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Abstract

Background: Evidence on the hydration status of adolescents and seasonal and time variations is scarce.

Aims: This study aimed to assess variations in the hydration status and total water intake of adolescents in Cyprus between winter and summer and between the morning and end of the school day. Subjective feelings and cognitive function associated with hypohydration were also examined.

Methods: Fifty-three adolescents (39 boys) with a mean age (standard deviation, SD) of 15.1 (1.9) years were included in the study. Participants provided urine samples and completed a cognitive function test and a questionnaire on subjective feelings upon arrival at school and at the end of the school day. Data were collected in winter and summer in 2016–2017. Hydration level was determined by urine specific gravity and cognitive function was assessed with a symbol cancellation test. Total water intake was estimated from a food and fluid record kept by the participants.

Results: A high prevalence of hypohydration was found in both seasons ranging from 72% to 94%. Hypohydration was associated with perceptions of lower concentration and alertness ($P = 0.008$ and $P = 0.047$, respectively). Adolescents had significantly higher mean urine specific gravity in winter than in summer: 1.026 (SD 0.007) versus 1.023 (SD 0.007), respectively ($P = 0.002$). Hydration status was not associated with cognitive function or total water intake.

Conclusions: The high prevalence of hypohydration and the associated feelings of lower concentration and alertness in adolescents suggests that educational measures are needed to promote good drinking behaviour and improve hydration.

Keywords: adolescents, cognitive function, hydration, water intake, Cyprus

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Introduction

Body water is tightly regulated and daily fluctuations are maintained around 0.5% of body mass even in hot weather conditions. Water is essential for cellular homeostasis as well as for thermoregulation of the human body (1). Hydration status reflects the balance between water intake and loss (2). Body water content deficit beyond the normal fluctuation is called hypohydration (3) and is associated with a number of negative effects on health (4). Fluid restriction leading to hypohydration has been shown to be associated with increased feelings of fatigue, decreased alertness and concentration, and lower levels of vigour/activity (5,6). Cognitive function has also been shown to be negatively affected by low hydration status (7), especially when combined with heat stress (8). Children with hypohydration living in a warm climate have been shown to perform more poorly in cognitive tests (9), while children's performance in cognitive tasks appears to improve after drinking water (10).

Many children appear to have a low hydration status at some point during a typical school day (11,12). Water intake and drinking behaviour of children and adolescents varies substantially between countries and most studies have been done in countries with a temperate climate, or

outside summer months (12,13). In addition, data on hydration in adolescents are scarce.

Living in a hot climate increases water loss and the risk of dehydration (14). Adolescents living in the eastern Mediterranean may face a higher risk of water loss and dehydration, as this area is characterized by mild winters and hot summers. School in Cyprus starts early in the morning and ends at 13:30 when the temperature exceeds 30 °C from April–May onwards. If adolescents fail to maintain a normal level of hydration (euhydration), their overall health, concentration and cognitive performance at school could be adversely affected (9,11,15,16).

The primary aims of our study were to compare hydration status of adolescents and total water intake from fluids and solid food during school hours between winter and summer. Our secondary aim was to investigate the relationship between hydration status and cognitive function and subjective feelings relevant to hypohydration.

Methods

Fifty-three adolescents from three main cities of Cyprus (39 boys) volunteered for the study. Their mean age and standard deviation (SD) was 15.1 (1.9) years, mean height was 165 (SD 10) cm, mean body mass was 55.7 (SD 13.1) kg and mean body mass index was 20.4 (SD 3.4) kg/m2. The study was carried out between 2016 and 2017. Data were collected on two occasions, once in the winter time (February) and once in the summer time (during the first two weeks of June – the end of the school year), in random order to avoid any potential learning effect. Half of the participants provided data first in winter and then in summer, and the other half gave data first in the summer and then in the winter. This way we aimed to avoid potential learning effect on the cognitive tests, and any changes in drinking behaviour following the first set of data collection. On each occasion data were collected in the morning, at the beginning of the school day (about 07:30) and at the end of the school day (about 13:30). The outdoor temperature was measured to the nearest 0.1 °C using a portable hygro thermometer (Radiance Instruments Ltd, Hong Kong). The temperature ranged between 10 °C and 15 °C from morning to 13:30 during the winter period, and between 26 °C and 30 °C during the summer period.

Hydration level assessment

Hydration level was assessed by urine specific gravity from the first morning void and from one sample at the end of the school day, before leaving the school premises. Urine collection bottles (60 mL) were given to the participating students at the appropriate time. Urine specific gravity was determined shortly after urine collection and the remaining urine samples were immediately disposed of by the researchers. Urine specific gravity was assessed using a urine refractometer (DIGIT 0-12, Medline Scientific Limited, United Kingdom of Great Britain and Northern Ireland).

The participants were then assigned into three groups according to their urine specific gravity level: euhydrated (urine specific gravity