

## Author Response: Is Whole Body Hydration an Important Consideration in Dry Eye?

We would like to thank Professor McMonnies for his interest in our work, for the excellent points he raises in his letter,<sup>1</sup> and *IOVS* for inviting us to respond. Our article, that Professor McMonnies refers to, provided the first published evidence that elderly individuals classified as dry eye (DE)—using either tear fluid osmolality alone or composite self-report assessments—have suboptimal hydration (higher plasma osmolality) compared with non-DE individuals.<sup>2</sup> In the context of managing conditions such as hypertension, Professor McMonnies raised the possibility that reducing salt intake, either alone or in conjunction with increased whole-body hydration, might be more appropriate than only increasing water consumption. There is little doubt that dietary salt restriction (the United States Food and Drug Administration recommends <6 g salt daily) causes a small blood pressure reduction; but a recent systematic review has cast doubt over whether dietary salt restriction is as strongly associated with reduced mortality and cardiovascular morbidity as once thought.<sup>3</sup> Dietary salt restriction actually increased the risk of all-cause death in those with congestive heart failure. The impact of dietary salt restriction on whole-body hydration is little understood. The study that Professor McMonnies mentions<sup>4</sup> showed an improvement in hydration (significant decrease in plasma sodium concentration) in participants consuming a low-salt diet compared with a high-salt diet, but a limited effect of the low-salt diet compared with the participants' normal diet on hydration status. Avoiding a high-salt diet may be important for hydration, but appropriate daily water intake to avoid the adverse effects of a body water deficit on health should be a primary consideration, as we will discuss.

Body water deficits are relatively common in the elderly; for example, one large US study showed that 50% of elderly people had elevated plasma osmolality, indicating suboptimal hydration.<sup>5</sup> Elevated plasma osmolality has long been associated with increased mortality in the elderly population.<sup>6</sup> Causes of dehydration in the elderly include, among others, a decreased thirst mechanism; declining kidney function; medications (e.g., diuretics); cognitive disorders; reduced appetite; swallowing malfunction; and an increased reliance on care providers to provide drinks.<sup>7</sup> The advantages of maintaining euhydration for optimal cognitive and physical function are widely recognized.<sup>7,8</sup> Although the evidence is sometimes inconsistent, dehydration, particularly chronic dehydration, has been associated with numerous adverse health outcomes across the lifespan, including: falls and fractures in the elderly,<sup>9</sup> increased heat stroke mortality during heat waves in the elderly,<sup>10</sup> heart disease,<sup>11</sup> bronchopulmonary disorders,<sup>12</sup> kidney disease,<sup>13</sup> urolithiasis,<sup>14</sup> bladder and colon cancer,<sup>9</sup> urinary tract infections,<sup>14</sup> constipation,<sup>14</sup> decreased salivation,<sup>15</sup> dental caries,<sup>16</sup> decreased mucosal immunity,<sup>17</sup> and dose-dependent cataract formation.<sup>18</sup> Our data indicate that DE should be added to this long list of adverse health outcomes associated with dehydration.

Professor McMonnies also highlighted the need for appropriate monitoring of DE patients during fluid intervention studies. The prospect that improving whole-body hydration may decrease tear fluid osmolality<sup>19,20</sup> in DE patients and serve as a nondrug therapy, at least for some DE patients, is exciting; however, there is currently little evidence to support this concept. In our recent *IOVS* article,<sup>2</sup> we also showed in a small pilot with eight mild/moderate DE patients that an improve-

ment in hydration status (decrease in plasma osmolality) during a 2-day hospital stay was accompanied by a meaningful decrease in tear fluid osmolality. In line with Professor McMonnies's sound reasoning, we acknowledged the need for carefully controlled fluid intervention trials to assess the efficacy of optimizing hydration status as a nondrug therapy in DE patients.<sup>2</sup> It is quite conceivable, but remains to be shown, that following the recommended daily fluid intake (set out below) may only benefit DE patients who show evidence of whole-body dehydration (e.g., raised plasma osmolality) and that optimizing whole-body hydration may not improve DE symptoms in all DE sufferers. For example, aqueous-deficient DE sufferers may respond more favorably to improvements in whole-body hydration than evaporative DE sufferers. We do not recommend DE sufferers consume very large boluses of fluid at one sitting (often coined "water loading") as this can increase the risk of water intoxication (maximal kidney excretion rate is ~0.7–1.0 L per hour). Rather, active adults and the elderly should follow the recommended daily water intake of 2.0 L for females and 2.5 L for males,<sup>21</sup> which ideally should be spread evenly across the day. Although approximately 20% to 30% of this water intake is typically consumed as water in food, the risk of water intoxication with these recommended daily water intakes is so low that these recommendations can be interpreted as daily fluid requirements to drink (i.e., all beverages). These recommended fluid intakes should be increased when undertaking vigorous physical activity and during the warmer summer months. The increased deaths associated with inadequate fluid intake and dehydration in the 2003 heat wave in Europe support this recommendation.<sup>10</sup> Finally, lower daily fluid intakes may be recommended for congestive heart failure patients (typically 1.5–2.0 L per day)<sup>22</sup>; chronic hemodialysis patients<sup>23</sup>; and in patients following thoracic surgery to prevent postoperative acute lung injury.<sup>24</sup>

We would once again like to thank Professor McMonnies for highlighting important issues regarding the potential practical applications of our work for DE sufferers and we eagerly await the results from studies investigating the efficacy of improving whole-body hydration as a nondrug treatment for DE.

Neil P. Walsh<sup>1</sup>  
Matthew B. Fortes<sup>1</sup>  
Christine Purslow<sup>2</sup>  
Marieb Esmaelpour<sup>3,4</sup>

From the <sup>1</sup>College of Health and Behavioural Sciences, Bangor University, Bangor, United Kingdom; the <sup>2</sup>School of Health Professions, Plymouth University, Plymouth, United Kingdom; the <sup>3</sup>Department of Ophthalmology, Rudolf Foundation Clinic, Vienna, Austria; and the <sup>4</sup>Center of Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna, Austria.

E-mail: n.walsh@bangor.ac.uk

## References

1. McMonnies CW. Tear osmolality and whole-body hydration. *Invest Ophthalmol Vis Sci.* 2013;54:1712.
2. Walsh NP, Fortes MB, Raymond-Barker P, et al. Is whole-body hydration an important consideration in dry eye? *Invest Ophthalmol Vis Sci.* 2012;53:6622–6627.
3. Taylor RS, Ashton KE, Moxham T, Hooper L, Ebrahim S. Reduced dietary salt for the prevention of cardiovascular

- disease: a meta-analysis of randomized controlled trials (Cochrane review). *Am J Hypertens*. 2011;24:843-853.
4. He FJ, Markandu ND, Sagnella GA, MacGregor GA. Effect of salt intake on renal excretion of water in humans. *Hypertension*. 2001;38:317-320.
  5. Stookey JD, Pieper CF, Cohen HJ. Is the prevalence of dehydration among community-dwelling older adults really low? Informing current debate over the fluid recommendation for adults aged 70+ years. *Public Health Nutr*. 2005;8:1275-1285.
  6. O'Neill PA, Faragher EB, Davies I, Wears R, McLean KA, Fairweather DS. Reduced survival with increasing plasma osmolality in elderly continuing-care patients. *Age Ageing*. 1990;19:68-71.
  7. Ferry M. Strategies for ensuring good hydration in the elderly. *Nutr Rev*. 2005;63:S22-S29.
  8. Grandjean AC, Reimers KJ, Buyckx ME. Hydration: issues for the 21st century. *Nutr Rev*. 2003;61:261-271.
  9. Popkin BM, D'Anci KE, Rosenberg IH. Water, hydration, and health. *Nutr Rev*. 2010;68:439-458.
  10. Vandentorren S, Bretin P, Zeghnoun A, et al. August 2003 heat wave in France: risk factors for death of elderly people living at home. *Eur J Public Health*. 2006;16:583-591.
  11. Chan J, Knutsen SF, Blix GG, Lee JW, Fraser GE. Water, other fluids, and fatal coronary heart disease: the Adventist Health Study. *Am J Epidemiol*. 2002;155:827-833.
  12. Kalhoff H. Mild dehydration: a risk factor of broncho-pulmonary disorders? *Eur J Clin Nutr*. 2003;57(suppl 2):S81-S87.
  13. Hebert LA, Greene T, Levey A, Falkenhain ME, Klahr S. High urine volume and low urine osmolality are risk factors for faster progression of renal disease. *Am J Kidney Dis*. 2003;41:962-971.
  14. Manz F, Wentz A. The importance of good hydration for the prevention of chronic diseases. *Nutr Rev*. 2005;63:S2-S5.
  15. Walsh NP, Montague JC, Callow N, Rowlands AV. Saliva flow rate, total protein concentration and osmolality as potential markers of whole body hydration status during progressive acute dehydration in humans. *Arch Oral Biol*. 2004;49:149-154.
  16. Smith AJ, Shaw L. Mild dehydration: a risk factor for dental disease? *Eur J Clin Nutr*. 2003;57(suppl 2):S75-S80.
  17. Fortes MB, Diment BC, Di Felice U, Walsh NP. Dehydration decreases saliva antimicrobial proteins important for mucosal immunity. *Appl Physiol Nutr Metab*. 2012;37:850-859.
  18. Minassian DC, Mehra V, Verrey JD. Dehydrational crises: a major risk factor in blinding cataract. *Br J Ophthalmol*. 1989;73:100-105.
  19. Fortes MB, Diment BC, Di Felice U, et al. Tear fluid osmolality as a potential marker of hydration status. *Med Sci Sports Exerc*. 2011;43:1590-1597.
  20. Walsh NP, Fortes MB, Esmacelpour M. Influence of modest changes in whole-body hydration on tear fluid osmolality: Important considerations for dry eye disease detection. *Cornea*. 2011;30:1517-1518.
  21. Gibson S, Shirreffs SM. Beverage consumption habits "24/7" among British adults: association with total water intake and energy intake. *Nutr J*. 2013;12:9.
  22. Gibbs CR, Jackson G, Lip GY. ABC of heart failure. Non-drug management. *Brit Med J*. 2000;320:366-369.
  23. Kalantar-Zadeh K, Regidor DL, Kovesdy CP, et al. Fluid retention is associated with cardiovascular mortality in patients undergoing long-term hemodialysis. *Circulation*. 2009;119:671-679.
  24. Evans RG, Naidu B. Does a conservative fluid management strategy in the perioperative management of lung resection patients reduce the risk of acute lung injury? *Interact Cardiovasc Thorac Surg*. 2012;15:498-504.
- Citation: *Invest Ophthalmol Vis Sci*. 2013;54:1713-1714.  
doi:10.1167/iovs.13-11869