults and 15% of total body weight in infants. In a 70-kg adult this is equivalent to 2,500 to 3,000 mL/day, or 1,000 mL/day in a 7-kg infant (31). Water loss from the lungs and skin (insensible losses) are responsible for half of the total water turnover (30). Insensible losses are sensitive to environmental conditions, and can be increased at high temperatures, high altitude, and low humidity. Losses from urine and stool account for the rest of the total losses.

1977-1978 Per capita median daily intake of drinking water	672 mL (2.8 c)
1981 Per capita milk intake	312 mL (1.3 c)
1981 Per capita coffee and tea intake	360 mL (1.5 c)
1981 Per capita soft drink intake	420 mL (1.75 c)
Total daily per capita fluid consumption	1,764 mL (7.35 c)

FIG 1. Daily fluid intakes of persons in the US population. Source: references 30, 35, and 36.

- **Twenty-four hours before exercise**
  Consume a nutritionally balanced diet.
  Drink adequate fluids.
- **Two hours before exercise**
  Drink 500 mL (about 17 oz) fluid.
- **During exercise**
  Drink cool (15° to 22° C), palatable fluids at a rate of 4 to 8 oz every 15 to 20 min.
- **Exercise less than 1 hour**
  Water is adequate for hydration and rehydration.
- **Exercise longer than 1 hour**
  Fluids, including 4% to 8% carbohydrate and/or electrolyte, may improve hydration or performance.
- **After exercise**
  Drink 16 to 20 oz fluid for every pound lost during exercise. Including sodium may promote more rapid recovery, but it is not necessary as long as sodium is sufficiently available from food.

FIG 2. Fluid guidelines for exercise performance. Source: reference 24.

The human requirement for water is metabolic and highly variable. Insensible losses may vary widely, yet there must be a minimal amount available to maintain a tolerable solute load by the kidneys. Water is manufactured in small amounts by the body through oxidation. Solid foods, especially fruits and vegetables, contribute fluids to the diet. Based on a 2,900-kcal diet (70-kg adult man), solid foods contribute approximately 1 L water per day, and the water of oxidation contributes another 250 mL (31). The rest must be supplied by fluid intake.

The National Research Council (30) recommends fluid intake of 1 mL/kcal energy expenditure for adults living under average conditions of energy expenditure and environmental exposure. For average males, this is the equivalent of 2,900 mL (12 c) fluid per day, and for average females, 2,200 mL (9 c) fluid per day. Recent research into fluid requirements during exercise have led to more specific recommendations for athletes and active persons, and is discussed below.

The fluid recommendations for 3 specific populations require special attention here. Despite a blunted thirst mechanism (discussed below) healthy elderly persons may still follow the aforementioned fluid recommendations. However, fluid requirements of the dependent elderly, those who are too ill or incapacitated to live independently, can be more precisely calculated by the following formula: 100 mL fluid/kg for the first 10 kg actual body weight, 50 mL fluid/kg for the remaining kilograms of actual body weight (32,33).

A pregnant woman has a slightly increased water requirement because of the expanding extracellular fluid space, the needs of the fetus, and the amniotic fluid. According to the National Research Council (32), compared with the nongravid state, pregnancy requires approximately 30 mL extra fluid per day. This does not take into account any increase in fluid losses from increased heat production and perspiration during pregnancy, especially during the summer months. It is therefore likely that the water requirement of pregnancy is variable, and greater than the minimum recommendation of 30 mL/day above the nongravid recommendation. A lactating woman must replace the fluid lost in breast milk. Eighty-seven percent of milk is water, and the average milk production during the first 6 months of lactation is 750 mL/day (30,34). The increased fluid need of a lactating woman is therefore 750 to 1,000 mL/day above the basic recommendation (30).

The average water recommendation for infants and children is 1.5 mL/kcal energy expenditure per day. This recommendation takes into account the larger surface area per unit of body weight of children compared with adults, their higher percentage of body water and its high rate of turnover, and the limited capacity of their kidneys for handling the solute load from high protein intakes required for growth. Additionally, because infants are unable to express thirst, they are susceptible to severe dehydration (30).

FLUID INTAKES OF THE US POPULATION

Virtually no large population data are available regarding individual consumption of drinking water in the United States since the 1977-1978 Nationwide Food Consumption Survey (NFCS) (35). (See Figure 1.) NFCS data do not include the water found in food, but they do include data for caffeinated beverages (27).

In a further analysis of the data from the NFCS (36), nonpregnant, nonlactating control women drank a mean of 624 mL (2.6 c) water per day, pregnant women drank a mean of 744 mL (3.1 c) water per day, and lactating women drank a mean of 720 mL (3.0 c) water per day. The age range for all women was 15 to 49 years. When tap-water intake (which includes drinking water as well as tap water added in final preparation of foods and tap water–based beverages) was analyzed, the median daily intake was 1,128 mL (4.7 c) for control women, 1,128 mL (4.7 c) for pregnant women, and 1,416 mL (5.9 c) for lactating women.

Based on these estimates, a proportion of the population may be chronically mildly dehydrated. A study investigating the appropriate plasma specific gravity for identifying hypovolemia, or volume depletion (37), discovered that among the 170 new house officers at Johns Hopkins Hospital (Baltimore, Md) who were used as a control group (age range=23 to 44 years), 5% (9 subjects) probably had hypovolemia (plasma specific gravity 1.0280 to 1.0294) or were moderately dehydrated, and 27% (43 subjects) possibly had hypovolemia (plasma specific gravity 1.0265 to 1.0279) or were mildly dehydrated. Of the group of 100 free-living, healthy retirees (≥65 years) who were studied, 8% (8 subjects) probably had hypovolemia and 33% (15 subjects) possibly had hypovolemia. Performance measures were not taken of the subjects in this study, but the consequences of these data in regard to performance and health are discussed in the sections that follow.

INFLUENCE OF HYDRATION ON HEALTH AND DISEASE

Stone Disease

It was a practice of Hippocrates to recommend large intakes of water to increase urine output and decrease the recurrence of urinary tract stones (38). Today, approximately 12% to 15% of the general population will form a kidney stone at some time (39,40). Many factors can modify the urinary risk factors for developing stones, including age, sex, heredity, occupation, social class and affluence, geographic location and climate, and diet. Of these, diet—especially fluid intake—is the only factor that can be easily changed and that has a marked effect on all urinary risk factors (41).

Stone prevalence is higher in populations with low urinary volume (38-46). Decreased fluid intake leads to low urine volume and increased concentrations of all stone-forming salts. Risk of stone formation is increased with urine volumes of less than 1 L/day. When fluid intake is increased to allow for urinary volumes of more than 2 to 2.5 L/day, without any changes in diet or other pharmacologic intervention, recurrences of all types of stones can be prevented in a large number of patients (38,41,42,44). Research by Borghi et al (38) demonstrated that in a group treated with a high intake of water without any diet changes, 87.9% of the patients were stone-free after 5 years, vs 73% of the untreated group (P=.008). Furthermore, the interval before the onset of a recurrence in the treated group was statistically greater than in the control group (mean=38.7±13.2 months vs 25.1±16.4 months, P=.016).

According to Hughes and Norman (41), persons at risk for urinary stone formation should consume at least 250 mL fluid with each meal, between meals, before bedtime, and when they get up at night to void. This pattern will ensure that fluid intake is spread throughout the day and that the urine is not concentrated. Patients with stones should also increase their fluid intake in hotter weather and after vigorous exercise.

Cancers

Several studies have discovered a direct correlation between the quantity of fluid consumed and the incidence of certain cancers (47-50). In Israel, Bitterman et al (47) found that patients with urinary tract cancer (bladder, prostate, kidney, testicle) consumed significantly smaller quantities of fluid compared with healthy control subjects. No association with specific beverages was found.

- Diminished physical performance (1,2,4-6,29,64)
- Diminished mental performance (29)
- Diminished salivary gland function (56)
- Increased risk of kidney stones in susceptible population (38,41,42,44)
- Increased risk of urinary tract cancers[1] (47,50)
- Increased risk of colon cancer[1] (48)
- Increased risk of breast cancer[1] (49)
- Increased risk of childhood obesity (53,54)
- Increased risk of mitral valve prolapse in susceptible population (55)

FIG 3. Possible influence of chronic, mild dehydration and poor fluid intake on human health and performance factors. Note: Some of these associations need further confirmation.
[1]Specifically associated with water consumption.

Fluid requirement: 1 mL per kilocalorie per day
- 2,200-kcal diet=2,200 mL/day (9 c)
- 2,900-kcal diet=2,900 mL/day (12 c)

Factors that add to fluid needs
- Exercise
- High temperature
- Low humidity
- High altitude
- High-fiber diet
- Increased fluid losses (caffeine, alcohol consumption)

FIG 4. Sample fluid plan.

In Hawaii, Wilkens et al (50) showed that total fluid intake, and intake of tap water in particular, had a strong inverse dose-response relationship to risk of lower urinary tract cancer (bladder, renal pelvis, ureter) among women. The association was stronger among smokers than nonsmokers.

Similar findings have been made regarding colon and breast cancer. In a population-based case-control study of the association between food groupings and colon cancer in Seattle, Wash (48), researchers identified a strong inverse dose-response relationship between water intake, measured as glasses of water consumed per day, and risk of colon cancer among women. Women who drank more than 5 glasses of water a day had a 45% decreased risk of colon cancer vs those who consumed 2 or fewer glasses per day (odds ratio [OR] for >5 glasses/day vs ≤2 glasses/day=0.55; 95% confidence interval [CI]=0.31-0.99; P=.004). Among men there was a 32% decrease in risk with increasing water consumption (>4 glasses/day vs ≤1 glass/day), although it was not statistically significant (48).

It is critical to remind clients and patients of the importance of proper fluid intake; total water and fluid intake should always be part of the diet record

In a letter to the editor, Stookey and colleagues (49) announced the results of their hospital-based, case-control pilot study of the protective effects of drinking water on breast cancer risk. Water drinking was strongly, inversely, and significantly associated with breast cancer risk. Amounts of water intake were not reported. Overall, the risk for developing breast cancer was reduced by 79% among water drinkers when adjusted for age; height; exercise; family history; use of hormone replacement therapy; endogenous estrogen exposure; use of oral contraceptive or birth control pill; and tea, coffee, and alcohol consumption (OR=0.21; 95% CI=0.07-0.62). When stratified for pre- and postmenopausal stage, risks were reduced by 33% for premenopausal women (OR=0.67; 95% CI=0.17-2.69; n=35) and 79% for postmenopausal women (OR=0.21; 95% CI=0.07-0.62; n=64). The authors hypothesize that "subclinical or 'chronic' dehydration may compromise intracellular water, alter cellular concentrations, affect the activity of enzymes in metabolic regulation, and inhibit cellular carcinogen removal" (49, p 657). As the authors of these 4 studies state, water intake as a risk factor for cancers of the breast, colon, and urinary tract merits further study.

Other Clinical Issues

Patients often report that drinking fluids helps them feel fuller and eat less. The LEARN program, a behavioral weight control program, suggests that participants "drink a lot of water to take the edge off of hunger" (51). The results of 2 studies may indicate that this is true in both adult and child populations (52,53). Levine (54) reviewed the role of liquid intake as a factor in childhood obesity and disease. She makes several important points, including the suggestion that replacing soft drinks in the diet with milk and water would help with weight control and greatly improve the overall health of the child and adolescent populations in the United States.

Lax et al (55) investigated the influence of mild dehydration on inducement of mitral valve prolapse in women with phenotypic body habitus of mitral valve prolapse and prior normal cardiac findings. Mitral valve prolapse was induced by mild dehydration in 7 women after furosemide treatment and in 7 women after administration of placebo. All changes were resolved with rehydration.

Saliva, which is primarily water, is essential for the maintenance of oral health. Decreased body water has been associated with salivary dysfunction, especially among the elderly. Ship and Fischer (56) investigated the relationship between mild dehydration (mean weight loss of 2.31% to 2.84%) and parotid salivary gland function in both young and older healthy adults, and found that decreased salivary gland function is associated with dehydration independent of age.

Acute, nonspecific diarrhea, even though transient, can cause mild to moderate dehydration that can become chronic if adequate rehydration does not occur. Patients with signs or symptoms of dehydration, including dry mouth, excessive thirst, wrinkled skin, little or no urination, dizziness, or lightheadedness, should see a physician. Children with severe diarrhea or vomiting that continues for more than 24 hours should be evaluated for potential dehydration. Fluid intakes should equal 2 to 3 L/day to avoid the hypohydration associated with acute diarrhea (57).

Numerous studies have demonstrated significant hypodipsia and diminished thirst sensations in the elderly (37,58,59). In spite of the fact that these changes may be a normal adaptation of the aging process (58), the consequences of dehydration in the elderly are serious and range from constipation and fecal impaction to cognitive impairment, functional decline, and death (22). Patients with Alzheimer's disease may have additional impairment to their thirst mechanism (60). Specific recommendations to avoid dehydration in the elderly have been published (22,61).

INFLUENCE OF HYDRATION ON PERFORMANCE

Cognitive/Mental Performance

The effect of dehydration on mental performance has not been adequately studied, but it seems likely that as physical performance is impaired with hypohydration, mental performance is impaired as well (62,63). Gopinathan et al (29) studied variation in mental performance under different levels of heat stress-induced dehydration in acclimatized subjects. After recovery from exercise in the heat, subjects demonstrated significant and progressive reductions in the performance of arithmetic ability, short-term memory, and visuomotor tracking at 2% or more body fluid deficit compared with the euhydrated state.

Physical Performance and Exercise

Heat is produced as a byproduct of exercise. Evaporation is by far the most effective method of cooling the body (6).

Environmental conditions influence fluid losses. When exercise is performed in excessive heat or cold, low humidity, or high altitude, fluid losses increase (8,12,13,28,64). Sweat rates of 1 to 2 L/hour are typical of most persons performing moderately hard exercise, but sweat rates in excess of 2 L/hour (as high as 4 to 6 L/hour) are not unusual when the ambient temperature is high (65).

It is not the purpose of this article to review in-depth the numerous studies of the effects of hydration on physical performance. This has been done elsewhere (11-13,24,28,62, 65,66). It is well established that dehydration of as little as 1% decrease in body weight will impair physiologic and performance responses during continuous exercise (1,2,4-6). A 1998 study of the influence of hydration status and fluid replacement on heat tolerance and work concluded that even a minor 2.2% body mass loss in fluid negatively influences heart rate, tolerance times, and stroke volume during both light and heavy exercise in the heat (64).

In practical terms, if a 150-lb athlete loses 2% of his or her body weight (3 lb), physical and mental performance will decrease by 20% (4,5). Hence, chronic mild dehyration (1% to 2% loss of body weight) negatively affects athletic performance.

Numerous dietary studies have demonstrated that, on average, athletes do not consume adequate fluids before, during, or after exercise (62,67-73). Many athletes habitually self-induce dehydration to make a designated weight class for competition (66,69,70,74-76). This practice can dramatically influence exercise performance, including losses in strength, anaerobic power, anaerobic capacity, lactate threshold, and aerobic power (66,76). In extreme cases, self-induced dehydration practices have resulted in death (77).

Children exercising in the heat will also dehydrate (26,78), and they will be at risk of the negative side effects of dehydration more readily than adults (79). Children will rehydrate voluntarily when adequate fluids are made available (26,78).

Recommendations for adequate fluid intake before, during, and after exercise have been made by the American College of Sports Medicine (24) (see Figure 2). Careful attention to these guidelines will help avoid dehydration, as well as the hyperhydration (hyponatremia) that has periodically been associated with endurance exercise (80,81).

CONCLUSIONS, APPLICATIONS, AND RECOMMENDATIONS

Even though dietitians are well educated in the area of hydration, it is critical to remind ourselves and our clients/patients of the importance of proper fluid intake (see Figure 3). Total water and fluid intake should always be part of the diet record. As we encourage higher intakes of fiber, patients need to be informed regarding adequate fluid intake. Simple field techniques, such as evaluating the color of urine, can be used to help clients/patients assess their own hydration status.

Design a fluid plan (just as one would design a food plan) to help clients/patients stick to a healthful drinking schedule (see Figure 4). Water and other noncaffeinated and nonalcoholic beverages should be available as a constant reminder to drink. If taste is a reason for low water intake, methods to improve the taste of water should be investigated. Such possibilities include removing off-flavors through filtering or purchasing bottled purified or flavored water. ■

This project was funded by The Brita Company, Oakland, Calif.

The author would like to thank Kyle Horner for his excellent assistance.

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