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MAINTAINING HYDRATION IN CADET STUDENTS: ISSUES AND GUIDELINES

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ABSTRACT

The objective of the review is to a) highlight the issues and challenges in cadet students in maintaining hydration, and b) provide strategy and guidelines in managing hydration among cadet students. During prolonged activity in a hot and humid environment, cadet students exposed to the risk of dehydration. Dehydration may lead to heat injury, decrease physical activity, performance and cognitive function. This got worsen as the cadet students have limited access to fluids and breaks during training. More challenges experiences by the cadet students may due to military uniforms, carrying equipment or other protective gear results in higher thermal stress. Dehydration can be minimised by educating drinking behaviour and acclimatization to heat environment. Assessment of hydration status is also necessary for prevention, recognition and to assist in hydration strategy. Therefore, this review provides proper strategy and practical recommendation regarding the fluid replacement for cadet students.

1.0 INTRODUCTION

During physical activities, it is essential to drink adequate fluid to make sure that the body stays hydrated [1]. This can help to maintain physical performance and cognitive function such as attention, short-term memory and decision-making [2]. It is well documented that fluid losses of 2% body mass are enough to impair both functions [3]. During the 1967 Six-Day War, many Egyptian soldiers lost their lives. They were deprived of necessary supplies and suffered from water shortages and fever. This is an extreme example of the threat that dehydration poses with soldiers [4]. Therefore, recommending a fluid replacement may be crucial to cadet students. In contrast to civilian students, cadet students' daily routines are a blend of traditional education and military training [1]. Typically, they have daily physical training and others military activities over the weekends. This puts more challenges for them and heightens the risk of dehydration. Military planners or logistics personnel must ensure that there is enough drinking water for their cadets during physical activity. Cadet also needs to understand the importance of drinking, make time to drink, and drink properly. This will be beneficial for long term fluid replacement practice as they will be serving in the armed forces.

Voluntary dehydration in athletes has become a common phenomenon, with a significant decrease in sports performance, cognitive functions and increase health risks such as heat illnesses [5]. It was observed, athletes across environmental condition were already dehydrated pre-game/training and rarely replace the fluid matched to the fluid lost [6]. Similarly, voluntary dehydration is common in the military and has been reported in few studies [7]. Cadet students would normally be expected to be dehydrated pre activity and have poor fluid replacement because of limited access to fluids and the absence of breaks during training. The condition worsens by prolonged exposure to hot environments and training included carrying equipment and ammunition for long periods. In addition, wearing uniforms, body armour or other protective gear for too long may lead to inappropriately high thermal stresses [8]. It is recommended that soldier should carry mass that not exceed 50% of their own body mass. For a soldier, exceeding this value may decrease in endurance, situation awareness and to respond

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quickly to threats [9]. It is a common practice to carry a minimal level of water replacement during a mission. For cadet students, a strategy of providing fluid is extremely important as they are expected to loss fluids during military activities.

Prolonged military training activity places high demands on body thermoregulatory mechanisms. The thermoregulation is a process to maintain body temperature to prevent overheating and overcooling. No study has examined the thermoregulatory response through the measurement of core temperature during actual cadet training in Malaysia presumably due to technological limitation. However, the thermoregulatory stresses have been estimated using a laboratories match simulation in athletes. It was found that during 45 min, the core temperature slightly increased to 39 ± 0.7°C and 38.7 ± 0.4°C during intermittent and steady state respectively. This suggests that prolonged exercise results in increased body temperatures. During prolonged activity, the temperature in the body's core rise and heat loss mechanisms play its role to prevent overheating. Cardiac output and blood volume contribute to redirection of blood flow during exercise. This force working muscles and skin to compete for blood supplies, worsening the thermoregulatory process. Therefore, particular care must be taken in the preparation of military training activities. Previous studies have shown that ingestion of fluid may assist in thermoregulation process.

Yet, no study has examined the hydration status among military cadet students in Malaysia and very limited guidelines have been described in this population. The purpose of this review is to: a) highlight the issues and challenges cadet students in maintaining hydration, and b) to provide strategy and guidelines in managing hydration among cadet students. This helps to minimize the risk of injuries such as heat illnesses, degradation of physical performance during military training and cognitive function that is necessary for education.

2.0 ASSESSMENT OF HYDRATION STATUS

Prior to introducing hydration strategy to cadet students, it is important to measure the hydration status so that we understand the mechanism of dehydration; for instance, either through loss of body water/ sweating or pre-existing dehydration condition [13]. To date, various methods have been developed to measure hydration status. Hydration can be assessed through simple and non-invasive methods. Monitoring the body mass (BM) loss (kg) is the main non-invasive technique [1]. Commonly, the BM is measured pre and post activity. If the BM loss is ≥2%, the person should have been considered dehydrated. This method is commonly used when investigating soccer players where the pre- and post-match BM was recorded [1], [14-15].

The measurement of the BM loss was used to replace the fluid losses during continuous activity. For instance, Atan & Kassim (2020) use this strategy to minimise BM loss during prolonged 80 minutes soccer activity [14]. The soccer player consumed 5 $mL \bullet kg^{-1}$ BM of water as it equated to the typical volume would expect for athletes to consume before exercise and equivalent of 2 $ml \bullet kg^{-1}$ BM of water at regular intervals during exercise. By using this strategy, every participant was drinking the same amount of water according to the individual BM. This amount was appropriate/palatable for exercise and also in line with The American College of Sports Medicine (ACSM) guidelines for fluid intake during exercise [16](Casa et al., 2000). The participant's BM loss was about 0.22 ± 0.4 kg and within the normal hydration status. Another study using the same methodology investigating hydration status in young soccer players in hot and humid environments (33.1 ± 2.4°C, 43.4 ± 3.2%, respectively). Surprisingly, the results also indicate the participants were in normal hydration status. This indicates an effective hydration strategy, especially in hot and humid environment which can also be applied to the cadet students [1]. Although commonly used, the BM measurement suffered some limitations. First, there must be a protocol for standardization of measurements obtained for each cadet such as minimal clothing, removal of excess sweat from the skin, bladder voiding, and removal of sweat-soaked clothing.

Another method is through measuring the urine osmolality. It was suggested by the National Collegiate Athletic Association (NCAA), to use the handheld refractometer to measure osmolality by urine specific gravity (USG). This method provides reliable and accurate readings of hydration status [17]. The USG compares between the density of water and density of urine. The urine composition includes water, urea, uric acid, sodium, potassium, creatinine, glucose and proteins [18]. Urine that is too dense and concentrated indicate dehydration and can be categorised into mild and serious dehydration [17]. In sport setting, the use of handheld refractometer is very common and can be conducted in the field or

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laboratory [1], [5-6], [18]. The advantage of this method is easy and require simple procedure. Prior to analysis, the refractometer needs to be calibrated by placing distilled water on the glass plate make sure the scale to read 1.000 (see Figure 1). For this assessment, small midstream urine used to provide accuracy and consistency [16]; place in the glass plate to determine the hydration status (see Figure 1). The disadvantage of this method, it is not cost efficient as the refractometer may not easily accessible and time consuming when measuring a large group of participants. The value proposed for a normally hydrated range from 1.020 to 1.030, greater than 1.030 represents dehydration [9].

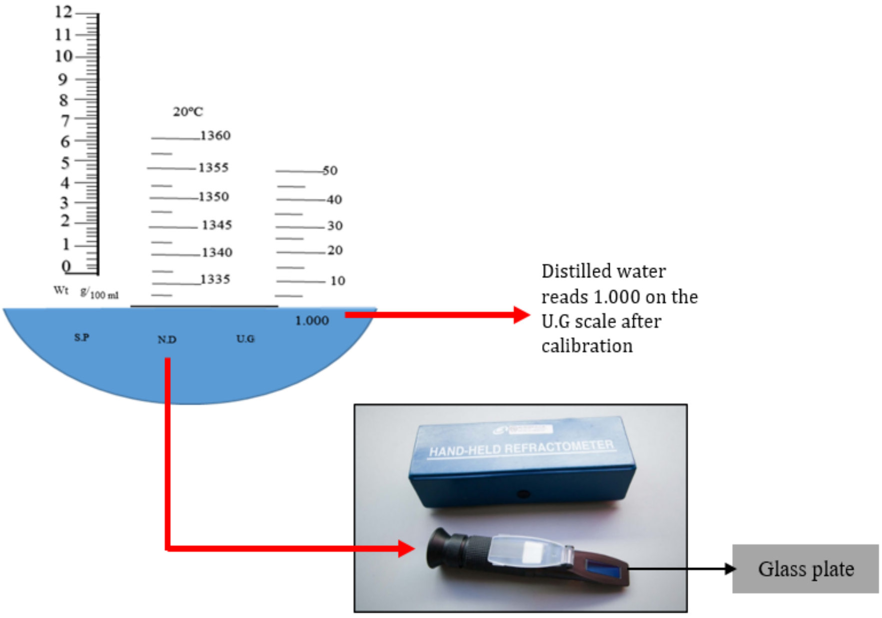

Figure 1. Hand-held refractometer analysis

The simplest and most straight forward method is by observing the urine colours. Small urine sample is required, and the colour was assessed using a urine colour to chart with a 1 to 8 scale (Dietitians in Sport and Exercise Nutrition, London, UK) (refer Figure 2 [19]. Hydrated urine colour is light yellow or close to clear area and vice versa the colour is dark and near to light brown. However, careful consideration should be made when interpreting the results. Urine colour can be influenced by food or medications [20]. Therefore, it is suggested to record the dietary intake prior to investigation on hydration status. Furthermore, it is suggested that the invalidity of self-evaluation of urine colour evaluation may occur, therefore, the assessment should be performed by a single evaluator to ensure the results is accurate and reliable [21].

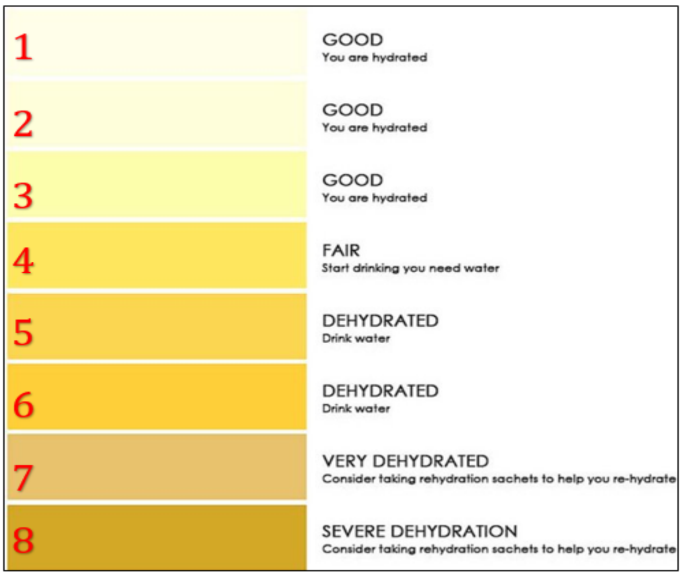

Figure 1. Urine colour chart for hydration measurement

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Table 1. Indexes of hydration status [16]

Condition	% Body weight change	Urine colour	USG
Well hydrated	+1 to -1	1 or 2	< 1.010
Minimal hydration	-1 to -3	3 or 4	1.010 – 1.020
Significant dehydration	-3 to -5	5 or 6	1.021 – 1.030
Serious dehydration	> 5	> 6	> 1.030

3.0 EFFECTS ON DEHYDRATION IN PHYSICAL PERFORMANCE, COGNITIVE FUNCTIONS AND RELATION TO HEAT RELATED ILLNESSES

Dehydration can be defined as the active process of losing water from a dehydrated state [22]. There are few detrimental effects of dehydration that can impair on health such as physical performance and adverse effects on several physiological and cognitive functions [13]. Loss of water from the body can occur in all environments either from sweating, inadequate water availability or water intake, excessive water loss from diuresis, vomiting or diarrhoea [4]. For military officers or cadets, even though a routine activity (marching) was performed in a relatively comfortable environment, the standard uniform, military boots and bush has increased the level of heat stress [9]. Water and hydration in soldiers nowadays are important as they were during the world war. There are still cases in training or others military operation due to dehydration leads to severe condition or death [9]. Educate cadet students regarding the risk of dehydration is essential. Due to a lack of understanding of the amount of fluid that is needed to balance hydration status (hydration), voluntary dehydration is typical in a military setting. This can occur, especially without considering the amount of daily activity.

Therefore, particular care must be taken when doing prolonged military activity. For example, a study by Fogt et al. (2009) investigated hydration status of Air Force military basic trainees [23]. The U.S. Air Force (USAF) tries to prevent dehydration and heat related fitness because the training was conducted in Lackland Air Force Base, located in hot and dry climate area. The findings showed inadequate fluid intake contributes to lost training time and qualified trainees leaving military services without completing the basic military training (BMT). The BMT includes physical readiness conditioning and training, drill and ceremony, classroom instruction and field exercises. The early signs of dehydration or with the approximately loss of 2% from the body mass, a person can develop heat oppression, weariness, sleepiness, impatience and flushed skin. Dehydration of greater than 3% increases greater risk of developing heat illnesses such as heat cramps, heat exhaustion and heat stroke. At 4%, a person may complain muscle fatigue or nausea. At 6% symptom like dizziness, headache, dyspnoea, dry mouth and tingling of the limb, vertigo, visual changes, or in worst the case are angina and seizures may occur because of hyper viscosity; a condition in which blood isn't able to flow freely through arteries [4, 24].

Investigation into dehydration and cognitive function has been done systematically in the military population. Few cognitive abilities such as numerical ability, short term memory, psychomotor function and attention, visual –motor abilities impaired, but also depending on the severity of dehydration [25]. The relation between cognitive function and dehydration occurs because water accounts 75% of brain mass and the brain regulates cognitive performance [26]. Impaired cognitive performance may have serious consequences on the decision making in a military setting. An example of reduce cognitive function can be seen in [7]. This study investigating Australian army helicopter pilot, flying the Sikorsky S-70A-9 Blackhawk tactical helicopter. The pilot trained in a warm and tropical environment with the ambient temperature was 35°C. The findings showed dehydration significantly affects the visual and motor abilities, reduces tolerance G forces in longitudinal axis and head to foot direction (+Gz). This is also positively associated with the reduction in circulating blood volume. The +Gz tolerance can reduce to 16% to 40% when subject loss 3% body fluids. Furthermore, it was reported that the common reason pilot was dehydrated because lack of opportunity to replace fluid and the cockpit temperature would be 7°C higher than the ambient temperature [7].

Besides physical performance and cognitive functions, dehydration also may lead to heat illnesses. Excessive core temperature cause lost in thermoregulatory mechanisms and potentially life threatening [26]. The heat is dissipated mainly through a) dry: radiation and convection and b) wet: evaporation mechanisms. When doing physical activity in a natural environment, the radiant energy from the sun can bring a significant heat load and increased heat produced by working muscles. This accentuates the core temperature. The ability to maintain body temperature in any given environment depends on the individual's metabolic rate, external work rate, convection, radiation, evaporation, and conductive heat

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exchange, which also depends on sweating and cardiovascular of a person [27]. Under extreme temperature or in in a dehydrated state, lower sweating rates may fail to provide sufficient evaporative cooling. The accumulative effects of heat, resulting in an injury. These range from mild to severe; from minor heat rash, heat cramp, to the serious heat exhaustion and severe heat stroke [27]. Symptoms of heat illness can present with headache and nausea, fatigue, dizziness, confusion and disorientation, irrational or aggressive behaviour, loss of consciousness, and in the excessive rise in body temperature cause death [16]. A military based on USAF recorded a 3-heat stroke and 30 heat exhaustion cases per year and one fatal heat stroke [23]. The USAF taking the dehydration effects seriously as suspected heat injury/illnesses requires medical attention, results in delay on military training schedule and medical expenses cost. Heat illnesses are primarily caused by the effects of dehydration. Therefore, the key aspects affecting the health and performance of cadet students that required to train in the hot temperate environment is to guide appropriate strategies to reduce the effects and to improve the safety of the military training [18]. By identifying the early signs of dehydration can limit the risk to heat illnesses among cadets.

4.0 STRATEGY TO MAINTAIN HYDRATION: FLUID INTAKE AND ACCLIMATISATION

The National Athletic Trainers' Association (NATA) claimed that proper hydration during exercise assists in thermoregulation, cardiovascular function, fluid volume status, muscle functioning as well as exercise performance [16]. Fluid intake during team sports is largely determined by opportunities to drink during formal break or informal stoppages during match-play such an injury, substitution or rule infringement [8]. Therefore, it is proposed that athletes should drink pre-exercise, during half time break and/or when they have the opportunity during breaks in play. This method can be replicated among cadet students to replace fluid during training. During military training, regular water intake reduces the problems associated with dehydration or overheating [23].

The strategy is to consume fluids when there is an opportunity for fluid intake, for instance before military training, during breaks and after completion of military training. Cadet students should aware the importance of hydration and should begin their military training in a well hydrated status. The suggestion is to drink about 500 mL of fluid at least 2 hours before the training session, so that allows ample time to urinate the excess fluids. The amount to drink during training is about 200 mL of water. This amount is sufficient to maintain hydration during physical activity [16]. Rehydration during training is also important cause it helps to maintain thermoregulatory and cardiovascular function, consequently, maintain the physical performances [9]. The cadets should consume fluids when there is a window of opportunity to drink the water. The strategy to replace fluid after training can be determined by measuring the BM loss as mentioned earlier in the assessment of hydration. After training, if dehydration is cadet loss more than 5% of body mass drink ~1.5 L of fluid for each 1 kg of body mass deficit. When the amount of water consumed equalled the amount of sweat loss, this will help in thermoregulatory function, increased blood volume and maintenance of extravascular fluid volume [16].

Furthermore, water may be considered the best way for rehydration during exercise but considering the loss of electrolytes (such as sodium, potassium, calcium, magnesium) and glycogen stores during prolonged activities [13], carbohydrate electrolyte (CHO-E) may offer more advantages than ingesting water alone. Consumption of CHO-E beverages has been shown to increase the concentration of blood glucose, enhance oxidation of exogenous CHO, and spare muscle glycogen [22]. Regardless of the mechanism of action CHO-E ingestion has been shown to delay fatigue and improve on sports performance. Having evidence that CHO-E ingestion in athletes have a significant enhancement of intermittent endurance capacity [28], as well as better maintenance of skills and sprint performance [29], improved thermoregulation and reduced risk of heat injury [12]. These findings highlight the possibility of CHO-E supplementation to cadet students to maintain physical performance and contribute significantly to energy supply during prolonged intermittent exercise. Since sports drinks are easily available and has greater application compared to the plain water due to palatability and the potential ergogenic effects, it also can be suggested for cadet students to consume this type of drinks [30].

The other strategy for cadet students to cope with training in hot and temperate environment is by doing the heat acclimatisation. The heat acclimatisation is a process of repeated exposure to heat over a period of approximately 7–14 days, with most adaptations taking place in the first 4–6 days [31]. It is recommended to do exercise that like the actual training for the heat acclimatisation process and should be performed at greater than 50 % of maximal aerobic capacity for 90 - 100 minutes. Performing such

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activity in the heat on consecutive days will maximise the benefits obtained from an acclimatisation program. This physiological process adaptation leads to improved heat transfer from the core to the skin and the environment and improved cardiovascular function. The adaptations of acclimatisation can be reversed with a cessation of exposure to exercise heat stress or dehydration. Performing these activities at high temperatures for several days will maximize the benefits of the heat acclimatisation program. However, adaptation is reversible by stopping exposure to heat stress from exercise [18].

5.0 CONCLUSION

There is clear evidence that dehydration impaired both cognitive and physical performance. This situation is not ideal for cadet students as they need to perform military training and getting their degree simultaneously. Therefore, it is important for them to understand what the effects of dehydration are, how to assess hydration status and what are the strategies to cope with dehydration. Education about the importance of fluid ingestion is fundamental and should be common practice among cadet students.

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