A pilot study examining the likelihood and the implications of hypohydration in pilot and air traffic controller

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ABSTRACT

Adequate fluid consumption is essential for humans to function optimally. However, anecdotal evidence suggests that some aspects of the working environment of air traffic controllers and pilots may encourage hypohydration. In both professions a high level of cognitive performance is required; however, at 2% hypohydration fundamental cognitive abilities such as arithmetic efficiency, working memory, short-term memory and visuomotor tracking involving attention and motor speed are likely to be impaired.

The aim of this thesis was to examine thirst and fluid intake, as a surrogate for hypohydration, in two key areas of the aviation industry (controllers and pilots) where fluid intake may at times be restricted. Also examined are why fluid intake is sometimes restricted and whether thirst is related to affect, psychological stress and fatigue.

A 67-item questionnaire battery was completed by air traffic controllers in Mongolia and the pilot instructors and student pilots from a tertiary training institute in NZ. The battery included 2 measures of thirst, the Samn-Perelli Fatigue scale, the Perceived Stress Scale and a series of demographic questions.

In total there were 101 participants (50 air traffic controllers and 51 pilots), representing an overall return rate of 80%. Thirst related sensations were significantly higher in controllers than in pilots. 14% of pilots restricted their fluid intake before flying to avoid needing to use the toilet and 48% of the reported starting a flight feeling thirsty; 38% of pilots reported having to rush to a toilet to urinate after a flight. Similar, although less pronounced effects were reported by air traffic controllers. Increases in subjective feelings of thirst were correlated with increases in the fatigue scale. Participants who reported higher subjective feelings of thirst and fatigue, also reported higher levels of stress.

In conclusion, the findings in this thesis provide some insights regarding hypohydration in aviation professionals. Most importantly, because of the high numbers of people working in these professions, and the potentially disastrous costs of making mistakes through a lack of concentration, that there were participants who reported restricting their fluid intake, feeling thirst, under stress and fatigued is cause for some concern. Both regulators and future studies might investigate ways in which workers in these occupations can maintain optimal fluid intake, or, at the very least (in the case of GA pilots), be made aware of the possible effects of restricting fluid intake.

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ABBREVIATIONS

AIP	Aeronautical Information Publication
ATC	Air traffic control
ATS	Air traffic service
ATSD	Air Traffic Services Division
CATAM	Civil Air Transport Administration of Mongolia
CS	Categorical Scale
˚C	Celsius
FAA	Federal Aviation Administration
Ft	Feet
ICAO	International Civil Aviation Organisation
kts	Knots
L/d	Litres per day
MCAA	Mongolian Civil Aviation Authority
MIAT	Mongolian airlines
Min	Minute
Ml	millilitre
MU	Massey University
MFSC	Milson Flight Systems Centre
Nm	nautical mile
RH	Relative Humidity
UB FIR	Ulaanbaatar Flight Information Region
VAS	Visual Analog Scale

CHAPTER ONE

1. INTRODUCTION

1.1. General

Mongolia is a landlocked country which borders with Russia and China. Air transportation plays a very important role in connecting Mongolia with the outer world (InterVISTAS, March 2011). During the last twenty years, the scope of its international flights has expanded. Mongolian airspace has become the shortest connection between the North America/Europe and the Southeast Asia, so the number of over flights and the currency income have dramatically increased, thus making a considerable contribution to the state economy. Thus, it can be concluded that aviation sector is of strategic importance to the development of Mongolian infrastructure and economy (InterVISTAS, March 2011; Ministry of Nature and Environment, 2013).

New Zealand is a remote country, situated in the south west Pacific Ocean. It is 1500 kilometres east of Australia and about 1000 kilometres south of the Pacific countries such as Fiji, New Caledonia and Tonga (Naden, 2014). Most international visitors arrive via air (Ministery of Economic Development, June 2009). New Zealand has seven airports that offer international arrivals and departures. The two largest international airports are Auckland Airport and Christchurch Airport which connect directly with countries other than Australia and Fiji (Ministery of Economic Development, June 2009).

1.2. Brief history and introduction of Mongolian Civil Aviation Authority

The Mongolian Civil Aviation Authority (MCAA) is an implementing agency of the Mongolian government. MCAA is responsible for providing air traffic services, the operation of airports, setting safety standards and the oversight thereof, and the regulatory aspect of civil aviation system. Its mission is “to provide a safe, secure and efficient aviation system that contributes to the national economy of Mongolia” (MCAA, 2013).

The history of the Mongolian civil aviation industry dates back to the day when a Yonkers-13 freight aircraft landed in Mongolia from the former Soviet Union. That day, 25th of May in 1925, is widely considered to be the establishment day of the Mongolian Air Force (MIAT, 2013).

The Civil Air Transportation was founded in 1946 with 7 super airplanes and 1 Po-2 airplane and started civil air services to domestic destinations. By 1970, the Mongolian Civil Air Transportation Corporation (MIAT) was serving 130 local destinations including province centres, village centres and collective farms (MIAT, 2013). MIAT started its international operation with Tu-154 aircraft leased from the Soviet Union and representative offices of MIAT in Irkutsk and Moscow, Russia and Beijing, China were opened in 1987 (MIAT, 2013).

Mongolia's relationship with the International Civil Aviation Organisation (ICAO) and other countries was expanded and re-organisation was needed to comply with the requirements to operate flights internationally. Thus, the Minister of Road, Transport and Communication established MIAT as a self-dependent state owned enterprise - MIAT Mongolian Airlines on 12th of August 1993 (MIAT, 2013). At the same time, the Civil Air Transport Administration of Mongolia (CATAM) was established to ensure civil aviation safety security and to provide air traffic services and the operation of airports (MCAA, 2012).

The Civil Aviation Law of Mongolia was passed by the Parliament of Mongolia in 1999 and the CATAM was renamed Mongolian Civil Aviation Authority (MCAA), the Implementing Agency of Government of Mongolia. Mongolia has adopted the "New Zealand" civil aviation rules as the basis of its own regulatory system (MCAA, 2013).

MCAA operates the only International Airport Chinggis Khaan, in Ulaanbaatar, the capital city, and 23 smaller domestic airports. The Chingiss Khaan International Airport serves air passengers and cargo flights in and out of Mongolia (MCAA, 2013).

The MCAA employs a total staff of 2054 people (MCAA, 2013). The revenues for 2013 were USD 75.6 million, from which a total of USD 28.2 million was contributed to the government's budget of Mongolia, and the total expenditure for its own operations was USD 47.4 million (MCAA, 2011).

1.3. Brief history and introduction of National Air Traffic Services of Mongolia

The first temporary air traffic services course that was held under the MIAT in 1957 was the foundation of air traffic services organisation (MCAA, 2013). MIAT was divided into two organisations due to the need to separate airline service from the regulating authority in 1993: MIAT- Mongolian Airlines and CATAM, the current MCAA (MCAA, 2013; MIAT, 2013).

MCAA is charged with the responsibility of managing air traffic within the Ulaanbaatar Flight Information Region (UB FIR) (MCAA, 2013). The Air Traffic Services Division (ATSD) of MCAA is the sole Air traffic service (ATS) provider in Mongolia. There are 180 air traffic control (ATC) staff working 24 hours in shifts is a complex system which consists of a web of airways within the designed UB FIR (MCAA, 2013). ATSD is the responsible authority for the provision of air traffic services within the area of its responsibility. ATS are provided for the entire territory of Mongolia (MCAA, 2013). The following types of services are provided:

- Area Control Service;
- Radar services are provided in certain sectors;
- Approach Control Service;
- Aerodrome Control Service;
- Alerting Service;
- Flight Information Service;
- Aerodrome Flight Information Service (AIP Mongolia, 2013).

According to the statistics provided by the Flow Management Services Division of MCAA, more than 20 airlines operate to and from the Chingiss Khaan International Airport every day and some 120 airlines operate through the UB FIR to other smaller airports (MCAA, 2013). All the flight paths of these aircraft are controlled and handled by Mongolian ATC (see Figure 1). Flight movement record (2013) of ATSD indicates that the total average flight movements are more than 280 flights per day (MCAA, 2013). All these flights coming into and going out of UB FIR are required to establish radio communication and establish radar control contact with Mongolian ATC for flight clearance and aircraft separation purposes (MCAA, 2013).

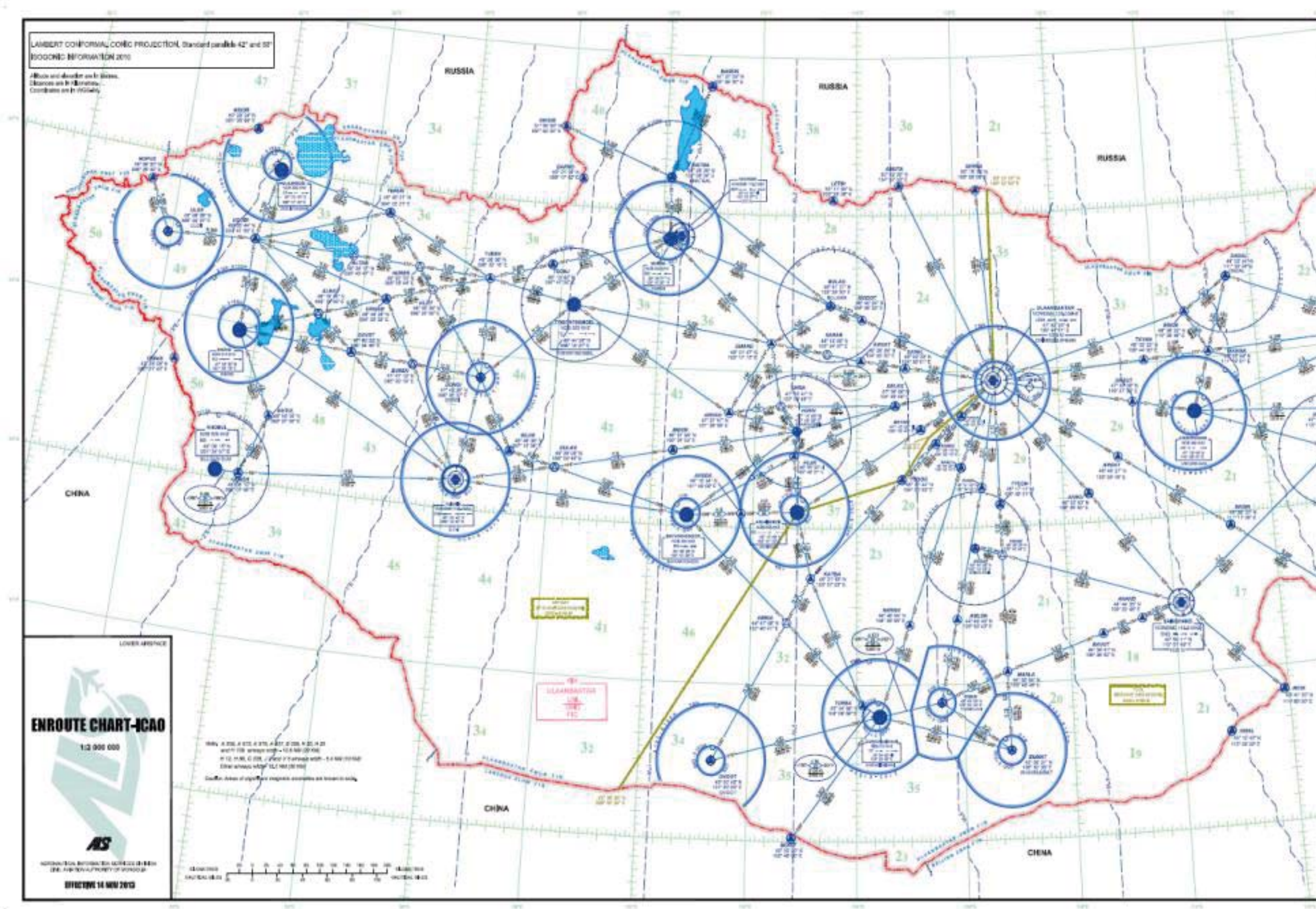

Figure 1: Enroute Chart (MCAA, 2013)

1.4. Brief history and introduction of School of Aviation, Massey University

The School of Aviation is one of the five schools that make up Massey University's College of Business, which is one of New Zealand's leading and largest business schools. It was established in 1990 to provide airlines with graduates with a wide industry perspective. The programs include a professional degree for future pilots incorporating flight training with academic studies and academic degrees for aviation managers (Massey University, 2013). The school offers academic excellence, innovative training methods and front-line equipment and technology to create professional pilots, managers and industry leaders. The School of Aviation was the first New Zealand training organisation to meet the requirements for Civil Aviation Authority Rule Part 141 – Aviation Training Organisations Certification (Massey University, 2013).

Massey University School of Aviation works closely with airlines to ensure that the programmes and research meet business needs. It supervises and undertakes research in many different areas that enhances aviation industry knowledge. The staff and postgraduate students present their research findings at domestic and international conferences and publish articles in academic journals (Massey University, 2013).

The school is based at two locations: the Milson Flight Systems Centre at Palmerston North International Airport, and the Massey University Manawatu campus in Palmerston North (Massey University, 2013). Students enrolled in academic programs such as Bachelor of Aviation Management study at the Manawatu campus whereas the Milson Flight Systems Centre (MFSC) is the main base for the Bachelor of Aviation programme. MFSC houses the latest Diamond Aircraft fleet and flight simulators, flight instruction staff and some academic staff, as well as the school's maintenance facility (Massey University, 2013). MFSC maintains a large fleet of single and twin-engine training aircraft as part of the Air Transport Pilot programme. All the aircraft are fitted with the latest Garmin cockpit and Spidertracks tracking systems (Massey University, 2013).

Figure 2: Diamond DA40 Single-Engine and Diamond DA42 Twin-Engine trainer (Massey University, 2013)

Number in Fleet – 12	Number in Fleet – 2
PERFORMANCE DATA	PERFORMANCE DATA
Engine 180hp	Engine 180hp x2
Top Speed: 178 Knots	Top Speed:194 Knots
Cruise Speed: 150kts	Cruise Speed: 165kts
Max Operating Altitude: 16,400ft	Max Operating Altitude: 18,000ft
Rate of Climb: 1,120ft/min	Rate of Climb: 1,280ft/min
Range: 720nm (Massey, 2013)	Range: 917nm (Massey, 2013).

Massey University first offered the Bachelor of Aviation in 1993. From 2011, Air New Zealand has selected the School of Aviation as a collaboration partner and preferred training provider for the Air New Zealand Aviation Institute. This privilege enables students to compete for a "pool" of preferred pilots for induction by Air New Zealand. All of the International Civil Aviation Organisation (ICAO) licensing requirements are integrated within the papers of the degree (Massey University, 2013).

1.5. Nature of an air traffic controller's working environment

According to ICAO Annex 11 – Air Traffic Services – Air Traffic Service (ATS) includes flight information service, alerting service, air traffic advisory service, air traffic control service (area control service, approach control service or aerodrome control service).

ATS is a service provided for the purpose preventing collisions between aircraft and on the manoeuvring area between aircraft and obstructions and expediting and maintaining an orderly flow of air traffic (ICAO Annex 11, 2001). ICAO recommends air traffic controllers to be licensed (ICAO Annex 1, 2011). Moreover, Class 3 Medical Assessment applies to applicants for and holders of air traffic controller licences (ICAO Annex 1, 2011).

The ATC profession is considered as one of the most mentally challenging careers around the world, and can be extremely stressful due to the characteristics of the job experience and the extensive responsibilities shouldered by ATCs (Jou, Kuo, & Tang, 2013; Wickens, Mavor, & McGee, 1997), although Gilbey, Fifield, and Roger (2006) found ATCs reported lower stress level than tertiary students. ATC is a 24-hour, 365-day-a-year job where ATCs work rotating shifts of seven and a half hour, including nights, weekends and public holidays, usually in control towers at airports or at radar centres (Air Traffic Controller, 2013; Barshi & Farris, 2013).

Air traffic controllers may do some or all of the following:

- receive information about flights from flight plans, pilot reports, radar and observations;
- direct aircraft and manage aircraft traffic flows;
- advise pilots on weather conditions, the status of facilities and airports;

- give pilots permission to take off, land, and change altitude and direction;
- give airport workers permission to move around the tarmac and runway;
- monitor aircraft on a radar and look for possible conflicts;
- alert airport fire crew and rescue services in emergencies;
- write reports on incidents (2013; Nolan, 2011).

The main responsibility is the safe operation flight by maintaining a safe distance between aircrafts while organising the orderly, expeditious flow of aircrafts (Jou et al., 2013). Air traffic controllers communicate with pilots, while watching aeroplane's movements on a screen (Air Traffic Controller, 2013). From a safety perspective, ATCs play an important role in both landing and take-off that are the most critical phases of a flight (Jou et al., 2013).

The ATCs cooperate with pilots, technical staff, other controllers and management (Jou et al., 2013) and interact with other human performance factors including software, hardware, environment, and organization (Vargas, de M. Guimarães, & Sant'Anna, 2012). Thus, similar to other studies, time sharing is the most required ability for recent air traffic control, followed by selective attention and problem sensitivity (Goeters, Maschke, & Eißfeldt, 2004).

The dynamic procedure of collecting, processing and distributing information is the principal aspect in ATC. The information comes from multiple sources and often has to be processed simultaneously, performing multiple tasks at the same time with high loads on information storing and modifications of plans due to new incoming information. High time criticality and the complexity of the task are typical for air traffic control (Adams, Tenney, & Pew, 1995). Level of attention determines performance status. Complex tasks may demand full attention and not be accomplished when attention is diverted (Gopinathan, Pichan, & Sharma, 1988). ATCs have to deal with different scenarios at different levels of complexity by and to coordinate their decisions and to act in a way that the system under control is safe and efficient (Vargas et al., 2012). Moreover, weather conditions (wind speed, rain, clouds) add to this complexity and unexpected changes of weather can directly bear on the safety of traffic (Vargas et al., 2012). Emergencies at times do require an operator to perform two jobs simultaneously (Sharma, Pichan, & Panwar, 1983).

1.6. Nature of a pilot's working environment

Airline pilots fly passengers and cargo on long or short-haul flights for business, leisure or commercial purposes. The aircraft is normally operated by two pilots; one is the pilot in command, while the other is the supporting first officer (Stanley, 2013). According to ICAO Annex 1 - Personnel Licensing, 'Pilot-in-command' is the pilot designated by the operator, or in the case of general aviation, the owner, as being in command and charged with the safe conduct of a flight.

The pilots often take turns to fly the plane to avoid exhaustion, with one operating the controls while the other speaking to ATC and completing the paperwork. In some cases, such as long-haul flights, there may be three or more pilots on board for the necessary breaks from flying. The pilot-in-command has the general responsibility for the safe and efficient operation of the aircraft and the safety of crew and passengers (Stanley, 2013). During aircraft operations, pilots gather information via advanced technical equipment and receive and follow instructions from the ATCs (Jou et al., 2013). Human errors could occur during interactions between pilots and air traffic controllers ATCs which are dangerous to flight safety (Woods, 2010).

Prospective pilots undergo a lot of training to get licensed to fly an aircraft, not to mention to be employed by a major airline. Pilots have a good amount of responsibility and must make critical decisions in seconds (What is the job description of an airline pilot?, 2009). In the area of Cognitive Abilities, several factors rated as relevant or very relevant have been known as criteria for pilot selection since World War II (Goeters et al., 2004): Time Sharing, Selective Attention, Spatial Orientation, Number Facility, Perceptual Speed, Memorisation and Visualisation (Gilbey et al., 2010; Goeters et al., 2004). ICAO recommends all flight crew namely, private, commercial, multi-crew, airline transport, glider and free balloon pilots and flight navigator and flight engineer to be licensed (ICAO Annex 1, 2011). Moreover, Class 1 Medical Assessment applies to applicants for and holders of Pilot licences (ICAO Annex 1, 2011).

An airline pilot's job description is to safely fly an airliner, but a pilot does much more than just flying. A typical day may start with the pilot using computer skills to check weather and flight plans (2009). The plane must be pre-flight checked and all aircraft logs reviewed. When ready, the pilot will oversee the push-back and then taxi to the runaway. Pilots work long hours and strange shifts, often being away from home for several days (2009).

While a passenger needs to consume about 110ml fluid an hour, a very active cabin crew member could perhaps need four times as much. This need is related to the rate of fluid loss and this varies with physical activity, temperature, air flow and relative humidity (RH) (Hawkins & Orlady, 1993).

However, the working environment often discourages pilots from consuming enough fluid. Long and irregular working hours as well as crossing multiple time zones are common working conditions of flight crew (van Drongelen, van der Beek, Hlobil, Smid, & Boot, 2013). Furthermore, tower controllers do not have direct access to the toilet (CBSNews, 2011).

1.7. Statement of the Problem

In order to increase general aviation's awareness of the often-ignored condition of hypohydration, the Federal Aviation Administration (FAA) has lately added pilot dehydration to its list of physiological conditions, in the latest Practical Test Standards – its symptoms, causes, effects and corrective actions (Anderson, 2013). Hydration is important to good health and even critical during the flight (Dara, 2009).

Both pilots and ATCs experience exhaustive workload and isolated and often uncomfortable working spaces which results in physical and mental stress. Due to the unique and demanding nature of their working environments, they often experience hypohydration which has a detrimental effect on mental performance. This is the focus of this study.

1.8. Aim and significance of Thesis

The aim of this thesis is to examine the relationship between hypohydration and subjective feelings of thirst, stress and fatigue in general aviation pilots and ATCs. In particular, the study aims to investigate the fluid intake of aviation professionals (air traffic controllers and general aviation pilots) and their subjective feelings of thirst (as a surrogate measure of hypohydration), and the relationship between thirst, fatigue, and psychological stress.

Objective of the thesis:

1) To examine the extent of thirst sensation and fluid intake in people who work within the aviation industry;

2) To examine whether thirst related sensations can be related to fatigue and stress status in general aviation pilots and air traffic controllers;
3) To compare the results between the two professions.
4) To investigate whether some aviation professionals report that they intentionally restrict their fluid intake (in particular, to avoid having to use a toilet).

This thesis contributes to the body of knowledge related to hypohydration among general aviation pilots and ATCs. This is the first attempt to investigate hypohydration among Mongolian air traffic controllers.

1.9. Structure of Thesis

This thesis consists of six chapters. Chapter 1 delivers introductory information about the MCAA, ANSD, Massey University School Aviation and the unique nature of pilot and air traffic control working environment and introduces the problem statement and significance of the thesis. Chapter 2 presents literature review on hydration, hypohydration, thirst and the measuring methods, and importantly the effect of hypohydration on mental performance. The method and procedures of this thesis are reported in Chapter 3. Chapter 4 presents the results which are then discussed in Chapter 5. In conclusion, Chapter 6 presents recommendations and implications derived from this study.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. The importance of water

Water is one of the most important components of people's body and their diet; without water, humans can survive only for days (Popkin, D'Anci, & Rosenberg, 2010). About two-thirds of human body weight is water that is in the cells, around the cells and in the blood circulation (Delorey, 2010). Water plays a crucial role for cellular homeostasis and life (Ferry, 2005; Popkin et al., 2010).

Water supports the transportation of nutrients, wastes and the structure of tissues cell functions including brain function in body (Ferry, 2005). Hydration status is very important to the body's process of temperature control (Popkin et al., 2010). Due to the close connection between cell hydration and cell function, maintaining hydration is essential (Ferry, 2005). Water in the body is continuously renewed at a rapid rate, remaining in balance between ingestion and losses, (Ferry, 2005). Consequently, maintaining a continuing state of optimal hydration is known to deliver health benefits (Millard-Stafford, Wendland, O'Dea, & Norman, 2012). The studies have not separated the effects of water intake from those of electrolytes and other drink components (Maughan, 2012). "About 30% of the average person's fluid intake comes from food" (Delorey, 2010, p. 4).

It has often been assumed that an individual's response to thirst would ensure adequate water intake to maintain euhydration (Kolasa, Lackey, & Grandjean, 2009). According to Shirreffs (2003), euhydration is the situation or state of being in water balance. However, euhydration is not a steady state, but rather is a dynamic state in that humans constantly lose water from the body and humans delay to replace it or they may consume a small excess and then lose this state (Greenleaf, 1992). Moreover, “hyperhydration is a state of being in positive waterbalance (a water excess) and hypohydration the state of being in negative water balance (a water deficit)” (Shirreffs, 2003, p. 6).

Although, for most fit individuals, thirst ensures adequate hydration, because of the great variability in water requirements for different individuals, there is not a single measure of water intake that would ensure acceptable hydration and optimal health for everybody in different environmental conditions (Kolasa et al., 2009). Moreover, people have diverse hydration needs and requirements due to the differences in personal metabolism, environmental conditions, activities engaged, availability of drinks, ambient temperature, favour and cultural variations (Kolasa et al., 2009).

2.2. The motives for consuming fluid

There is an extensive amount of information regarding hydration, accessible both in printed or online format, suggesting that individuals should drink adequately either for the benefits of health or exercise performance or both (Jusoh, 2010). However, not all information concerning hydration strategies are supported by the results of evidence-based research, and thus could be misleading. For example, the universal belief of “drinking at least eight glasses of water” per day to be healthy has little supporting evidence and is now receiving more critical logical valuation in the scientific literature (Lette & Dwyer, 2008; Valtin, 2002; Vreeman & Carroll, 2007). Other common beliefs such as consuming caffeinated beverages is dehydrating and plain water is the only source to prevent hypohydration, are also suggested to flawed (Grandjean, Reimers, Haven, & Curtis, 2003; Institute of Medicine, 2005; Maughan & Griffin, 2003). Moreover, athletes have primarily been the target population for scientific study (Clark et al., 2013; Jusoh, 2010). Thus, hydration information is still largely lacking for sedentary or recreationally active general populations (Manz & Wentz, 2005). However, increased water intake can promote weight loss in overweight adults (Dennis et al., 2010; Stookey, Constant, Popkin, & Gardner, 2008). With respect to kidney health, high fluid intake has proven to be the most effective therapeutic measure to prevent kidney stone formation (Curhan, Willett, Speizer, & Stampfer, 1998; Siener & Hesse, 2003).

Drinking is facilitated through the sensation of thirst most of the time although there are various reasons for drinking including hedonistic ones (Popkin et al., 2010). When dehydrated, animals and humans feel thirst and willingly drink fluids until satisfied (Millard - Stafford et al., 2012). However, satiation of thirst may occur rapidly in humans, but generally prior to changes in plasma sodium or osmolality, (Denton, 1982; Denton et al., 1999).

In comfortable conditions, hypohydration is normally balanced and sufficiently prevented by increases in thirst-driven drinking (Greenleaf, 1992). Thirst can be a guide for most healthy people to meet their regular hydration needs (Otten, Hellwig, & Meyers, 2006). Voluntary 'thirst-guided' drinking is also a behaviour affected by various social and psychological clues (Dietary Guidelines Advisory Committee, 2010; Millard - Stafford et al., 2012; Valtin, 2002). Therefore, whether the thirst-guided drinking retains optimal hydration status is poorly understood (Millard - Stafford et al., 2012). Generally, water intake is beneficial to individuals with a water deficit, but research does not support the perception that additional water in sufficiently hydrated individuals brings any benefit (Popkin et al., 2010).

Wealthy societies have highly pleasant drinks or fluids that contain other ingredients the drinker seeks such as sweeteners or alcohol for which water is used as a vehicle (Popkin et al., 2010). The types of fluid consumed are culturally varied; for example, beer is a popular drink in many countries (Kolasa et al., 2009).

Thirst plays little role in the day-to-day control of water consumption in healthy people living in temperate climates where people generally consume fluids not to satisfy thirst, but as components of everyday foods such as milk and soup, as drinks like tea or coffee used as mild stimulants and alcohol for pure pleasure and social interaction and milk or soft drinks for their energy content (Popkin et al., 2010).

"Drinking these beverages is not due to excessive thirst or hyperdipsia, as can be shown by offering pure water to individuals instead and finding out that the same drinker is in fact hypodipsic (characterized by abnormally diminished thirst)" (Popkin et al., 2010, p. 440). Moreover, drinks are also used for warming in cold weather and for cooling in warm weather (Popkin et al., 2010). Such drinking appears to also be facilitated through the taste buds, which communicate with the brain as a reward system, the mechanisms that humans are just beginning to understand. This bias in the way people rehydrate themselves may be beneficial because it allows water losses to be replaced before hypohydration and then thirst take place (Popkin et al., 2010).

Philips et al., (1984), Kenney and Chiu (2001) and Ferry (2005) discovered that thirst decreases with aging, thus elderly people have to drink without being thirsty. The water requirement is 1.5 L/d, and more as the outside temperature increases and when there is central heating, or when an elderly person has a fever (Ferry, 2005). It is better for elderly people to drink more often rather than drinking large amounts at one time, since gastric tightness rapidly decreases the sensation of thirst (Ferry, 2005). Research indicates that since elderly people often forget to drink frequently, they encounter a higher risk of developing hypohydration than younger adults (Ferry, 2005).

Particularly, women and elderly people tend to voluntarily restrict fluid due to a fear of incontinence or the inconvenience of having to find or be permitted access to restroom facilities, mobility status (Hodgkinson, Evans, & Wood, 2003), and lack of safe and/or acceptable beverages, and inability to swallow (Bratlund, O'Donoghue, & Rocchiccioli, 2010). However, females show more positive drinking habits than males in gender difference in hydration studies (Sichert - Hellert & Kersting, 2004). Moreover, water consumption seemed to benefit the women somewhat more than the men (Solomon, Glaze, Arnold, & van Mersbergen, 2003).

It was concluded from the earlier study that drinking water seemed to weaken the damaging effects of the active talking job in three of the four women (Solomon et al., 2003).

2.3. Causes of hypohydration and measuring hypohydration status

"Hypohydration is the process of losing water from the body and rehydration the process of gaining body water" (Shirreffs, 2003, p. 6). Hypohydration is a state of body water deficit due to main water losses such as sweating or gastrointestinal losses or to insufficient water intake (Sawka, 2005). Thus, the perception of hypohydration includes both the process of losing body water and the state of hypohydration (Popkin et al., 2010). Hypohydration is caused by many factors, such as a hot and dry environment, physical exercise, inadequate fluid intake and excess caffeine and antihistamines (Delorey, 2010).

Engell et al. (1987) revealed a strong and straight relationship between the severity of perceived thirst and degree of hypohydration before and after exercise in the heated environment. Moreover, there is a direct connection between fluid consumption during rehydration and the level of hypohydration (Maresh et al., 2004).

To prevent hypohydration, all land animals have developed a superbly sensitive network of physiological controls to preserve body water and fluid intake by thirst (Popkin et al., 2010). Unfortunately, overdrinking is not a good idea and does not prepare for hypohydration (Kolasa et al., 2009). First, the human brain protects the body from overhydration. When too much fluid is consumed, fluid-balance hormones and the central nervous system make urine volume increased rapidly. Secondly, the body's built-in mechanisms make it virtually impossible to stock excess water in the body. It is only a matter of few minutes or hours for total body water to return to normal (Kolasa et al., 2009).

Voluntary hypohydration is a state in which individuals, mainly children, while exposed to water loss due to environmental conditions, do not drink appropriately when there is adequate fluid available (Bar-David, Urkin, & Kozminsky, 2005). As a result of a state of hypohydration, a high urine osmolality follows. Urine osmolality is concentration of particles in urine and can be measured using a blood test (Bar-David et al., 2005). Voluntary hypohydration occurs most commonly to children who live in a hot climate, because their high proportion of body surface makes them more susceptible and they do not often restrict their physical activity during the days (Bar-David et al., 2005).

Hypohydration is often the cause of hospitalization, illness and mortality in elderly people who have risks of increasing water losses due to diabetes, vomiting, diarrhoea or fever (Ferry, 2005). Furthermore, elderly people frequently lack of access to drinking. Their resistance to water deficit and thermal stress is poor because they increase their liquid consumptions less than younger people (Ferry, 2005).

For many years, there have been attempts to assess hydration status in a variety of situations (Kolasa et al., 2009). Many indices such as body mass changes, urine indices, blood indices, and bioelectrical impedance analysis have been the most widely investigated to establish their potential as markers of hydration status (Shirreffs, 2003). When an approximation of hydration status is required, the best approach would be comparing information from two or more hydration indices (Kolasa et al., 2009).

The ever-changing nature of total body water explains why no single method can reliably represent hydration status in all situations although there are some advantages and disadvantages to different methods (Kolasa et al., 2009). In 1975, the tests that are used in a clinical setting were divided into three categories: laboratory tests, objective non-invasive measurements and subjective observations by Grant and Kubo (Shirreffs, 2003). The laboratory tests that were measures of serum and urine osmolality and sodium concentration, blood urea nitrogen and haematocrit were considered to be the most precise means to measure a patient's hydration status (Shirreffs, 2003). Urine indices are favoured recently as the most promising marker available (Shirreffs, 2003). Measurement of haematocrit and haemoglobin concentration in the blood has the possibility to be used as a marker of hydration status and a change in hydration status, if a reliable baseline can be established (Shirreffs, 2003).

Researchers need to develop definite hydration assessment techniques in the controlled laboratory environment (Kolasa et al., 2009). But, "during daily activities or exercise, when fluid compartments are constantly fluctuating, an evaluation of a single body fluid is insufficient to provide valid information about either total body water or the concentration of body fluids" (Kolasa et al., 2009, p. 194). Kolasa et al. (2009) concluded that all hydration assessment methods try to describe the complex network of interconnected liquid compartments in human body. Single measurements are insufficient because fluid gain and loss are dynamic and change total body water continuously throughout life (Kolasa et al., 2009). Body water content can be estimated or measured in a number of ways using complex methods, but currently tracer methodology which often uses deuterium oxide (D_2O or ^2H_2O) is considered to give the best measure of total body water (Shirreffs, 2003). In short, the tracers are spread comparatively fast in the body and correction can be made for exchange with no watery hydrogen. Then, the result of total body water measurement is of a precision and accuracy of 1–2% (Shirreffs, 2003).

Abraham, Epasinghe, Selva, and Casson (2006) proposed that an innovative approach to the assessment of hydration status was the measurement of the pressure within the eye (intraocular pressure) using a handheld device. It has been suggested that hypohydration could reduce the intraocular pressure (Hunt, Feigl, & Stewart, 2012). The study by Hunt et al. (2012) revealed that intraocular pressure was increasingly reduced during a period of exercise causing hypohydration, but remained moderately stable when hydration was preserved.

According to Shirreffs (2003), Ferry (2005) and Kolasa et al. (2009), change in weight simply indicates the changes in total body water. One ml of water equals a mass of 1 g (Lentner, 1981). Moreover, the effect of activity on fluid loss can be seen from the rate of sweating, although loss can also occur in other ways (Hawkins & Orlady, 1993). Very simply, body weight loss matches sweat loss (Kolasa et al., 2009). Thus, severe changes in body mass over a short time period can often be explained to be due to body water loss or gain and consequently changes in body mass can be used to measure water gain or loss. This assumption is possible, because no other body component will be lost at such a rate (Shirreffs, 2003). Indeed, this measuring method is commonly used and compared to other methods (Shirreffs, 2003). This measurement is particularly accurate for hypohydration that occurs over a period of 1 to 4 hours (Kolasa et al., 2009).

2.4. Body water

Although the percentage of body weight loss characterizes the severity of acute hypohydration, there is no common definition of various degrees of hypohydration in adults (Szinnai, Schachinger, Arnaud, Linder, & Keller, 2005). One to two percent loss of body weight is considered as mild hypohydration (Kleiner, 1999; Weinberg et al., 1995), a 2–5% loss of body weight is defined as moderate hypohydration (Szinnai et al., 2005) and a body weight loss of more than 5% is defined as severe hypohydration in adults (Holtzhausen et al., 1994; Noakes et al., 1988).

Body loses water mainly by the urinary system via the kidney, the respiratory system via the respiratory tract and lungs via the skin, and the gastrointestinal system as faeces or vomit (Shirreffs, 2003). The means of water gain into the body are gastrointestinally from food and drink intake and due to metabolic production (Shirreffs, 2003). Body water balance is kept via thirst, a feedback-controlled variable, controlled deeply by central and outer mechanisms (Boron & Boulpaep, 2012).

According to Kolasa et al. (2009), the two factors to be considered when using body weight to measure water loss are the basic value of an accurate baseline body weight and urine volume, density and colour. The basic value of an accurate baseline body weight should not be ignored. An easy way to determine baseline body weight is to weigh on five or more sequential mornings, after eliminating but before eating or drinking (Kolasa et al., 2009).

2.5. Thirst and its measurement

Water deficiency or the change in body fluids that are triggered by the function of hypothalamus generate the so-called regulatory or physical thirst (Popkin et al., 2010; Porth & Erickson, 1992). However, definitions of thirst suggest it as a symptom. For example, thirst has been defined as a motivational state in which there is a sensation of a need or desire for water (Woodtli, 1990), a subjective symptom or sensation associated with a craving to drink (Porth & Erickson, 1992), a sensation of dryness in the mouth and throat associated with a desire for liquids (Greenleaf, 1992), a deep-seated sensation or desire for water that cannot be ignored and causes a powerful behavioural drive to drink water (Toto, 1994), a subjective experience reflecting changes in a person's biopsychosocial function, sensation, or cognition under the University of California, San Francisco School of Nursing Symptom Management Model (Welch, 2002) and as a conscious and personal feeling of desiring fluids (Welch, 2002).

Symptoms are unnoticeable by other individuals (Welch, 2002). First, symptom assessment refers to the judgments individuals make about their symptoms, such as duration, frequency, intensity, and distress. Second, symptom response include physiological, emotional, and behavioural expressions of a symptom, such as cognitive, physical, and affective changes (Welch, 2002).

Most people will feel thirsty when they lose about 2% of total body weight that will trigger the thirst mechanism (Delorey, 2010). However, the thirst mechanism is not the proper signal to drink more water, because it arrives too late and too easily is turned off. Moreover, a small amount of fluid intake can turn off the thirst mechanism, which will further delay the replacement of body fluids spare (Delorey, 2010). However, Kolasa et al. (2009) indicated that thirst is a reliable indicator of 1% to 2% hypohydration as a physiological response to hypohydration.

Physiologically, increases in the osmotic pressure of extracellular fluid results in thirst and is closely connected to several fluid-regulating hormones (Maresh et al., 2004). However, during exercise, the human thirst mechanism may not be sufficient

(Maresh et al., 2004). There are two different mechanisms of physiological thirst: the intracellular and the extracellular mechanisms (Popkin et al., 2010). The brain's resolution to start or stop drinking and to choose the right drink is completed before the consumed fluid can reach the intra- and extracellular compartments (Popkin et al., 2010).

Limited empirical work has been done to investigate the symptom of thirst or to develop reliable and valid measures of thirst (Welch, 2002). Thirst assessment depends on an individual's recognition, awareness, and explanation of the sensation. Traditionally, numerous methods have quantified the subjective measurement of thirst. Both visual analog scales (VAS) and categorical rating instruments are mentioned in the literature (Millard-Stafford et al., 2012) (see Figure 3).

Visual Analog Scale (VAS):

How thirsty do you feel right now?

Not thirsty **very thirsty**

Categorical Scale (CS):

How thirsty do you feel right now?

1	**2**	**3**	**4**	**5**	**6**	**7**
not thirsty at all	**not thirsty**	**not very thirsty**	**neutral**	**thirsty**	**very thirsty**	**very, very thirsty**

Figure 3: The Visual Analog Scale (VAS) & Categorical Scale (CS) (Millard-Stafford et al., 2012).

Thirst intensity, defined as the severity, strength, or amount of thirst, has been successfully measured in past research using a visual analogue scale (see Figure 3) (Dominic, Ramachandran, Somiah, Mani, & Dominic, 1996; Martinez-Vea, Garcia, Gaya, Rivera, & Oliver, 1992; Phillips, Bretherton, Johnston, & Gray, 1991). Thirst is measured with a VAS as the deviation from perceived thirst by subject placing a mark on a 30-cm horizontal line indicating “not thirsty” at one end and “very thirsty” on the other (D. Thompson & Campbell, 1977). They also simultaneously used a 7-point categorical scale (see Figure 3), with numbers of 1 indicating extreme thirst, 4 being neutral, and 7 indicating no desire to drink even on request. Later, Rolls, Wood et al. (1980) published a VAS that traced with plasma osmolality. Subjects responded to questions about thirst by placing a mark on a 10-cm horizontal line attached by phrases “not at all” and “very thirsty” at the two end (Rolls et al., 1980). Bossingham, Carnell, and Campbell (2005), Farrell et al. (2008), Phillips, Rolls, and Ledingham (1984), Sinha, Ball, Jenkins, Hale, and Cheetham (2011) and Thompson, Bland, Burd, and Baylis (1986) have used this instrument with slight modifications.

Jusoh (2010) used the 10-cm VAS questionnaire in her studies and found that subjective feelings related to thirst such as thirst perception, mouth dryness, hunger rating and desire to drink could be used as a marker of hydration status to specify at least a 1% body mass loss due to food and fluid restraint in free living individuals.

There is also a categorical Likert rating instrument - The Thirst Sensation Scale (TSS) to assess thirst which consists of 37 survey items corresponding to numerous feelings, symptoms, and sensations about thirst (Engell et al., 1987).

Researchers like Brown, McCarty et al. (2011), D'Anci, Mahoney, Vibhakar, Kanter, and Taylor (2009), Kenefick, Hazzard, Mahood, and Castellani (2004) and Maresh et al. (2004) adopted a 9-point categorical rating scale with number descriptors ranging from “not thirsty at all” to “very, very thirsty” due to is comprehensive, but time-consuming nature. Greenfield, Webster et al. (1996) further simplified a Thirst

Likert scale ratings into three categories: no thirst, mild thirst, or moderate/severe thirst. Welch (2002) conceptualized three different dimensions of thirst, namely distress, duration and frequency developed a 6-item instrument to measure that measures thirst distress that has satisfactory reliability and validity for use in clinical studies. Still, a comparison of the different perceived thirst rating scales is evidently needed before a recommendation can be made concerning which to make use of in systematic studies on "thirst" (Millard - Stafford et al., 2012). However, the best technique to measure human thirst in research is undecided and merits further study (Millard - Stafford et al., 2012).

More investigation is needed to extend our understanding of whether drinking to thirst is appropriate across all segments of the population in their daily lives and under specific conditions (Millard - Stafford et al., 2012). Whether individuals should let thirst be their guide has motivated debate. The following recommendation was released from the International Life Sciences Institute North America Conference on Hydration and Health Promotion (November 29–30, 2006, Washington, DC): "Most healthy people adequately meet their daily water needs when they let thirst be their guide. However, this is not true for athletes, military in hot environments, people who are ill, the elderly or infants. The sense of thirst (or the ability to communicate it) of these populations is not an adequate reflection of their water needs" (S. Campbell, 2007, p. 154). Sensitivity of the thirst mechanism is reduced in elderly persons (Kriemler, Wilk, Schurer, Wilson, & Bar-Or, 1999; Phillips et al., 1984).

Also sodium balance may take priority over fluid restoration by the need for salt that also influences drinking (Skøtt, 2003). Ad libitum fluid replacement between individuals equally dehydrated (3% loss in body mass) may differ due to different sodium loss even when perceived thirst is similar (Brown et al., 2011). Thus, it is undecided how sodium concentration and osmotic pressure concurrently influence human thirst and its satiation with different fluids (Millard - Stafford et al., 2012).

2.6. Historical study between hydration and mental performance

Several studies regarding desert and jungle warfare conditions among military persons during the period of 1930s to 1950s indicated that fluid consumption during physical activity was favourable by maintaining body water balance (Adolph, 1947; Adolph & Dill, 1938; Talbott, Edwards, Dill, & Drastich, 1933). In as early as 1947, Rotshtein, Adolph, and Willis (1947) found that minor degrees of hypohydration cause fatigue, drowsiness, lack of appetite, and reluctance to participate in difficult tasks. Interestingly, however, the investigation of the impact of fluid loss of athletes suggested that successful runners showed a high tolerance to fluid loss and as the runners became dehydrated by 3% or more of body mass, the rectal temperature after the race increased linearly (Pugh, Corbett, & Johnson, 1967; Wyndham & Strydom, 1969).

The research into fluid balance and hydration continues to develop and the understanding about the importance of the role of fluid intake in general health and physical activity has changed considerably (Jusoh, 2010). The existing literature supports the conclusion that hypohydration will reduce mental performance in capacities such as psychomotor, motor control, dexterity, and cognitive functioning.

2.7. Effect of hypohydration on human performance and health

The body water content changes over the course of an average day with no implications for human physical or mental performance. But if sufficiently severe, loss of body water impairs most physiological functions (Maughan, 2012). “The point at which an effect of hypohydration becomes apparent has been the subject of much debate, in part, at least, because of the different tests that have been applied, differences in the methodologies used to induce hypohydration and also because of differences in the fitness and other physiological characteristics of the subjects studied" (Maughan, 2012, p. 128).

Common signs of hypohydration are headache, dizziness, fatigue, cramps and sleepiness (Delorey, 2010). Unreplaced water losses of 2% of body weight will degrade the ability to regulate heat. A 3% loss results in a decrease in muscle cell contraction times. When fluid loss equals 4% of body weight, a 5% to 10% drop in overall performance will occur which can last up to four hours (Delorey, 2010).

Recent literature has reported the negative effects of mild hypohydration on human performance and health, when only 1% or 2% of body weight is lost (Bar-David et al., 2005; Kolasa et al., 2009; Maughan, 2012). A drop in performance levels for different central intellectual abilities involving short-term memory, working memory or visuo-motor abilities was reported in response to hypohydration in studies conducted by (Cian, Barraud, Melin, & Raphel, 2001; Gopinathan et al., 1988; Sharma, Sridharan, Pichan, & Panwar, 1986). The decrease in performance is proportional to the degree of hypohydration and develops significant with a 2% body weight loss (Sharma et al., 1986; Gopinathan et al., 1988).

According to Maughan (2012), there is a strong body of evidence to support the idea that a considerable decline in the body water content will reduce performance in a variety of exercise tasks involving strength, endurance, power, or skilled movement. The results of long-term hypohydration can be impaired memory function, wrinkled skin, brittle nails, dry hair, constipation, and vulnerability to colds and sinus infections (Delorey, 2010).

2.8. Effect of hypohydration on mental performance

Studies of hydration and mental performance have proved that the techniques chosen to assess hydration level bring different results, therefore making the possibility to compare data from different studies more difficult (Kolasa et al., 2009). In most research cases on relation between water consumption and physical or mental functioning, an euhydrated state that is often achieved by provision of water adequate to overcome water loss, is compared to a dehydrated state that is achieved via restricting fluid intakes over time and during periods of high activity or heat stress (Popkin et al., 2010). Hypohydration is induced by a combination of exercise in heat and water restriction (Gopinathan et al, 1988).

The damaging effects might result from voluntary hypohydration due to inadequate water intake during heat exposures or exercise in a hot environment (Gopinathan et al., 1988; Sharma et al., 1986). Moreover, hypohydration produced a decline in tracking performance, and with respect to euhydration, it subdued psycho-motor skills (Cian et al., 2000).

Cian et al. (2000) found that only the short-term memory is affected by the hypohydration status, not the long-term memory. Short-term memory was considerably greater after hyperhydration than compared to euhydration. Moreover, long-term memory was decreased in both hypohydration and control situations, whereas there was no decrease in performance in the hyperhydration condition (Cian et al., 2000). Simultaneously, decrease in long-term memory is greater in the exercise-induced hypohydration than in the heat stress hypohydration or euhydration conditions (Cian et al., 2000).

Moreover, hypohydration via both heat stress or via exercise has a similar damaging effect on cognitive performance (Cian et al., 2000). Consistent with previous studies, exercise and heat stress had a negative effect on cognition, although there was no obvious difference between the two hypohydration methods (Cian et al., 2001). In contrast to previous studies by Gopinathan et al. (1988) and Cian et al. (2001), Szinnai et al. (2005) found no decline of cognitive-motor performance during mild hypohydration.

Cortisol level is known to increase with hypohydration (Cian et al., 2001; Francesconi et al., 1987) and also to affect memory function adversely (Kirschbaum, Wolf, May, Wippich, & Hellhammer, 1996). Nevertheless, this could not clarify the comparable drop in memory performance in control and hypohydration conditions. Indeed, it can be presumed that in the control situation, cortisol levels are maintained and are lesser than in the hypohydration situation (Cian et al., 2001).

A 2% loss of body fluids was assessed to cause a 20% decline in physical performance (Sawka & Pandolf, 1990). Sharma et al., (1983; 1986) identified the effects of hypohydration at different levels (1, 2, and 3% of body weight deficit) on mental functions of various complexities in adults. Cian et al. (2000) have revealed that the response to hypohydration, whether following exposure to heat or exercise-induced, was a substantial reduction in cognitive performance for different abilities, such as perceptual or decisional tasks. This decrease seemed to be relative to the degree of hypohydration, becoming substantial after a loss of 2% of body weight (Bar-David et al., 2005).

Numerous studies report that exercise-induced hypohydration harms adults' cognitive performance (Gopinathan et al., 1988; Sharma et al., 1986; Tomporowski, Beasman, Ganio, & Cureton, 2007). Although exercise-induced hypohydration did not affect participants' performance on a symbol substitution task, hypohydration of 2% or more showed negative impact on participants' working memory and psychomotor performance (Sharma et al., 1986). Declines in participants' serial addition, word recognition, and response alternation were correlated to their level of hypohydration, with significant reductions after 2% reductions in body weight (Gopinathan et al., 1988). The results of these studies are challenging to interpret, however, as exercises were performed in hot environments that levels of oral and skin temperature increased. Thermal stress is recognized to independently impact mental performance, principally when core body temperature exceeds 40˚C (Tomporowski et al., 2007).

Two studies were conducted in which men's core body temperature was kept below 39˚C while running on a treadmill for two hours (Cian et al., 2001; Cian et al., 2000). Exercise without fluid consumption resulted in 2 % to 2.8 % of body weight loss and declines in performance on tasks that involve speeded complex decision making (Cian et al., 2001; Cian et al., 2000), psychomotor control (Cian et al., 2001), and short-term memory functions (Cian et al., 2001; Cian et al., 2000), were discovered. However, performance on tasks that required long-term memory (Cian et al., 2001; Cian et al., 2000), simple-reaction time (Cian et al., 2001), serial-reaction time (Cian et al., 2000) were not considerably affected. The pattern of these results suggest that exercise-induced hypohydration may have a bigger negative impact on mental jobs that are cognitively effortful and require the provision of attention resources than tasks that are performed more automatically and require fewer resources (Tomporowski et al., 2007). Several theories of human performance expect that stressful environments will use a greater impact on the performance of complex, cognitively difficult tasks that drawn on decision-making functions than on simple or well-learned tasks (Colcombe & Kramer, 2003; Hancock & Warm, 2003).

According to the study of exercise-induced hypohydration by Tomprowski et al. (2007), although it did not adversely influence participants' short-term memory, it did affect participants' executive functioning. Participants' short-term memory performance enhanced following exercise conditions, irrespective of the level of hypohydration. These results are different from those acquired in research procedures in which there were a considerable delay between the termination of exercise and cognitive testing (Cian et al., 2001; Cian et al., 2000; Sharma et al., 1986).

Heat exposure may play an independent role in the impairment of cognitive abilities (Sharma et al., 1983; Sharma et al., 1986). Sharma et al. (1983) conducted an investigation to determine the nature of effects of variable degrees of heat stress on mental alertness, reasoning ability, associative learning, and dual-performance efficiency. Thermally comfortable settings are seemingly beneficial for optimal mental activity (Sharma et al., 1983). Moist conditions are more damaging to effectual psychological performance than dry ones. Moreover, it is clear that mental competence is not disturbed considerably in environments that are only slightly hotter than the comfort zone (Sharma et al., 1983).

Several studies relate to the effect of heat stress to mental performance (Sharma et al., 1983). One variable that seems to have escaped consideration in these studies is the degree of hypohydration which was a definite consequence of heat exposure (Gopinathan et al., 1988).

There is no report in the literature related to this variable concerning mental performance under heat stress. Hence, the study was undertaken by Gopinathan et al.

(1988) to determine the effects of various degrees of hypohydration on mental performance by assessing the psychological functions such as arithmetic ability, short-term memory and visumotor tracking. They found significant deterioration in mental functions at 2% or more body hypohydration levels (Gopinathan et al., 1988).

Moreover, Cian et al. (2000) reported that hypohydration via exercise or via heat stress have a similar detrimental consequence on cognitive performance. Some of the effects detected can be rapidly reversed, although the subjects feel more tired two hourse after hypohydration. At the same time, decrease in long-term memory is greater in the exercise-induced than in the heat stress hypohydration or euhydration conditions (Cian et al., 2000). In these earlier reports, however, performance was measured after an additional physical exercise, so that it is not certain whether decrease in performance are the result of the hypohydration method or of differences in adaptableness to physical workload (Cian et al., 2001).

Hypohydration conditions by both the controlled passive hyperthermia or exercise on a treadmill, weakened cognitive abilities such as perceptive discrimination, short-term memory and psycho-motor skills, and as well as subjective approximations of fatigue, without any significant differences between them (Cian, 1999).

Athletes use acute thermal hypohydration method to induce rapid weight loss when they compete within weight classification (Bigard et al., 2001). Passive hypohydration weakens muscle resistance to fatigue. EMG spectral changes associated with fatigue occurred earlier when subjects were dehydrated. Because rapid rehydration was unsuccessful to repair muscle endurance, sauna-induced hypohydration does not seem to be an appropriate practice to attain rapid weight loss before weight-class sporting competitions (Bigard et al., 2001).

The severity of hypohydration is categorized by the percentage of body weight loss (Phillips et al., 1984). However, there is no commonly accepted definition of different degrees of hypohydration. According to Ekblom, Greenleaf, Greenleaf, and Hermansen (1970), Kleiner (1999) and Weinberg and Minaker (1995), mild hypohydration has been defined as 1–2% loss of body weight while severe hypohydration is characterized by a body weight loss of more than 5% (Holtzhausen et al., 1994; Nielsen, 1974; Noakes et al., 1988). Moderate hypohydration in adults was defined as a 2–5% loss of body weight in the study (Szinnai et al., 2005).

Impaired or decrease working memory and alertness was reported at 1-2% of body weight loss induced by exercise (D'anci et al., 2009) and by exercise and heat (Armstrong, 2007). Decline of cognitive abilities after heat-induced hypohydration or short-term exercise have been found in normal participants at a hypohydration level of 2% or more (Cian et al., 2001; Gopinathan et al., 1988; Sharma et al., 1986). From these data, it could be reasonably assumed that constant water deprivation leading to an equal level of isotonic hypohydration (2–3%) would create similar negative effects on cognitive abilities (Szinnai et al., 2005). It could be argued that differences of hypohydration techniques are accountable for different effects on cognitive abilities. Cian et al., (2001) systematically compared the effects of heat and exercise-induced severe hypohydration on cognitive abilities in the same subjects and found that results at identical levels of hypohydration were similar. However, data on direct comparisons between heat or exercise-induced hypohydration and water deprivation are lacking (Szinnai et al., 2005). One reason could be the fact that exercise and heat lead to increased heart rate, affecting the cardiovascular system more than water deprivation. Another reason is that the rate of fluid loss may play a role (Szinnai et al., 2005).

While Gopinathan et al. (1988) and Cian et al. (2001) have experienced cognitive performance after severe hypohydration within 0.5–2 hours, water deprivation over 28 hours was required to extend to equal levels of hypohydration in the study. The results of the study by (Szinnai et al., 2005), indicate therefore that young healthy subjects are capable of adapting to a slowly progressive water deficit.

The initial descent of short-term memory instantly after severe hypohydration returned to baseline levels 3.5 hours later independent of water intake (Cian et al., 2001; Szinnai et al., 2005). Although, the mechanisms responsible for the adaptation remain imprecise, remarkably, performance became normal after rehydration, as well as after continuing hypohydration (Szinnai et al., 2005).

During hypohydration the subjects felt more fatigued and less alert. Cian et al. (2001) and Szinnai et al. (2005) both observed significantly increased fatigue ratings after hypohydration, lasting for 3.5 hours without fluid ingestion. Healthy young subjects of either sex were able to increase their task-related effort up to a moderate hypohydration level of 2.6% loss of body weight during slowly progressive hypohydration (Szinnai et al., 2005).

However, various means of assessing mental performance exist, and many complex factors affect performance, making it difficult to reach ultimate conclusions (Kolasa et al., 2009). Assessment of mental performance is complicated by a range of factors such as motivation, IQ, practice effect, physical stress, thermal stress, sex, diet, use of caffeine, beverage consumption during testing, disease states, drugs, time of day, and degree of hypohydration and any other conditions that affect the outcome of cognitive function assessments (Kolasa et al., 2009).

2.9. Relationship between pilot/air traffic controller work environment and hypohydration

Pilots and ATCs play key professional roles in air transport operations (Jou et al., 2013). Hydration is important to good health and even critical during the flight. First, hypohydration is more likely to occur at altitude. Levels on the flight deck can get as low as 3% (R. Campbell & Bagshaw, 2001). RH for military flights is 3-7% and 11-24% for commercial flights (Gilbey et al., 2010). Second, its effects are more noticeable and the consequences of losing one's competitive edge, when at the controls of a flying machine, are that much more life-threatening (Goeters, 2004; Woods, 2010).

There are many potentially hot military environments, such as the cockpits of supersonic aircraft, the engine rooms of naval ships, and the work places of tank crews to which airmen, sailors, and soldiers are exposed (Sharma et al., 1983).

Pilots in military flights, are likely to be moderately or severely hypo-hydrated and in commercial flights, mildly hypo-hydrated. The reasons can be voluntary pre-flight hypohydration, dry air, no lavatory facility, solo duty, busy workload, busy phases of flight and diuretic effect of coffee (Gilbey et al., 2010).

Overall body hypohydration can be prevented if adequate fluid is taken during the flight. Diuretics such as coffee and alcohol reduce the overall water content of the body, thus should preferably be avoided. Incidentally, the sensation of thirst is not a good indicator of thirst to avoid dehydration (Armstrong, 2007). It is essential to learn how much to drink and then drink it whether thirsty or not (Hawkins & Orlady, 1993).

There are some problems concerning the usage of lavatory for airline pilots although they are allowed to leave their work station as stated in PART-91(PART-91, 2014). During takeoff and landing, and while en route, each flight crewmember shall be at the crewmember station unless the absence is necessary to perform duties in connection with the operation of the aircraft or in connection with physiological needs (PART-91, 2014). Particularly after 9/11, in order to take physiological needs' break safely, pilots first alert the flight attendants on the intercom who create a barrier to the cockpit and give them an all-clear signal to open the door (Costantini, 2013). In short, the protocols for a pilot to use the lavatory during flight are very strict to ensure security considerations (US Today, 2014).

There was an incident that an Air India passenger jet was forced to make an emergency landing after its pilot was locked out of his own cockpit after visiting the lavatory (Nelson, 2013). Passengers make complaints saying that the cockpit door was opened many times and for a long period like 5 minutes (Romero, 2011). These are examples of problems that pilots face when using lavatory.

Glider pilots regularly fly at high altitudes for a long period of time in hot summer temperatures. The gliders clear canopy provides no protection from the sun and, at high altitudes; there are less air pollutants to diffuse the sun's rays. Moreover, the body continually attempts to regulate by perspiration. These lead to hypohydration if fluid is not taken which results in dizziness, nausea, weakness, tingling of hands and feet, extreme thirst and abdominal cramps (FAA, 2013).

A new environmental problem that high altitude jet flight brought – a very low RH, results from the very low water content of the air at the altitudes which are the most cost-effective for jet operation. The RH also depends on the number of passengers on board, as that is a major source of moisture in the cabin atmosphere (Hawkins & Orlady, 1993). "Relative humidity (RH) is the ratio of the actual amount of water vapour in the air to the amount that would be present if the air was saturated at the same temperature, expressed as a percentage" (R. Campbell & Bagshaw, 2001, p. 37). While 20% is normally accepted as comfort level, RH for military flights is 3-7% and 11-24% for commercial flights (Gilbey et al., 2010). Levels on the flight deck can get as low as 3% (R. Campbell & Bagshaw, 2001).

Research has shown that the maximum extra water lost from an individual during an 8-hour period in zero humidity, is around 100ml (R. Campbell & Bagshaw, 2001). The discomfort which arises from a continued exposure to low RH involves drying out of the upper respiratory tract, especially the nose and throat, and hypohydration of the skin normally (Hawkins & Orlady, 1993). The sensation of thirst experienced by a healthy individual in the low RH environment is due to drying of the pharyngeal membranes, and this itself may lead to the false sensation of thirst. Low humidity can cause mild subjective symptoms, such as dryness of the eyes and mucous membranes (R. Campbell & Bagshaw, 2001; Hawkins & Orlady, 1993).

The general job requirements to maintain safety of aircrafts and high-level performance expectations make the ATC profession complex (Jou et al., 2013). ATCs make multiple decisions in quick succession that are pressured by time. In addition to time constraints, ATCs experience exhaustive work schedules and isolated working spaces. The workplaces stressors cause both physical and mental stress for ATCs (Jou et al., 2013).

There is not a bathroom in the tower workroom which is like the cockpit of an airplane (CBSNews, 2011). ATCs have to walk down a flight of stairs to go to the bathroom. When a single ATC on duty at an airport tower takes a bathroom break, the tower is unattended (CBSNews, 2011). For instance, two aircrafts had to circle for 18 minutes and a plane transporting human lungs for transplant was temporarily delayed while an airport's only ATC took a bathroom break at the Manchester, New Hampshire airport in 2007 (CNN, 2007). The controller had been on duty for about two hours and 40 minutes when he had to take a bathroom break (CNN, 2007).

ATCs get a short toilet break to get them through their eight hour shift (Air traffic controllers are crying out for help, 2008). The Airways Corporation states three airports - Gisborne, New Plymouth and Invercargill – with controller towers operated by a single ATC, might have to close between scheduled passenger flights to meet changes made to the Employment Relations Act. The changes require workplaces to provide two 10-minute breaks and one half-hour meal break during each eight-hour shift (Taranaki Daily News, 2009).

While many pilots are aware of the term "hypohydration," most pilots are unaware of its symptoms and deteriorating effects which can increase the risk of an accident, even during a mildly warm day (Delorey, 2010). The effects of hypohydration on a pilot's performance can be dangerous, particularly in warmer climates (FAA, 2013). Although the likelihood of hypohydration is hopefully relatively small, it may still be clinically significant when considering the very high number of pilots and ATCs actively working each day. Indeed, it may take only one mistake by one aviation professional affected by hypohydration for many lives to be lost in a major aviation accident.

Extant theories and anecdotal evidence were used to develop the following three hypotheses. The research hypotheses:

1. The general aviation pilots and ATCs are likely to be hypohydrated.
2. Nature of working environment of pilots and ATCs is likely to lead to hypohydration.

3. Hypohydration in aviation professionals is likely to lead to more fatigue and stress.

CHAPTER THREE

3. METHOD

3.1. Research Design

Research philosophies were studied to choose the right paradigm to guide the studies in this thesis. According to Saunders, Lewis, and Thornhill (2012), "paradigm is a way of examining social phenomena from which particular understandings of these phenomena can be gained and explanations attempted" (p.118). After some comparisons between four research philosophies in management research: positivism, realism, interpretivism and pragmatism, positivism was chosen as being the most appropriate. "Positivism is underpinned by the belief that reality is independent of us and the goal is the discovery of theories, based on empirical research (observation and experiment)" (Collis & Hussey, 2009, p. 56). Postal or internet questionnaire, face-to-face or telephone interviews are key methods for collecting survey data in a positivist study (Collis & Hussey, 2009).

The terms quantitative and qualitative are used extensively in research to distinguish both data collection techniques and data analysis procedures (Saunders et al., 2012). Quantitative is a mainly used as a synonym for any data collection technique (such as questionnaire) or data analysis procedure (such as graphs or statistics) that generates or uses numerical data (Saunders et al., 2012). Instead of relying on numbers, frequency-type data and counts, qualitative research will often contain the collection and analysis of detailed observations, narrative histories or stories, sounds, pictures, or videos (Weathington et al., 2012).

3.2. Research Strategy

The survey strategy is a popular strategy in research and is most often used to answer who, what, where, how much and how many questions and widely used for experiments on correlations (Saunders et al., 2012). Moreover, the information is collected quickly and with minimal expense (Weathington, Cunningham, & Pittenger, 2012). Surveys are very useful ways of gaining information, and they give correct estimates of important population parameters (Weathington et al., 2012). However, there is a limit to the number of questions that any questionnaire can cover, so the data collected by the survey strategy may not be as wide-ranging as those collected by other research strategies (Saunders et al., 2012).

The data collected by survey strategy can be used to recommend possible reasons for exact relationships between variables and to create models of these relationships (Saunders et al., 2012).

3.3. Participants

The participants recruited for this study were certified and current ATCs at the ANSD of MCAA in Ulaanbaatar, Mongolia and student pilots at Massey University School of Aviation in Palmerston North, New Zealand. This geographical spread of the intended participants needs some considerations such as time schedule and permission from appropriate authorities.

3.4. Materials

A 5-section, 67-item questionnaire battery was developed for the purpose of this thesis. The questionnaire battery comprised the following sections:

I. Demographic information

II. Health, life style and fluid intake habits

III. Subjective feelings – Thirst

IV. Fatigue

V. Perceived Stress

Two versions of the questionnaire were prepared, one for each of the professions. New Zealand student pilots were given the Questionnaire for Pilots version which can be found in Appendix A. Mongolian ATCs completed the Questionnaire for ATCs version (shown in Appendix B), translated into Mongolian. Although English is the language of instruction for Mongolian ATCs, the translated version of the questionnaire was offered to help them better understand and to improve response rates. The Mongolian version of the Questionnaire was reviewed and corrected by two administration personnel in Mongolia and can be found in Appendix C. The questionnaire was reviewed by the supervisor and several native speakers of English.

3.4.1 The questionnaire contents

Section I. Demographic information (5 questions)

In this section, the participants were asked their age group, gender, job title, and duration of working as a pilot or an ATC and hours of work/flight they had on that day. Furthermore, for research use, the date and weather information including temperature and humidity were also included in the questionnaire.

Section II. Health, life style and fluid intake habits (21 questions)

The amount, type and frequency of fluid intake were inspected in this section which also consisted of health and exercise questions. The last five questions were related to going to toilet to pass water. Answers for closed-ended question were either

“Yes” or “No”. Also a few choices were given and individuals were asked to write their answers to why questions. In this research, 1 unit equates to 1 small cup (200 ml).

Section III. Subjective feelings - Thirst (14 questions)

Questions about combinations of general symptoms related to sensations of thirst were included in 9 items. Engel et al. (1987) used 37 graded category scales paired with sensations and symptoms of thirst and suggested that as the hypohydration status increased, the sensations and symptoms of thirst intensified. Jusoh (2010) used 18 thirst related sensations in her study and reported a significant and positive correlation between thirst rating and dry mouth, irritated mouth and water pleasantness.

The categorical scale question “How thirsty do you feel?” was asked separately and “before work/flight” “during work/flight” and “after work/flight”. The answers were 1 (not at all thirsty) 2 (not thirsty) 3 (neither) 4 (thirsty) 5 (very thirsty) on 5-point scale. Thus, the range of possible scores was 3-15, with higher scores indicating higher subjective feelings of thirst.

The last question was “How thirsty do you feel right now?” and a 10cm visual analogue scale (VAS) (Engell et al., 1987) was used to measure the subjective feeling of thirst. The rating ranged from 0 (not thirsty) to 10 (very thirsty).

“How do you feel at this moment?” was asked in 37 graded category scales paired with symptoms and sensations of thirst in the investigation by Engell et al., (1987). They concluded that thirst sensations make a significant contribution to different fluid intake in humans. Furthermore, Jusoh (2010) used the 10cm VAS questionnaire in her studies and found that subjective feelings such as thirst perception, mouth dryness, desire to drink and hunger rating could be used as a marker of hydration status to identify at least a 1% body mass loss due to food and fluid restraint in free living individuals.

As the definitions suggest that the sensation of thirst is subjective, using self-report methods to measure thirst is appropriate (Welch, 2002). In this study, the state of being thirsty is defined as a conscious and subjective sensation of desiring fluids. The most common Likert scale was used as it is considered to have good reliability (De Vaus, 2002). The use of Likert scale in this study delivers measurement on the degree of subjective feeling of thirst and therefore it falls within the ordinal level of measurement. Bakeman (2005) suggested that ordinal data can be considered as quantitative in a comparatively loose sense.

Section IV. Fatigue (3 questions)

"Samn-Perelli Fatigue Scale" – the one-item self-reporting instrument (Samn & Perelli, 1982) was used to measure the subjective fatigue level of participants. Instead of one item, three items were included in terms of "before work/flight" "during work/flight" and "after work/flight".

Participants were instructed to read each item in the questionnaire and to choose a response that best reflects each individual's feeling on a 7-point scale from 1 (fully alert, wide awake), 2 (Very lively, responsive, but not at peak), 3 (Okay, somewhat fresh), 4 (A little tired, less than fresh), 5 (Moderately tired, let down), 6 (Extremely tired, very difficult to concentrate), 7 (completely exhausted, unable to function effectively). Therefore, the variety of potential scores was 3-21, with higher scores representing higher level of fatigue.

According to Smets et al. (1995), fatigue is a common, everyday experience that most individuals report after insufficient sleep or rest, or after effort of physical power.

Smets et al., (1995) developed a tool “The Multidimensional Fatigue Inventory”, a 20-item self-report comprehensive instrument designed to explore the nature and intensity of the fatigue.

Section V. Perceived Stress (14 questions)

The “Perceived Stress Scale” is 14 a item self-reporting instrument (Cohen, Kamarck, & Mermelstein, 1983) used to measure the stress level of participants. Half of the questions related to positive items, and the other half to negative items.

Participants were instructed to choose a response that best reflects each individual’s feeling on a five-point scale from 0 (never) 1 (almost never) 2 (sometimes) 3 (fairly often) 4 (very often). Perceived Stress Scale total score was calculated by reversing the scores on the seven positive items and summing all 14 items. Therefore, the variety of potential scores was 0-56.

The Perceived Stress Scale was used in a study by Gilbey et al. (2006) that found female New Zealand controllers score (M = 21.45, *SD* = 7.16) were significantly higher than the male (M = 18.47, *SD* = 5.52), $t(148) = 2.51$, $p < 0.05$. Moreover, Togtokhbayar (2012) used the scale and concluded that Mongolian controllers working in rotating shifts (M = 22.20, *SD* = 4.52) reported significantly higher stress level than those who worked in fixed shifts (M = 18.78, *SD* = 4.71), $t(122) = 3.11$, $p < 0.001$.

3.5. Procedure

Mongolian ATCs were recruited through the ANSD. Prior approvals to conduct the study were obtained from the Director ANSD and the Director of ATS Division. New Zealand general aviation pilots were recruited through Massey School of Aviation. Prior approval to conduct the study was attained through the supervisor from the chief flight instructor at the Milson Flight Systems Centre.

Participants were asked to complete a questionnaire either before or after the active shift work or flight on that day. The questionnaire consisted of 67 items and took approximately 10-15 minutes to complete. Collis and Hussey (2009) suggested that anonymity and confidentiality contribute to a higher response rate and increase honesty. Thus, anonymity and confidentiality was continuously offered for all the participants in this research. Participants were informed about their right to withdraw anytime without having to giving a reason.

The researcher travelled to ANSD of MCAA to distribute and collect the questionnaire. The participants were requested to return the completed survey form individually to a designated locker at the ANSD. Only the researcher could gain access to the designated locker with the key. This was to ensure that participation was voluntary without any influence.

Brief introduction of the researcher and research was sent to participants at the Milford Flight Systems Centre via email first. Then a voluntary person at the Milford Flight Systems Centre distributed and collected the questionnaire which was then picked by the researcher.

According to Collis and Hussey (2009), in a positivist study, a survey methodology is used to collect primary or secondary data from a sample, in order to analyse them statistically and to generalize the results to a population.

3.5.1 Data collection

A total of 60 pilots and a total of 65 ATCs were invited to participate in the study. A period of 2 weeks was reserved for the return of survey forms from 5 separate ATC shifts. Also 2 weeks were spent for assembling the questionnaire from pilots at the

Milson Flight Systems Centre of the School of Aviation. All the collected data remained anonymous to the researcher.

3.5.2 Data analyses

All data analyses in this thesis were carried out using the statistical software package SPSS Statistics version 20. For all analysis, α was set at 5%.

3.6. Ethical Considerations

Ethical issues are always important in a research (Cozby, 2003). “Researchers must be extremely careful about potential invasion of privacy and must always ensure that confidentiality issues have been addressed” (Collis & Hussey, 2009, p. 89). Research topic brings a web of relationships which have the potential to raise ethical issues (Rountree & Laing, 1996). Some of the issues may include access to information, informed consent free of coercion, ownership of data, confidentiality, privacy, anonymity, risk of harm to subjects, gender and cultural sensitivity (Rountree & Laing, 1996).

A research proposal was submitted to the Massey University’s Human Ethics Committee seeking ethical approval. This research was considered low risk, so full approval from a Human Ethics Committee was not required. Consequently, it was recorded on the low-risk database of Massey University’s Human Ethics Committee. The letter of acknowledgement from a Human Ethics Committee can be viewed in Appendix D. Moreover, Massey University’s Human Ethics Committee guidelines were used as a general guiding framework. Basic ethical principles by Snook (1999) were also observed in conducting the survey. The principles are no harm, voluntary participation, confidentiality of participants, deceit avoidance and accurate data analysis and report.

CHAPTER FOUR

4. RESULTS

4.1. Demographic information

In total, 101 questionnaires were returned. Fifty questionnaires were received back out of a total of 65 survey forms distributed to air traffic controllers and 51 questionnaires were received back out of a total of 60 survey forms distributed to general aviation pilots, all of which were usable. The overall return rate was 80%.

Fifty controllers and 51 general aviation pilots participated in the survey. Out of the 101 participants, 26 (25.7%) were qualified controllers, 16 (18.8%) assistant controllers, 4 (4%) supervisors, 35 (34.7%) student pilots and 15 (14.9 %) instructors (Table 1).

The length of time participants had been employed as air traffic controllers ranged from 9 months to 24.2 years and as general aviation pilots (student pilots and instructors) ranged from 2 months to 15 years. Mean number years of experience is 4.92, SD = 5.04. There was significant difference of working experience between ATC (M = 6.88, SD = 5.95) and GA pilots (M = 3.01, SD = 3.02), $t(95) = 4.06$, $p < .05$.

The mean length of time participants had worked or flown on the day before completing the survey was 50 minutes to 8 hours. Forty seven (46.5%) of the participant had not worked/flown before answering the questionnaire. There was significant difference between the working hours of ATC (M = 2.05, SD = 1.91) and GA pilots (M = 0.56, SD = 0.95), $t(97) = 4.90$, $p < .05$.

Table 1: *Gender and profession.*

Variable		Frequency (n)	Percentage (%)
Gender	Male	84	84.8
	Female	15	15.2
ATCs	Supervisor	4	4.0
	Controller	26	25.7
	Coordination controller	16	15.8
	Assistant	3	3.0
Pilots	Instructor pilot	15	14.9
	Student pilot	35	34.7

There were 84 (83.2%) male and 15 (14.9%) female among the participants of the research. There were 38 (76%) male, 12 (24%) female controllers and 46 (93%) male, 3 (6%) female general aviation student pilots and instructors. A chi-square test of independence was performed to examine the relation between type of job and the gender. The relation between these variables was significant, x^2= 6.376, *df* = 1, *p* = .012. Females were less likely to be pilots than controllers.

Table 2: *Age group, by profession.*

	ATC	GA pilot
Less than 30	31	47
30-40	14	3
41-50	2	-
51-60	2	-
More than 60	-	-

The majority of the participants (78.2%) were less than 30 years as shown in Table 2. The remaining of the participants were age group 30-40 (16.8%) and 41-50 and 51-60 (2%).

4.2. Health, life style and fluid intake habits

Table 3 shows the mean volume of different type of beverages participants reported to have consumed in an average day. In this research, 1 unit equates to 1 small cup (200 ml). The results show that tap water accounts for the highest volume reported to be consumed by all the participants that was about 1.95, *SD* = 3.40 units per day (Table 3). The controllers' reports show that tea accounts for the highest volume reported to be consumed that was about 2.53, *SD* = 3.63 units per day. The general aviation pilots' reports show that tap water accounts for the highest volume reported to be consumed that was about 3.71, *SD* = 4.06 units per day. But general aviation pilots reported to drink tea about 0.43, *SD* = 0.85 units per day and the controllers reported to drink tap water about 0.14, *SD* = 0.74 units per day.

The participants consumed 9.62, *SD* = 5.38 units of nonalcoholic drinks and 0.23, *SD* = 0.71 units of alcoholic drinks per day. Overall, the total fluid intake is about 9.85, *SD* = 5.44 units (about 2 litres) per day.

It was summer during the study period in Ulaanbaatar, Mongolia and the average day time temperature was 20.02, *SD* = 2.61 Celsius (C°) and humidity was 56.63, *SD* = 20.02. The average day time temperature and humidity was 10.71, *SD* = 1.85 C° and 55.04, *SD* = 14.43 in winter in Palmerston North, New Zealand.

An independent-samples t-test was conducted to compare fluid intake between ATCs and GA pilots and between genders. There was no significant difference in fluid intake between ATCs (*M* = 9.55, *SD* = 5.90) and GA pilots (*M* = 10.15, *SD* = 4.98), $t(99) = .55$, $p = 0.58$. No significant difference was also found in fluid intake per day between men and women, $t(99) = .24$, $p = .81$. Fluid intake for men per day was *M* = 9.91, *SD* = 4.70, for women *M* = 9.55, *SD* = 8.12.

Table 3: *Mean volume of drink in an average day (N=101).*

Type of drink	Total fluid intake (units)		**Overall**	
	ATC	Pilot	**Mean**	***(SD)***
1. Tea	2.49	0.43	**1.47**	**(2.79)**
2. Green tea	0.51	0.31	**0.41**	**(0.85)**
3. Milk tea	1.34	0.08	**0.72**	**(1.25)**
4. Coffee	0.94	0.97	**0.95**	**(1.55)**
5. Bottled water	1.25	1.54	**1.39**	**(2.83)**
6. Filtered water	0.75	1.12	**0.93**	**(2.10)**
7. Tap water	0.22	3.71	**1.95**	**(3.40)**
8. Mineral water	0.18	0.06	**0.12**	**(0.63)**
9. Sport drinks	0.06	0.19	**0.12**	**(0.41)**
10. Energy drinks	0.02	0.21	**0.11**	**(0.38)**
11. Fruit juices	0.57	0.26	**0.42**	**(0.86)**
12. Milk	0.18	0.50	**0.34**	**(0.86)**
13. Fizzy drinks	0.47	0.30	**0.38**	**(0.91)**
14. Soup	0.33	0.06	**0.19**	**(0.51)**
15. Hot chocolate	0.02	0.08	**0.05**	**(0.15)**
16. Wine	0.03	0.02	**0.02**	**(0.15)**
17. Beer	0.16	0.23	**0.19**	**(0.65)**
18. Other alcoholic drinks	-	0.02	**0.01**	**(0.09)**
19. Any other drinks	0.04	0.06	**0.05**	**(0.29)**
TOTAL	**9.55**	**10.15**	**9.85**	**(5.44)**

Diabetes was not reported among any of the participants and only 3 participants were taking medicine. Under the Civil Aviation Rules, there are strict medical requirements for ATCs and pilots.

When asked if the participants did regular exercise for at least 30 minutes in one session, the responses were "no" (50.5%), "once a week" (11.9%), "two or three times a week" (17.8%) and "more than three times a week" (19.8%). Cross tabulation by job role may be inspected in Table 4.

Table 4: *Exercise ratio in two professions*.

	Controllers		Pilots	
Frequency of exercise	N	%	n	%
No	31	63.3	19	38.0
Once a week	5	10.2	6	12.0
Two or three times a week	10	20.4	8	16.0
More than three times a week	3	6.1	17	34.0

Most Mongolian participants were not doing regular exercises (63.3%) compared to NZ general aviation pilots (38.0%). More NZ general aviation pilots were doing exercise 'more than three times a week' (34.0%) than Mongolian controllers (6.1%). A Chi-square test was performed and relationship was found to be significant between type of job and the exercise, x^2= 12.98, *df* = 3, $p < .05$.

A summary of the drinking habits questions are shown in the Table 5. It can be seen that approximately 18% of participants do not drink fluids before work/flight and about 59% do not drink fluids during work/flight. Most participants (94.1%) drink fluids after work/shift. Nearly 38% of participants start work/flight feeling thirsty.

Table 5: *Drinking habits*.

Type of questions	Answers	n (%) ATC	Pilot	Overall
Q13. Do you drink any fluids before a work/flight?	Yes	41 (80.4)	41 (82.0)	82 (81.2)
	No	9 (17.6)	9 (18.0)	18 (17.8)
Reasons (if, no)	*Avoid using toilet*	-	7 (14.0)	7 (6.9)
	Too busy	1 (2.0)	-	1 (1.0)
	Do not feel it is needed	1 (2.0)	1 (2.0)	2 (2.0)
	Not feeling thirsty	2 (3.9)	-	2 (2.0)
Q15. Do you drink any fluids during a work/flight?	Yes	23 (45.1)	19 (38.0)	42 (41.6)
	No	28 (54.9)	31 (62.0)	59 (58.4)
Reasons (if, no)	*Avoid spill*	-	1 (2.0)	1 (1.0)
	Avoid using toilet	-	7 (14.0)	7 (6.9)
	Too busy	3 (5.9)	7 (14.0)	10 (9.9)
	Drink not available	-	6 (12)	6 (5.9)
	Not willing to drink	3 (5.9)	-	3 (3.0)
	Not allowed	13 (25.5)	3 (6.0)	16 (15.8)
	Not feeling thirsty	1 (2.0)	5 (10.0)	6 (5.9)
Q17. Do you drink any fluids after a work/flight?	Yes	50 (98.0)	45 (90.0)	95 (94.1)
	No	1 (2.0)	5 (10.0)	6 (5.9)
Reasons (if, no)	*Do not feel it is needed*	-	3 (6.0)	3 (3.0)
	Not feeling thirsty	-	1 (2.0)	1 (1.0)
Q19. Do you ever start a work/flight feeling thirsty?	Yes	14 (27.5)	24 (48.0)	38 (37.6)
	No	35 (68.6)	26 (52.0)	61 (60.4)
Reasons (if, yes)	*Prevent from feeling thirsty*	5 (9.8)	2 (4.0)	7 (6.9)
	Avoid using toilet	-	3 (6.0)	3 (3.0)
	Too busy	-	4 (8.0)	4 (4.0)
	Not willing to drink	-	1 (2)	1 (1.0)
	Forget to drink	-	3 (6.0)	3 (3.0)
	Not enough drinks available	1 (2.0)	6 (12.0)	7 (6.9)

When asked how the participants knew they need to drink, the response "feel thirsty" tops the list that leads them to drink during the day (61.4%) (Table 6).

Table 6: *Participants' responses to the question "How do you know when you need to drink?".*

How do you know when you need to drink?	n (%)		
	Controller	pilot	Overall
1. Feel thirsty	27 (52.9)	35 (70.0)	62 (61.4)
2. Feel dry mouth	3 (5.9)	6 (12.0)	9 (8.9)
3. Always want to drink	1 (2.0)	3 (6.0)	4 (4.0)
4. Feel dry mouth and headache	-	3 (6.0)	3 (3.0)
5. Feel thirsty and dry mouth	3 (5.9)	1 (2.0)	4 (4.0)
6. Feel dry throat	3 (5.9)	-	3 (3.0)
7. Feel thirsty and headache	1 (2.0)	2 (4.0)	3 (3.0)
8. Try to drink as much as possible	2 (3.9)	-	2 (2.0)
9. After talking too much	1 (2.0)	-	1 (1.0)

Mean score of the participants reported to the question "how many times do you go to the toilet to pass water during day?" was 4.20, SD = 1.75. In response to the question about frequency of going to toilet, there was no significant difference between ATCs (M = 4.44, SD = 1.90) and GA pilots (M = 3.96, SD = 1.58), t(90) = 1.34, p = 1.85. Also no significant difference was found in the same responses between men and women, t(88) = .10, p = .92. The frequency of going to toilet per day for men was M = 4.21, SD = 1.79, for women M = 4.26, SD = 1.69.

Forty eight (47.5%) of the participants reported they did not to rush to the toilet to pass water and 52 (51.5%) of them said they did. If they answered "Yes", they were asked what the reason was. Most of their answers were "after a long flight" (18.8%) and "after drinking too much" (9.9%) (Table 7).

Table 7: *Participants' responses to the question "Do you ever have to rush to the toilet to pass water?".*

Type of question	Answers	n (%)		
		ATC	Pilot	Overall
Do you ever have to rush to the toilet to pass water?	Yes	23 (45.1)	25 (50.0)	48 (47.5)
	No	27 (52.9)	25 (50.0)	52 (51.5)
Reasons (if, yes)	After a long flight	-	19 (38.0)	19 (18.8)
	After drinking too much	11 (21.6)	2 (4.0)	13 (10.9)
	Weak bladder	1 (2.0)	2 (4.0)	3 (3.0)
	Hurry back to work	3 (5.9)	-	3 (3.0)

The responses to the questions about avoiding drinking and urgently needing to go to the toilet are shown in Table 8. When they were asked if they ever avoided drinking so that they did not have to go to the toilet to pass water, the response "Yes" was 44 (43.6%) and "No" was 57 (56.4%). Next, they were asked if they ever urgently needed to go to the toilet to pass water during a flight or work. Fifty (49.5%) answered "Yes" and 51 (51.5%) answered "No" (Table 8).

Table 8: *Responses to the questions*.

Type of question	Answers	n (%)		
		ATC	Pilot	Overall
Do you ever avoid drinking so that you do not need to go to the toilet to pass water?	yes	18 (35.3)	26 (52.0)	44 (43.6)
	no	33 (64.7)	24 (48.0)	57 (56.4)
Do you ever urgently need to go to the toilet to pass water during a work/flight?	yes	25 (49.0)	25 (50.0)	50 (49.5)
	no	26 (51.0)	25 (50.0)	51 (50.5)

A Chi-square test was performed and relationship found between gender and question to avoid drinking so that they do not need to go to the toilet to pass water, x^2= 3.88, *df* = 1, *p* < .05.

Independent-samples t-test was conducted to compare fluid intake between drinking habits questions. The group who was feeling thirsty at the start of their flight or work, took slightly more fluids intake during the day (*M* = 10.34, *SD* = 6.34) than the other group (*M* = 9.80, *SD* = 4.73). This difference was not significant, *t*(97) = .48, *p* = 0.63. The group who rushed to the toilet to pass water, took slightly less fluids during the day (*M* = 9.58, *SD* = 6.02) than the other group (*M* = 10.32, *SD* = 4.73). This difference was a not significant, *t*(98) = .68, *p* = 0.50. The group who avoided drinking so that they did not need to go to the toilet to pass water, took slightly less fluids during the day (*M* = 8.87, *SD* = 6.25) than the other group (*M* = 10.71, *SD* = 4.47). This difference was a not significant, *t*(99) = 1.72, *p* = 0.09.

4.3. Subjective feelings – Thirst

Mean perceived thirst (subjective feelings to thirst) score was 2.48, *SD* = 0.54. The ATCs (*M* = 2.62, *SD* = 0.53) reported significantly higher levels of subjective feelings to thirst, compared to pilots (*M* = 2.36, *SD* = 0.53), *t*(99) = 2.41, *p* =.018 , *d* = 0.49 (Figure 4). Cronbach's alpha for the 9 items of thirst sensation was 0.80 (Table 9).

The scores of individual items are presented in Figure 4 to provide a more nuanced understanding of how thirst affects the two professions. The general symptoms related to thirst sensations in the questionnaire were pleasant mouth, dry throat, dizziness, concentration, energy, sleepiness or drowsiness, nauseousness and tiredness. Tests of difference between the two professions for each of the items may be inspected in Table 9

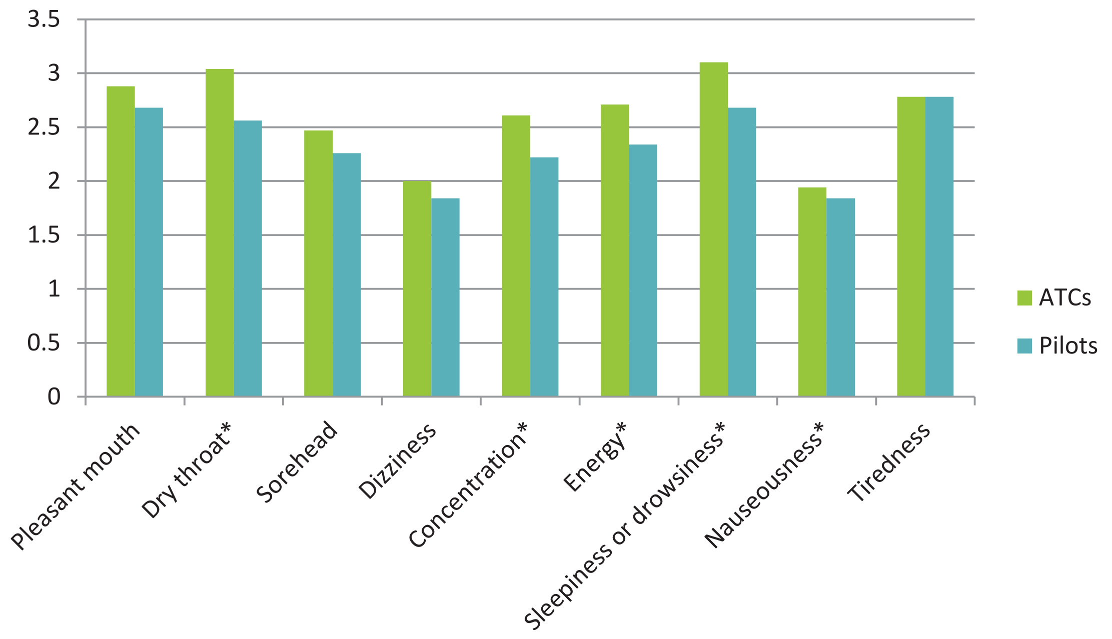

Figure 4: Thirst related sensations in ATCs and Pilot participants. * indicates values are significant at $p<0.05$ between professions.

Table 9: *Subjective feelings of thirst's Cohen's D, mean difference, standard deviation, degree of freedom, t-value and significance.*

Subjective feelings to thirst	Mean difference	*SD*	*df*	*t* value	*p*	Cohen's D
1. Pleasant mouth	0.20	0.82	99	1.24	= .22	0.25
2. Dry throat	0.48	0.92	99	2.71	< .05	0.54
3. Sorehead	0.21	0.99	99	1.07	= .29	0.21
4. Dizziness	0.16	0.89	99	0.90	= .16	0.18
5. Concentration	0.39	0.84	99	2.37	< .05	0.47
6. Energy	0.36	0.64	99	3.00	< .05	0.60
7. Sleepiness or drowsiness	0.42	0.84	99	2.59	< .05	0.52
8. Nauseousness	0.10	0.93	99	0.55	< .05	0.11
9. Tiredness	0.00	0.98	99	0.02	= .98	0

To further explore the relationship between subjective feelings to thirst, stress and fatigue, the following correlations were tested (Table 10). Highly significant positive correlation between subjective feeling of thirst and the perceived stress scale score, $r = .37$, $N = 101$, $p < 0.01$. Increases in subjective feeling of thirst were correlated with increases in the perceived stress scale. Highly significant positive correlation between subjective feeling of thirst and the thirst (Categorical scale) score, $r = .42$, $N = 101$, $p < 0.01$. Increases in subjective feeling of thirst were correlated with increases in the thirst. Highly significant positive correlation between subjective feeling of thirst and the fatigue scale score, $r = .33$, $N = 101$, $p < 0.01$. Increases in subjective were correlated with increases in the fatigue scale.

Table 10: *Pearson's product moment correlations.*

	Stress	Categorical Scale	Subject feelings to thirst	Visual Analog Scale	Fatigue	Temperature
Stress	-	-	-	-	-	-
Categorical Scale	.27**	-	-	-	-	-
Subjective feelings to thirst	.37**	.42**	-	-	-	-
Visual Analog Scale	.17	.23*	.39**	-	-	-
Fatigue	.36**	.19	.33**	.48**	-	-
Temperature	.29**	.22*	.23*	.01	-.01	-

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

A significant positive correlation was observed between subjective feelings of thirst and the ambient temperature, $r = .23$, $N = 101$, $p < 0.05$. Higher temperature led to more subjective feeling of thirst.

The overall mean score on Visual Analog Scale (VAS) was 4.03, *SD* = 2.23. There was not a significant difference in the thirst for the ATCs (*M* = 4.06, *SD* = 2.42) and NZ general aviation pilots (*M* = 4.02, *SD* = 2.06) conditions; $t(99) = .99$, $p = .323$. Participants were asked about their thirst before, during and after the work or flight. Mean thirst score was 3.18 (*SD* = 0.60). There was not a significant difference in the thirst for the ATCs (*M* = 3.24, *SD* = 0.65) and NZ general aviation pilots (*M* = 3.12, *SD* = 0.55) conditions; $t(99) = .99$, $p = .321$.

The overall mean score on Categorical scale (CS) was 2.97, *SD* = 0.89. There was not a significant difference in the thirst for the ATCs (*M* = 3.06, *SD* = 0.89) and NZ general aviation pilots (*M* = 2.88, *SD* = 0.91) conditions; $t(99) = .99$, $p = .323$.

It was summer during the study period in Ulaanbaatar, Mongolia and the average day time temperature was 20.02, *SD* = 2.61 Celsius (C$^{\circ}$) and humidity was 56.63, *SD* = 20.02. The average day time temperature and humidity was 10.71, *SD* = 1.85 C$^{\circ}$ and 55.04, *SD* = 14.43 in winter in Palmerston North, New Zealand.

4.4. Subjective Fatigue

The total mean score on the Samn-Perelli fatigue scale was 2.78, *SD = 0*.99, the mean response was close to that of “Okay, somewhat fresh”. An independent samples *t*-test was conducted to examine the difference in the levels of fatigue in ATCs and general aviation pilots. The ATCs (*M* = 2.75, *SD* = 1.16) reported somewhat lower levels of fatigue than general aviation pilots (*M* = 2.83, *SD* = 0.81), $t(97) = 0.391$, $p < 0.69$. Table 11 shows the results of fatigue at the beginning, in the middle and at the end of flight or work shift. At the beginning of flight/work, pilots reported higher level of fatigue, at the middle of flight/work, ATCs reported higher level of fatigue. However, of particular interest, was that participants responded the same levels of fatigue at the end of flight or work.

Table 11: *Fatigue.*

Type of question	N	ATC	Pilot	Mean	*SD*
At the beginning of flight/work.	101	1.69	2.10	1.89	1.08
At the middle of flight/work.	101	2.65	2.46	2.55	1.17
At the end of flight/work.	101	3.92	3.92	3.92	1.53

The relationship between Samn-Perelli fatigue scales at the beginning, at the middle and at the end of flight or work was examined using Pearson's product moment correlation (Table 12).

Table 12: *Pearson's product moment correlation.*

Type of question	At the beginning of flight/work	At the middle of flight/work	At the end of flight/work
At the beginning of flight/work	-	-	-
At the middle of flight/work	.38**	-	-
At the end of flight/work	.26**	.57**	-

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Highly significant positive correlation between fatigue scales at the beginning and at the middle of flight or work; $r = .38$, $N = 101$, $p < 0.01$, between fatigue scales at the beginning and at the end of flight or work; $r = .26$, $N = 101$, $p < 0.01$. Moreover, highly significant positive correlation between fatigue scales at the middle and at the end of flight or work, $r = .57$, $N = 101$, $p < 0.01$. Participants started working with higher fatigue finished work with higher fatigue.

4.5. Perceived Stress

The overall mean score on the perceived stress scale was 22.93 ($SD = 7.90$). Cronbach's (1951) alpha for the 14 items of perceived stress scale was .76. However, ATCs ($M = 24.86$, $SD = 7.87$) reported significantly higher stress levels, compared to pilots ($M = 20.96$, $SD = 7.50$), $t(97) = 2.63$, $p < 0.01$.

Perceived stress scale scores were related to thirst, subjective feelings to thirst, fatigue and temperature (Table 10). Highly significant positive correlation between perceived stress scale score and the subjective feeling of thirst; $r = .37$, $N = 101$, $p < 0.01$, between perceived stress scale score and fatigue scale; $r = .36$, $N = 101$, $p < 0.01$. Participants, who reported higher subjective feeling of thirst and fatigue, were found to score higher on stress.

A significant correlation was found between the length of time they had worked on that day and the perceived stress scale score, $r = .20$, $N = 101$, $p < 0.05$. Increases in length of time they had worked on that day were correlated with increases in the perceived stress scale.

However, perceived stress scale scores were not related to gender and how many hours they had flown or worked on that day and there was no evidence of a correlation between the total fluids intake and the participants' age group.

4.6. Correlations

A correlational test was used to assess the relationship between fluids intake and each pair of thirst related questions. The following correlations were found (see Table 13).

- A highly significant positive correlation between positive response to start flight/work feeling thirsty and the positive response to avoid drinking, $r = .33$, $N = 99$, $p < 0.01$, two-tails;
- A highly significant positive correlation between positive response to avoid drinking so that they do not need to go to toilet and occurrence to rush to toilet, $r = .30$, $N = 100$, $p < 0.01$, two-tails;
- A highly significant positive correlation between positive response to avoid drinking so that they do not need to go to toilet and occurrence to urgently rush to toilet during a flight or work, $r = .41$, $N = 101$, $p < 0.01$, two-tails;
- A highly significant positive correlation between positive response to rush to go to toilet and occurrence to urgently rush to toilet during a flight or work, $r = .26$, $N = 100$, $p < 0.01$, two-tails;
- A significant negative correlation between being thirsty and occurrence to urgently rush to toilet during a flight or work, $r = -.21$, $N = 101$, $p < 0.05$, two-tails.

Table 13: *Pearson's product moment correlations.*

	Total fluids intake	Start flight/work feeling thirsty	Do you ever rush to go to the toilet	Avoid drinking to avoid using toilet
Total fluids intake	-	-	-	-
Start flight/work feeling thirsty	-.03	-	-	-
Do you ever rush to go to the toilet	.06	.08	-	-
Avoid drinking to avoid using toilet	.16	.33**	.30**	-
Urgently need to go to the toilet during a flight/work	-.05	.11	.26**	.41**
How thirsty do you feel now	-.08	-.13	.04	-.01

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

CHAPTER FIVE

5. DISCUSSION

5.1. The main findings

The findings in this thesis suggest that there is evidence of hypohydration among Mongolian ATCs and New Zealand pilots. This result supports hypothesis $H_{1:}$ The general aviation pilots and ATCs are likely to be hypohydrated and hypothesis $H_{2:}$ Nature of working environment of pilots and ATCs lead to hypohydration. Almost half of the participants avoided drinking so that they did not have to go to the toilet to pass water. Approximately 50% of participants urgently needed to go to the toilet to pass water during work or flight. Because of the working environment of pilots and ATCs, the possibility of using a lavatory normally and whenever they need is not practicable. For example, there is not a bathroom in the tower workroom of ATC which is like the cockpit of an airplane (CBSNews, 2011). The protocols for a pilot to go to the lavatory during flight are very strict (US Today, 2014).

Interestingly, approximately 18% of participants did not drink before a work/shift, 58.4% during a work/shift (Table 5). Hence, most participants (94.1%) drank after a work/shift. Not surprisingly though, the main reasons for not consuming fluids before or during work or flights were ‘to avoid using the toilet’ and ‘too busy’ followed by ‘drink not available’. ATCs reported that they did not drink because they were ‘not allowed’ during the shift. Those were also the reasons why 37.6 % participants started work/flight feeling thirsty. Dry air, no lavatory facility, solo duty, busy workload, and busy phases of flight and diuretic effect of coffee are the causes of involuntary hypohydration among pilots as pre-flight hypohydration (Gilbey et al., 2010). Most of these causes are also applicable to ATCs.

Moreover, the results show that 'feel thirsty' (61.4%) was the main cause for drinking during the day. Similarly, Jusoh (2010) reported that 'feel thirsty' was the main trigger for drinking in general during the day and during exercise. 'Feel dry mouth' was also the cause for 8.9 %. Holmes and Gregersen (1947) reported that a dry mouth sensation is often associated with thirst induced drinking. Moreover, Igbokwe and Obika (2008) examined the thirst perception and dryness of mouth in healthy young adult Nigerians and found that the sensation of thirst is closely associated with a dry mouth.

On the one hand, in comfortable conditions, thirst is sufficient to encourage fluid intake in order to prevent hypohydration (Greenleaf, 1992). Furthermore, Campbell (2007) suggested that most healthy people except for athletes, sickly or elderly people, infants and military people in hot environments adequately met their everyday water requirements when they let thirst be their guide. However, on the other hand, Jusoh (2010) found no correlation between thirst perception and fluid intake, suggesting that thirst is not always the foremost reason that stimulates drinking behaviour in general population.

The main reasons for 47.5% of participants rushing to the toilet to pass water were 'after a long flight' (18.8%) for pilots and 'after drinking too much' (9.9%) for controllers. The controllers (5.9%) rushed to the toilet to pass water, because they had to hurry back to work. This could be explained by the extended duty times that exceed 8 hours that are already common in aviation. Increased demands on both civilian and military pilots will undoubtedly require additional work hours in the future (Caldwell & Caldwell, 2003). Furthermore, 43.6% of participants avoided drinking in order not to go to the toilet to pass water and 49.5% urgently needed to go to the toilet to pass water during a flight or work. ATCs have a short toilet break during their eight hour shift

(2008). However, the procedures for a pilot to use the lavatory during flight are strict in order to ensure security considerations (US Today, 2014). This study also suggests that females tend to avoid drinking so that they do not need to go to the toilet to pass water.

The result of this thesis also supports hypothesis H_3: Hypohydration in aviation professionals leads to more fatigue and stress. A highly significant positive correlation was observed between subjective feeling of thirst and the fatigue scale score. Increases in subjective feeling of thirst were correlated with increases in the fatigue scale. This result is supported by the finding that participants reported fatigue, headache and constipation as the effect of little water consumption (Jusoh, 2010). Furthermore, 80% of participants reported that they were aware of their hydration status based on subjective feelings such as 'feel thirsty' and 'headache' (Jusoh, 2010).

ATCs reported significantly higher levels of subjective feelings of thirst, compared to pilots. Moreover, thirst related sensations such as dry throat, concentration, energy levels, sleepiness/drowsiness and nauseousness were significantly higher in controllers than in pilots.

A subjective feeling of thirst has long been related to fluid intake behaviour. However, an attempt has been made to associate fluid intake with other subjective feelings such as tiredness or headache (Rolls et al., 1980; Engel et al., 1987). Rolls and colleagues (1980) piloted a study on the outcome of 24 hour water deprivation on physiological and subjective responses as well as fluid consumption in five healthy adults. The changes in subjective sensations namely thirst, mouth dryness, pleasantness of drinking water and unpleasantness of taste in mouth were significantly correlated with fluid intake (Rolls et al., 1980). Similarly, the findings of the study by Engel et al. (1987) showed that 18 out of 37 subjective feelings related to thirst namely scratchy mouth and throat, tiredness, light-headedness, irritability, dizziness and loss of appetite rating increased with increasing level of hypohydration. This suggests that subjective feelings other than thirst may contribute to fluid intake in hypohydrated individuals.

This study also indicated a significant positive correlation between subjective feeling of thirst and the perceived stress scale score. Increases in subjective feeling of thirst were correlated with increases in the perceived stress scale. The effect of thirst on fatigue and stress has not been studied extensively. Wardle, Steptoe, Oliver, and Lipsey (2000) investigated the effect of mood on food intake and found that high work-related stress contributed to increased eating. Yannakoulia et al. (2008) found a positive correlation between higher depression levels and increased intake of coffee, soft drinks and meat. Depression was found to correlate well with fluid intake in females (Jusoh, 2010).

5.2. Health, life style and fluid intake habits

The results suggest that tap water was consumed the most every day by the participants compared to other beverages. Tap water accounts for consumption of 3.40 units per day in the present study. This finding is supported by the results from the study by Heller et al., (1999) which revealed that plain water made up almost one-third of overall beverage consumption among individuals ages 20-64 years old in the USA. Schroder et al. (2004) reported that water was the main beverage consumed by the Spanish basketball players during training and competition. Moreover, Jusoh (2010) found that participants believed water was the most hydrating.

Tea and milk tea were consumed the most for the controllers while tap water as well as bottled and filtered water was consumed the most for pilots. This shows a cultural difference between the two countries. The kinds of fluid consumed are culturally varied; for example, beer is a standard drink in many countries (Kolasa et al., 2009). Salted milk tea has been the most popular everyday drink in Mongolia, but in modern society, young people often drink more regular tea without milk. Drinks are also consumed for cooling in warm weather and for warming in cold weather (Popkin et al., 2010). As Mongolia is a cold country, hot beverages are often preferred to cold water.

The overall total fluid intake for participants was about 2 litres per day. This amount is more than the universally accepted, but scientifically unproven, recommendation of drinking "at least eight glasses of water" to be healthy.

Half of the participants did not regularly exercise for at least 30 minutes in one session. Most Mongolian participants (63.3%) were not doing regular exercises compared to NZ general aviation pilots (38.0%). More NZ general aviation pilots were doing exercise, 'more than three times a week' (34.0%), compared to Mongolian controllers (6.1%).

Highly significant positive correlations were found between

- starting flight/work feeling thirsty and avoiding drinking;
- avoiding drinking so that they do not need to go to the toilet and rushing/urgently rushing to the toilet during a flight or work;

A significant negative correlation was found between being thirsty and urgently rushing to the toilet during a flight or work.

5.3. Subjective feelings – Thirst

The results show a highly significant positive correlation between subjective feeling of thirst and the thirst (Categorical Scale) score. Increases in subjective feeling of thirst were correlated with increases in thirst. However, the present study found no evidence of difference between the thirst scores (CS) among controllers and pilots before, during and after the work or flight.

Engel et al., (1987) used 37 graded hypohydration levels to measure thirst sensations and concluded that changes in the symptoms and sensations of thirst contributed significantly to both the detection and correction of body fluid deficits in humans. Moreover, Jusoh (2010) used the 10cm VAS questionnaire in her studies and found that subjective feelings related to thirst such as thirst perception, mouth dryness, hunger rating and desire to drink, could be used as a marker of hydration status.

Furthermore, a significant positive correlation was found between subjective feeling of thirst and the temperature. Higher temperatures led to more subjective feelings of thirst. Heat stress in any working situation results from a complex interaction of several variables such as air temperature, radiant heat, relative humidity and wind movement (Sharma et al., 1983). Simple cognitive functions such as mental alertness, associative learning and reasoning ability were observed to be adversely affected in terms of both accuracy and speed under the influence of high thermal stress (Sharma et al., 1986).

5.4. Subjective Fatigue

The mean response was close to that of “Okay, somewhat fresh”. An independent sample *t*-test showed that the controllers reported slightly lower levels of fatigue than the pilots. Of particular interest was that both sets of participants responded with the same levels of fatigue at the end of flight or work. At the beginning of flight/work, pilots reported higher levels of fatigue, while at the middle of flight/work, ATCs reported higher levels of fatigue. This could be explained by the differences in working environments of the two professions. On the one hand, a typical flying day starts with the pilot using the computer to check weather and flight plans. The plane must be pre-flight checked and all aircraft logs reviewed. When ready, the pilot will oversee the push-back and then taxi to the runway (2009). On the other hand, the start of the ATC shift may not be as hectic as pilots. However, events happen rapidly and are often complex, requiring cognitive effort and professional skill from the controller. A controller has to make a decision under a lot of time pressure, and rapidly change his/her strategy of action in order to suit each situation (Vargas et al., 2012). Another interesting finding was a highly significant positive correlation between fatigue scales at the beginning, in the middle and at the end of flight or work. In short, participants who started shift/flight with higher fatigue finished shift/flight with higher fatigue.

5.5. Perceived Stress

The finding suggests that the participants, who reported higher subjective feeling of thirst and fatigue, were found to be more stressed. Perceived stress scale scores were related to thirst, subjective feelings to thirst, fatigue and temperature.

The overall mean score on the perceived stress scale was 22.93 (*SD* = 7.90). ATCs reported significantly higher stress levels, compared to pilots. These scores were higher than the overall mean perceived stress score in previous studies for controllers. For example, the overall mean score on the perceived stress scale was *M* = 19.09, *SD* = 6.0 for New Zealand controllers (Gilbey et al., 2006) and *M* = 21.21, *SD* = 4.82 for Mongolian controllers (Togtokhbayar, 2012). However, these scores were lower than that of college students and that of the smoking-cessation group (Cohen et al., 1983). Thus, the findings are consistent with the opinion of Gilbey et al. (2006) that controllers are not more stressed than other groups of population.

This study indicated a significant positive correlation between subjective feeling of thirst and the perceived stress scale score. Increases in subjective feeling of thirst were correlated with increases in the perceived stress scale. However, perceived stress scale scores were not related to gender and how many hours they had flown or worked on that day and there was no evidence of a correlation between the total fluids intake and the participants' age group.

5.6. Future research

Although the results of the present study show a significant correlation between hypohydration and stress and fatigue levels of aviation professionals, future studies should include whether the correlation is similar and whether avoiding drinking is common to other professionals and whether the subjective feeling of thirst is higher in ATCs than in pilots in other countries.

Moreover, both regulators and future studies might inspect ways in which these professionals can keep optimum fluid intake, or, at the very least be made aware of the potential effects of restricting fluid intake.

5.7. Limitations of Study

Although this study was exploratory and comparatively simple, the result of the study did disclose some possible relationship between hypohydration and subjective feeling of fatigue and perceived stress. However, there were some limitations to this research as follows:

1) The number of participants was limited making the sample small. The two samples were drawn only from the controllers at the ATSD in Mongolia and the instructors and student pilots at Massey University School of Aviation in

New Zealand. Many confounding factors such as workload, aviation management, procedures, the level of sophistication of the equipment and general lifestyle in Mongolia differ from other countries. Moreover, the pilots were either instructors or student pilots in New Zealand, not airline pilots. Thus, the findings of this study may not be transferable to other countries' pilots and controllers.

2) The results of the present study should possibly only be applied to healthy young adults because the mean age of the participants in this study was less than 30 years old. Moreover, Class 1 Medical Assessment applies to holders of pilot licences and Class 3 Medical Assessment applies to holders of air traffic controller licences (ICAO Annex 1, 2011) which means that controllers and pilots health is important for doing the job.

   Data from previous studies has suggested that thirst declines with aging (Philips et al., 1984; Kenney & Chiu, 2001; Ferry, 2005). Therefore, additional research into this topic would be proper to see whether the results would be reproducible in different professions or populations.

3) It should be noted that the use of subjective feelings to measure hydration status lacks strength of evidence (Armstrong, 2007). The best technique to measure human thirst in research is still unresolved and merits further study.

5.8. The implications for aviation safety

The impairment reported in mental performance is comparable to the degree of hypohydration and is highly significant at 2% hypohydration for fundamental cognitive abilities such as arithmetic efficiency, working memory, short-term memory and 'visuomotor' tracking involving attention and motor speed (Gopinathan et al., 1988). A drop in performance levels for different central intellectual abilities involving short-term memory, working memory or visuo-motor abilities was reported in response to hypohydration was found in the studies (Cian et al., 2001; Gopinathan et al., 1988; Sharma et al., 1986). The decrease in performance is proportional to the degree of hypohydration and develops significantly with a 2% body weight loss (Sharma et al., 1986; Gopinathan et al., 1988).

Continuous physical activity that results in hypohydration and exhaustion of energy reserves is commonly assumed to have weakening effects on mental performance (Davis & Bailey, 1997). The results of long-term hypohydration can be impaired memory function, wrinkled skin, brittle nails, dry hair, constipation, and vulnerability to colds and sinus infections (Delorey, 2010). Thus, hydration is important to good health and even critical during the flight (Dara, 2009).

The ATC profession is considered as one of the most mentally challenging careers and can be extremely stressful due to the characteristics of the job experience and the extensive responsibilities shouldered by ATCs (Jou et al., 2013; Wickens et al., 1997). Events happen rapidly, are often complex and made up of several components that require cognitive effort and professional skill from the controller who has to make a decision under a lot of time pressure, and rapidly change his/her strategy of action in order to suit each situation (Vargas et al., 2012). Similarly, pilots have large amount of responsibility and must make critical decisions in seconds (What is the job description of an airline pilot?, 2009).

The average humidity in the cockpit is rather low, which can lead to a considerable amount of lost fluid (Delorey, 2010). The working environment often discourages pilots and ATCs from consuming enough fluid. Long and irregular working hours as well as crossing multiple time zones are common working conditions of flight crew (van Drongelen et al., 2013). Moreover, there is not a bathroom in the tower workroom which is like the cockpit of an airplane (CBSNews, 2011). Gilbey et al. (2010) summarised the reasons of involuntary hypohydration among pilots as pre-flight hypohydration, dry air, no lavatory facility, solo duty, busy workload, busy phases of flight and diuretic effect of coffee.

Legg et al., (2012) reported significant impairment in complex decision-making and multiple memory performance in 25 student pilots following exposure to mild hypoxia (equivalent to 8000ft altitude). It can disturb the performance of some difficult cognitive performance tasks involving multiple demands characteristic of emergency responsibilities that may have to be performed by pilots (Legg et al., 2012).

Human errors are recognized as the primary or secondary cause of more than 75% of accidents or incidents (Smets et al., 1995). The correlation between hypohydration and fatigue and stress levels among ATCs and pilots generate implications for aviation safety. One of the threats to aviation safety and the concerns of human factors is human error. It is important to reduce the possibility of human errors (Maurino, Reasonson, Johnstonton, & Lee, 1995). Work factors of ATCs and pilots relate to error rates and safety and possible countermeasures (Luna, 1997).

The findings in this study suggest that for aviation professionals, voluntary or involuntary fluid restriction is a common occurrence which may lead to a human factor and consequently, a safety problem. In 2011, the International Federation of Air Traffic Controllers' Associations (IFATCA), the worldwide organization represented more than 50,000 air traffic controllers in 137 countries (ICAO, 2014). Some countries are not represented in the IFATCA. By 31 December 2010, the total number of active pilots in

FAA was 587’000 (FAA, 2014). Thus, the high numbers of professionals working in the ATS and airlines, the potential danger of making a mistake must be taken seriously.

CHAPTER SIX

6. CONCLUSION

The aim of this thesis was to examine the thirst and fluid intake in ATCs and general aviation pilots and if thirst is related to fatigue and stress.

Many of the participants in this study self-reported restricting their fluid intake, feeling thirsty, fatigued and under stress. Both of these professions work in a safety-critical industry that requires a high level of concentration and on-job performance. It is considered likely that hypohydration, fatigue and stress are present in at least some of the workers in both occupations, which may impair fundamental cognitive abilities and potentially affect safety.

The reasons why hypohydration occur were related to simple physiological functions such as not having to go to the toilet when so doing would be inconvenient or highly difficult (e.g., whilst flying a light aircraft or working as a single controller in a control tower, both of which may be particularly hot environments).

Discovering solutions to this problem are beyond the scope of the research reported here, but it is strongly recommended that they are investigated as part of an overall safety management system approach within the workplace. If hypohydration is found to be a problem that cannot be eradicated, then at least being awareness of the problem may help to prevent it becoming the cause of accident.

This thesis contributes to the body of knowledge related to hypohydration among general aviation pilots and ATCs and it was the first attempt to investigate hypohydration and subjective feeling of thirst among Mongolian air traffic controllers.

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APPENDIX A. QUESTIONNAIRE FOR PILOTS

Project title: ‘’Factors affecting dehydration in General Aviation Pilots and Air Traffic Controllers”

Researchers

Odgerel Chagnaadorj

Student

School of Aviation, Massey University, Palmerston North

Participant recruitment:

Two separate groups: General aviation pilots and air traffic controllers

Project procedures: The data you supply will be anonymous and all statistical analyses will be on group data. Data will be stored securely at Massey University for 5 years, after which it will be destroyed. Neither you nor the institution at which you are studying will be identified.

Participant involvement

Approximately 5-10 minutes of your time will be required to complete this questionnaire.

Participant’s Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- ask any questions about the study at any time before or during participation

Committee Approval Statement

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University’s Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director (Research Ethics), telephone: +64 6 350 5249, e-mail: humanethics@massey.ac.nz

Please turn over and begin.

The Questionnaire for Pilots

Section I. *Demographic information*

1. What is your job title?	………
2. How long have you been flying?	Yrs………… Mths…………
3. How many hours have you flown today?	Hrs…………Mins…………
4. Please state your gender.	☐ Male ☐ Female
5. Please indicate your age group.	☐ Less than 30, ☐ 30-40 ☐ 41-50 ☐ 51-60 ☐ more than 60

Section II. *Choose the right answer to indicate your health, life style and fluid intake habits. Please be open and honest in your responding.*

6. What kind of drinks do you usually drink each day? (You may select more than one, if, for example, you drink tea, coffee and alcohol)	☐ Tea	☐ Green tea
	☐ Milk tea	☐ Coffee
	☐ Bottled water	☐ Filtered water
	☐ Tap water	☐ Mineral water
	☐ Sport drinks	☐ Energy drinks
	☐ Fruit juices	☐ Milk
	☐ Fizzy drinks	☐ Soup
	☐ Hot chocolate	☐ Wine
	☐ Beer	☐ Other alcoholic drinks
	☐ Any other drinks________________	

7. How much do you drink in a day? (Please indicate the quantity in units. 1 unit equates to 1 small cup (200mls))	Tea _______ Green tea _______ Milk tea _______ Coffee _______ Bottled water _______ Filtered water _______ Tap water _______ Mineral water _______ Sport drinks _______ Energy drinks _______ Fruit juices _______ Milk _______ Fizzy drinks _______ Soup _______ Hot chocolate _______ Wine _______ Beer _______ Other alcoholic drinks _______ Any other drinks _______		
8. Do you regularly exercise for at least 30 minutes in one session?	☐ Yes	☐ No	
9. How often do you exercise?	☐ Once a week	☐ Two or three times a week	☐ More than three times a week
10. Do you have diabetes?	☐ Yes	☐ No	
11. Do you take medicine?	☐ Yes	☐ No	
12. If yes, could you state the prescription medicine you have taken in the last	....		

two weeks.		
13. Do you drink any fluids before a flight?	☐ Yes	☐ No
14. If no, what is the reason?	…………..	
15. Do you drink any fluids during a flight?	☐ Yes	☐ No
16. If no, what is the reason?	…………..	
17. Do you drink any fluids after a flight?	☐ Yes	☐ No
18. If no, what is the reason?	…………..	
19. Do you ever start a flight feeling thirsty?	☐ Yes	☐ No
20. If yes, Why?	…………..	
21. How do you know when you need to drink?	…………	
22. How many times do you go to the toilet to pass water during the day?	…………	
23. Do you ever have to rush to the toilet to pass water?	☐ Yes	☐ No
24. If, yes, Why?	…………	
25. Do you ever avoid drinking so that you do not need to go to the toilet to pass water?	☐ Yes	☐No
26. Do you ever urgently need to go to the toilet to pass water during a flight?	☐ Yes	☐ No

Section III. *Choose the right answer to indicate HOW YOU HAVE FELT, ON THE WHOLE, DURING THE DAY TODAY.*

27. How thirsty do you feel now?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
28. How thirsty do you feel at the beginning of the flight?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
29. How thirsty do you feel at the middle of the flight?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
30. How thirsty do you feel at the end of the flight?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
31. How pleasant does your mouth taste now?	Not at all pleasant	Not pleasant	Neutral	Pleasant	Very pleasant
32. How dry does your throat feel now?	Not at all dry	Not dry	Neutral	Dry	Very dry
33. How does your head feel now?	Not at all sore	Not sore	Neutral	Sore	Very sore

34. How dizzy do you feel now?	Not at all dizzy	Not dizzy	Neutral	Dizzy	Very dizzy
35. How well can you concentrate just now?	Not at all well	Not well	Neutral	Well	Very well
36. How much energy do you feel you have now?	No at all energy	No energy	Neutral	Energy	Full of energy
37. How sleepy or drowsy do you feel now?	Not at all sleepy	Not sleepy	Neutral	Sleepy	Very sleepy
38. How nauseous do you feel now?	Not at all nauseous	Not nauseous	Neutral	Nauseous	Very nauseous
39. How tired do you feel now?	Not at all tired	Not tired	Neutral	Tired	Very tired

Place a vertical mark on the lines below to indicate HOW YOU FEEL AT THE MOMENT

40. How thirsty do you feel right now?	Not thirsty Very thirsty ______________________________

Section IV. *Try to think of an average flight day and then indicate how you feel.*

	1 Fully alert, wide awake	2 Very lively, responsive, but not at peak	3 Okay, somewhat fresh	4 A little tired, less than fresh	5 Moderately tired, let down	6 Extremely tired, very difficult to concentrate	7 Completely exhausted, unable to function effectively
1. At the beginning of flights	☐	☐	☐	☐	☐	☐	☐
2. At the middle of flights	☐	☐	☐	☐	☐	☐	☐
3. At the end of flights	☐	☐	☐	☐	☐	☐	☐

Section V. *The following questions are about your feelings and thoughts during the past few days. For each question, please indicate how often you have felt or thought the way that is described. Although some questions appear may appear similar, there are differences between them and each should be treated as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up actual instances, but rather indicate the answer which seems like a reasonable estimate. Please mark the appropriate response.*

	1 Never	2 Almost never	3 Some-times	4 Fairly Often	5 Very often
1. In the past few days, how often have you been upset because of something that happened unexpectedly?	☐	☐	☐	☐	☐
2. In the past few days, how often have you felt that you were unable to control the important things in your life?	☐	☐	☐	☐	☐
3. In the past few days, how often have you felt nervous or stressed?	☐	☐	☐	☐	☐

4. In the past few days, how often have you dealt with irritating life hassles?	☐	☐	☐	☐	☐
5. In the past few days, how often have you felt that you were effectively coping with important changes that were occurring in your life?	☐	☐	☐	☐	☐
6. In the past few days, how often have you felt confident about your ability to handle your personal problems?	☐	☐	☐	☐	☐
7. In the past few days, how often have you felt that things were going your way?	☐	☐	☐	☐	☐
8. In the past few days, how often have you found that you could not cope with all the things you had to do?	☐	☐	☐	☐	☐
9. In the past few days, how often have you been able to control irritations in your life?	☐	☐	☐	☐	☐
10. In the past few days, how often have you felt that you were on top of things?	☐	☐	☐	☐	☐
11. In the past few days, how often have you been angered because of things that happened that been outside your control?	☐	☐	☐	☐	☐
12. In the past few days, how often have you found yourself thinking about things that you have to accomplish?	☐	☐	☐	☐	☐
13. In the past few days, how often have you been able to control the way you spend your time?	☐	☐	☐	☐	☐
14. In the past few days, how often have you felt difficulties were piling up so high you could not overcome them?	☐	☐	☐	☐	☐

Thank you for participating in this survey.

Once again, I would like to emphasize that your responses are anonymous, and will not be made available to anyone other than the researcher(s) for the purposes of statistical analysis.

For Research use only: Date:

Weather information: Temperature: Humidity:

APPENDIX B. QUESTIONNAIRE FOR ATCS (MONGOLIAN VERSION)

Massey University

COLLEGE OF BUSINESS
Kaupapa Whai Pakihi

SCHOOL OF AVIATION
Private Bag 11 222
Palmerston North
New Zealand

Төслийн нэр: Нислэгийн удирдагч болон нисгэгч нарын шингэн дутагдалд нөлөөлдөг хүчин зүйлс

Хүндэт Нислэгийн удирдагч танаа,

Би таныг шингэн дутагдалын улмаас таны стресс болон ядаргааны эрсдлийн үнэлгээг судлах судалгааны ажилд оролцохыг урьж байна. Энэхүү судалгааны ажлыг Шинэ Зеланд улсын Массей Их сургуулийн оюутан Чагнаадоржийн Одгэрэл явуулж байгаа болно.

Энэхүү асуулгын нийт 5 хэсгийг бөглөхөд 5-10 орчим минут зарцуулах бөгөөд та өөрийн нэрээ дурьдах шаардлагагүй.

Хэрэв та энэхүү судалгаанд хамрагдах хүсэлтэй байгаа бол, асуулгыг бөглөж өөрийн менежерт өгнө үү. Та бөглөсөн асуулгыг өгсөнөөр судалгаанд хамрагдахын зөвшөөрч байгаа гэсэн үг болно.

Асуулгын эхний хуудсан дээр төслийн талаархи дэлгэрэнгүй мэдээлэл байгаа болно.

Цаг гаргасанд баярлалаа.

Чагнаадоржийн Одгэрэл

Мэдээллийн хуудас
Төслийн нэр: Нислэгийн удирдагч болон нисгэгч нарын шингэн дутагдалд нөлөөлдөг хүчин зүйлс

Судлаач:

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Оролцогчдын мэдээлэл
Монгол Улсын Иргэний Нисэхийн Ерөнхий Газрын Нислэгийн Хөдөлгөөний Үйлчилгээний Албаны нийт нислэгийн удирдагчдыг энэхүү судалгаанд оролцохыг урьж байна.

Төслийн явц
Таны бөглөн илгээсэн асуулганд хувь хүний талаар тодорхой мэдээлэлийг дурьдахгүй бөгөөд асуулгатай холбоотой мэдээллийг багцлан статистик дүн шинжилгээ хийх болно. Таны бөглөсөн асуулгыг Массей Их Сургуульд нууцлалтайгаар 5 жилийн хугацаанд хадгалж, үүний дараа устгалд оруулах болно. Энэхүү төслийн дүгнэлтийг төслийн төгсгөлд нийт нислэгийн удирдагч нарт хүргэх болно.

Оролцогчдоос шаардагдах зүйл
Энэхүү асуулгыг бөглөхөд танд ойролцоогоор 5-10 минут шаардагдах болно.

Оролцогчдын эрх
Та энэхүү судалгаанд заавал оролцох шаардлагагүй болно. Хэрэв та оролцохоор шийдвэл та дараах эрхтэй. Үүнд:

- Тодорхой асуултанд хариулахаас татгалзах;
- Судалгааны өмнө, судалгааны үеэр, мөн түүнчлэн судалгааны дараа энэхүү судалгааны талаар аливаа асуулт асуух. (Энэ тохиолдолд дээр байгаа хаягаар хандана уу)
- Судалгааны дундуур судалгаанд оролцохоос татгалзах.

Ёс зүйн хорооны баталгаа
Энэ төслийг бусад судлаачид үнэлж үзээд ёс зүйн хувьд эрсдэл багатай гэж дүгнэсэн бөгөөд Массейн Их Сургуулийн Хүний Ёс Зүйн Хороогоор хянагдаагүй болно. Дээр нэр нь дурьдагдсан судлаач энэ судалгааны ёс зүйн талаар хариуцах болно.

Судалгааны явцад аливаа асуулт гарвал судлаачаас гадна дараах хаягаар хандан зөвлөмж авч болно.

Хэрэв танд энэхүү судалгааны талаар аливаа асуулт байгаа бөгөөд судлаачаас өөр хүнтэй тэр талаар ярилцахыг хүсвэл:

Professor John O'Neill, Director (Research Ethics),
telephone: +64 6 350 5249,
e-mail: humanethics@massey.ac.nz

хаягаар хандана уу.

Асуулга А:
Хэсэг I.

1. Таны ажлын байрны нэр?	………
2. Та нислэгийн удирдагчаар хэдэн жил ажиллаж байна вэ?	Жил………… Сар………….
3. Та хэдэн цаг идэвхтэй ажилласан вэ?	Цаг…………Минут…………
4. Таны хүйс.	☐ Эрэгтэй ☐ Эмэгтэй
5. Таны насны ангилал.	☐ 30-аас доош, ☐ 30-40 ☐ 41-50 ☐ 51-60 ☐ 60-аас дээш

Хэсэг II*. Таны эрүүл тэнд, атьдралын хэв шинж болон уух хэвшилийн талаарх тохирсон хариултыг сонгоно уу? Та хариулахдаа үнэн зөв, нээлттэй, чин сэтгэлээсээ хариулна уу?*

6. Та өдөрт ихэвчлэн юу уудаг вэ? (Нэгээс дээш хариулт сонгож болох бөгөөд жишээ нь: Та өдөрт цай, кофе болон шар айраг уудаг бол бүгдийг тэмдэглэнэ үү.)	☐ Цай ☐ Сүүтэй цай ☐ Савласан ус ☐ Крантны ус ☐ Спорт ундаа ☐ Жимсны жүүс ☐ Хийжүүлсэн ундаа ☐ Халуун шоколад ☐ Шар айраг ☐ Бусад төрлийн спиртын агууламжтай ундаа ☐ Бусад _______________________________	☐ Ногоон цай ☐ Кофе ☐ Шүүсэн ус ☐ Эрдэст ус ☐ Энергийн ундаа ☐ Сүү ☐ Шөл ☐ Дарс

7. Та өдөрт хир хэмжээний шингэн зүйл уудаг вэ? 1 аяга (200мл)-ыг дунджаар нэг нэгж гэж тооцоолоод дундажаар хэдэн нэгж шингэн уудагаа бичнэ үү?	Цай _______ Ногоон цай _______ Сүүтэй цай _______ Кофе _______ Савласан ус _______ Шүүсэн ус _______ Крантны ус _______ Эрдэст ус _______ Спорт ундаа _______ Энергийн ундаа _______ Жимсны жүүс _______ Сүү _______ Хийжүүлсэн ундаа _______ Шөл _______ Халуун шоколад _______ Дарс _______ Шар айраг _______ Бусад төрлийн спиртын агууламжтай ундаа _______ Бусад … _______			
8. Та тогтмол дасгал хийдэг үү? (Нэг удаа хийхдээ хамгийн багадаа 30 минутаас багагүй хийдэг бол тийм гэж хариулана уу)	☐ Тийм		☐ Үгүй	
9. Хэрэв хийдэг бол давтамжаа бичнэ үү?	☐ Долоо хоногт 1 удаа	☐ Долоо хоногт 2-3 удаа	☐ Долоо хоногт 3-аас дээш	
10. Та сахарын дутагдалтай юу?	☐ Тийм		☐ Үгүй	
11. Та ямар нэг эмийг тогтмол хэрэглэдэг үү?	☐ Тийм		☐ Үгүй	

12.	Хэрэв хэрэглдэг бол сүүлийн 2 долоо хоногт хэрэглэж буй эмийн нэрээ бичнэ үү.	....	
13.	Та идэвхтэй ажиллахын өмнө ямар нэгэн шингэн зүйл уудаг уу?	☐ Тийм	☐ Үгүй
14.	Хэрэв үгүй бол, шалтгаанаа бичнэ үү?	....	
15.	Та идэвхтэй ажиллах үедээ ямар нэгэн шингэн зүйл уудаг уу?	☐ Тийм	☐ Үгүй
16.	Хэрэв үгүй бол, шалтгаанаа бичнэ үү?	....	
17.	Та идэвхтэй ажилласаны дараа ямар нэгэн шингэн зүйл уудаг уу?	☐ Тийм	☐ Үгүй
18.	Хэрэв үгүй бол, шалтгаанаа бичнэ үү?	....	
19.	Та идэвхтэй ажиллаж эхлэхдээ цангасан байдаг уу?	☐ Тийм	☐ Үгүй
20.	Хэрэв тийм бол, шалтгаанаа бичнэ үү?	....	
21.	Шингэн зүйл уух хэрэгтэй байгаагаа та хэрхэн мэддэг вэ?	....	
22.	Та өдөрт хэдэн удаа хөнгөнөөр бие засдаг вэ?	....	
23.	Танд яаралтай хөнгөнөөр бие засах шаардлага гардаг уу?	☐ Тийм	☐ Үгүй
24.	Хэрэв тийм бол, шалтгаанаа бичнэ үү?	....	
25.	Та бие засах шаардлага гарахаас зайлс хийж шингэн зүйл уухаас татгалздаг уу?	☐ Тийм	☐ Үгүй
26.	Та идэвхтэй ажиллаж байхдаа зайлшгүй хөнгөнөөр бие засах хэрэг гардаг уу?	☐ Тийм	☐ Үгүй

Section III. *Танд өнөөдөр ямар мэдрэмж төрж байгаа талаархи тохирсон хариултыг сонгоно уу.*

27.	Та яг одоо хэр их цангаж байна вэ?	Огт цангаагүй	Цангаагүй	Хэвийн	Цагнасан	Их цангасан
28.	Та ажлаа эхлэхдээ хэр их цангаж байсан бэ?	Огт цангаагүй	Цангаагүй	Хэвийн	Цагнасан	Их цангасан
29.	Та ажлын дундуур хэр их цангаж байсан бэ?	Огт цангаагүй	Цангаагүй	Хэвийн	Цагнасан	Их цангасан
30.	Та ажиллаж дуусаад хэр их цангаж байсан бэ?	Огт цангаагүй	Цангаагүй	Хэвийн	Цагнасан	Их цангасан
31.	Таны ам одоо хэр таатай мэдрэгдэж байна вэ?	Маш тааламжгүй	Тааламжгүй	Хэвийн	Таатай	Их таатай байна
32.	Таны хоолой одоо хэр хатаж байна вэ?	Огт хатаагүй	Хатаагүй	Хэвийн	Хатаж байна	Их хатаж байна
33.	Таны толгой одоо хэр өвдөж байна вэ?	Огт өвдөөгүй	Өвдөөгүй	Хэвийн	Өвдөж байна	Их өвдөж

					байна
34. Таны толгой одоо эргэж байна уу?	Огт эргээгүй	Эргээгүй	Хэвийн	Эргэж байна	Их эргэж байна
35. Та одоо хэр төвлөрч чадаж байна вэ?	Огт төвлөрч чадахгүй	Төвлөрч чадахгүй байна	Хэвийн	Төвлөрч чадаж байна	Сайн төвлөрч чадаж байна
36. Танд одоо хэр их энергитэй байна гэж бодож байна вэ?	Огт энергигүй байна	Энергигүй байна	Хэвийн	Энергитэй байна	Их энергитэй байна
37. Таны нойр одоо хэр хүрч байна вэ?	Огт нойр хүрэхгүй байна	Нойр хүрэхгүй байна	Хэвийн	Нойр хүрч байна	Их нойр хүрч байна
38. Таны дотор муухайрч байна уу?	Огт үгүй	Бага зэрэг	Хэвийн	Муухайрч байна	Их муухайрч байна
39. Та одоо хэр их ядарч байна вэ?	Огт үгүй	Бага зэрэг	Хэвийн	Ядарч байна	Их ядарч байна

Та яг одоо хэр их цангаж байгаагаа доорх зураас дээр хөндлөн зурж тэмдэглэнэ үү.

40. Та яг одоо хир их цангаж байна вэ?	Цангаагүй ———————————— Маш их цангаж байна

Хэсэг III.

III. Өөрийн ердийн ажлын өдрийн талаар бодож байгаад ээлжийн тухайн үед та ямар нөхцөлд байдаг талаар тэмдэглэнэ үү.

	1 Бүрэн бэлэн байдалд, маш сонор сэрэмжтэй	2 Маш сэргэлэн, хариуцлагатай, гэхдээ дээд зэргээр биш	3 Зүгээр, сэргэгдүү	4 Бага зэрэг ядарсан, бага зэрэг сэргэг	5 Нилээн ядарсан, сулдсан	6 Маш ядарсан, төвлөрөхөд хүндрэлтэй байх	7 Бүрэн эцсэн, үр ашигтайгаар үүрэг гүйцэтгэх боломжгүй
1. Ээлжийн эхэнд	☐	☐	☐	☐	☐	☐	☐
2. Ээлжийн дунд үед	☐	☐	☐	☐	☐	☐	☐
3. Ээлжийн төгсгөлд	☐	☐	☐	☐	☐	☐	☐

Хэсэг V.

Дараах асуултууд өнгөрсөн хэд хоногийн туршид таны санаа сэтгэл болон мэдрэмжийн талаар байгаа болно. Таны санаа сэтгэл болон мэдрэмж ихэвчлэн ямар байдаг талаар асуулт тус бүрт тохирох тэмдэглэгээг хийнэ үү. Хэдийгээр зарим асуултууд адилхан мэт харагдаж буй боловч тэдгээрийн хооронд тодорхой ялгаанууд бий бөгөөд тусдаа асуулт гэж ойлгон тохирох хариултыг бөглөнө үү. Тухайн асуултанд хурдан хариулах нь чухал юм.

	1 Үгүй	2 Бараг үгүй	3 Заримдаа	4 Үе үе	5 Үргэлж

1. Өнгөрсөн хэд хоногт, та санамсаргүй тохиолдсон ямарваа зүйлээс болж хэр их сэтгэл зовсон бэ?	☐	☐	☐	☐	☐
2. Өнгөрсөн хэд хоногт, танд амьдралынхаа чухал зүйлсийг удирдах боломжгүй болсон мэт мэдрэмж хэр их төрсөн бэ?	☐	☐	☐	☐	☐
3. Өнгөрсөн хэд хоногт, та хэр их бухимдах эсхүл стрестсэн бэ?	☐	☐	☐	☐	☐
4. Өнгөрсөн хэд хоногт, та амьдралын төвөгтэй асуудалд бухимдсан бэ?	☐	☐	☐	☐	☐
5. Өнгөрсөн хэд хоногт, та амьдралд тань болж буй чухал зүйлсийг үр ашигтайгаар зохицуулсан мэт мэдрэмж хэр их төрсөн бэ?	☐	☐	☐	☐	☐
6. Өнгөрсөн хэд хоногт, та хувийн асуудлаа зохицуулах өөрийн чадварт итгэлтэй байгаа мэдрэмж хэр их төрсөн бэ?	☐	☐	☐	☐	☐
7. Өнгөрсөн хэд хоногт, бүх зүйл таны төлөвлөснөөр болж байгаа мэт мэдрэмж хэр их төрсөн бэ?	☐	☐	☐	☐	☐
8. Өнгөрсөн хэд хоногт, та хийх ёстой байсан бүх зүйлээ зохицуулж чадаагүй тохиолдол хэр их байсан бэ?	☐	☐	☐	☐	☐
9. Өнгөрсөн хэд хоногт, амьдралынхаа бухимдлыг хянах боломж хэр их байсан бэ?	☐	☐	☐	☐	☐
10. Өнгөрсөн хэд хоногт, та бүгдээс дээгүүр байгаа мэт мэдрэмж хэр их төрсөн бэ?	☐	☐	☐	☐	☐
11. Өнгөрсөн хэд хоногт, таны хяналтаас гадуур тохиолдсон зүйлээс болж хэр их уур уцаартай байсан бэ?	☐	☐	☐	☐	☐
12. Өнгөрсөн хэд хоногт, та өөрийн амжилттай хийж дуусгах ёстой зүйлсийн талаар хэр их бодсон бэ?	☐	☐	☐	☐	☐
13. Өнгөрсөн хэд хоногт, та цагаа хэрхэн өнгөрөөж буйгаа хянах боломж хэр их байсан бэ?	☐	☐	☐	☐	☐
14. Өнгөрсөн хэд хоногт, хүндрэл бэрхшээлүүд таны дийлэхээргүй их бөөгнөрсөн байгаа мэт мэдрэмж хэр их төрсөн бэ?	☐	☐	☐	☐	☐

Судалгаанд оролцсонд баярлалаа.

Дахин хэлэхэд, таны бөглөсөн мэдээлэлд таны нэр дурьдагдахгүй бөгөөд зөвхөн статистикийн дүн шинжилгээний зорилгоор ашиглах, судлаачидаас бусад этгээдэд ил гарахгүй байх болно гэдгийг онцлон тэмдэглэж байна.

Судалаач бөглөнө: Өдөр:

Цаг агаар: Агаарын температур: Агаарын чийгшил:

APPENDIX C. QUESTIONNAIRE FOR ATCS (ENGLISH VERSION)

Project title: ‘’Factors affecting dehydration in General Aviation Pilots and Air Traffic Controllers”

Researchers

Odgerel Chagnaadorj

Student

School of Aviation, Massey University, Palmerston North

Participant recruitment:

Two separate groups: General aviation pilots and air traffic controllers

Project procedures:

The data you supply will be anonymous and all statistical analyses will be on group data. Data will be stored securely at Massey University for 5 years, after which it will be destroyed. Neither you nor the institution at which you are studying will be identified.

Participant involvement

Approximately 5-10 minutes of your time will be required to complete this questionnaire.

Participant’s Rights

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- ask any questions about the study at any time before or during participation

Committee Approval Statement

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University’s Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director (Research Ethics), telephone: +64 6 350 5249, e-mail: humanethics@massey.ac.nz

Please turn over and begin.

The Questionnaire for ATCs

Section I. *Demographic information*

41. What is your job title?	………
42. How long have you been working?	Yrs………… Mths…………
43. How many hours have you worked today?	Hrs…………Mins…………
44. Please state your gender.	☐ Male ☐ Female
45. Please indicate your age group.	☐ Less than 30, ☐ 30-40 ☐ 41-50 ☐ 51-60 ☐ more than 60

Section II. *Choose the right answer to indicate your health, life style and fluid intake habits. Please be open and honest in your responding.*

46. What kind of drinks do you usually drink each day? (You may select more than one, if, for example, you drink tea, coffee and alcohol)	☐ Tea ☐ Milk tea ☐ Bottled water ☐ Tap water ☐ Sport drinks ☐ Fruit juices ☐ Fizzy drinks ☐ Hot chocolate ☐ Beer ☐ Any other drinks________	☐ Green tea ☐ Coffee ☐ Filtered water ☐ Mineral water ☐ Energy drinks ☐ Milk ☐ Soup ☐ Wine ☐ Other alcoholic drinks

47. How much do you drink in a day? (Please indicate the quantity in units. 1 unit equates to 1 small cup (200mls))	Tea _______ Green tea _______ Milk tea _______ Coffee _______ Bottled water _______ Filtered water _______ Tap water _______ Mineral water _______ Sport drinks _______ Energy drinks _______ Fruit juices _______ Milk _______ Fizzy drinks _______ Soup _______ Hot chocolate _______ Wine _______ Beer _______ Other alcoholic drinks _______ Any other drinks _______		
48. Do you regularly exercise for at least 30 minutes in one session?	☐ Yes	☐ No	
49. How often do you exercise?	☐ Once a week	☐ Two or three times a week	☐ More than three times a week
50. Do you have diabetes?	☐ Yes	☐ No	
51. Do you take medicine?	☐ Yes	☐ No	

52. If yes, could you state the prescription medicine you have taken in the last two weeks.	....	
53. Do you drink any fluids before a work?	☐ Yes	☐ No
54. If no, what is the reason?	…………..	
55. Do you drink any fluids during a work?	☐ Yes	☐ No
56. If no, what is the reason?	…………..	
57. Do you drink any fluids after a work?	☐ Yes	☐ No
58. If no, what is the reason?	…………..	
59. Do you ever start a work feeling thirsty?	☐ Yes	☐ No
60. If yes, Why?	…………..	
61. How do you know when you need to drink?	…………	
62. How many times do you go to the toilet to pass water during the day?	…………	
63. Do you ever have to rush to the toilet to pass water?	☐ Yes	☐ No
64. If, yes, Why?	....	
65. Do you ever avoid drinking so that you do not need to go to the toilet to pass water?	☐ Yes	☐No
66. Do you ever urgently need to go to the toilet to pass water during a work?	☐ Yes	☐ No

Section III. *Choose the right answer to indicate HOW YOU HAVE FELT, ON THE WHOLE, DURING THE DAY TODAY.*

67. How thirsty do you feel now?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
68. How thirsty do you feel at the beginning of the flight?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
69. How thirsty do you feel at the middle of the flight?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
70. How thirsty do you feel at the end of the flight?	Not at all thirsty	Not thirsty	Neutral	Thirsty	Very thirsty
71. How pleasant does your mouth taste now?	Not at all pleasant	Not pleasant	Neutral	Pleasant	Very pleasant
72. How dry does your throat feel now?	Not at all dry	Not dry	Neutral	Dry	Very dry

73. How does your head feel now?	Not at all sore	Not sore	Neutral	Sore	Very sore
74. How dizzy do you feel now?	Not at all dizzy	Not dizzy	Neutral	Dizzy	Very dizzy
75. How well can you concentrate just now?	Not at all well	Not well	Neutral	Well	Very well
76. How much energy do you feel you have now?	No at all energy	No energy	Neutral	Energy	Full of energy
77. How sleepy or drowsy do you feel now?	Not at all sleepy	Not sleepy	Neutral	Sleepy	Very sleepy
78. How nauseous do you feel now?	Not at all nauseous	Not nauseous	Neutral	Nauseous	Very nauseous
79. How tired do you feel now?	Not at all tired	Not tired	Neutral	Tired	Very tired

Place a vertical mark on the lines below to indicate HOW YOU FEEL AT THE MOMENT.

80. How thirsty do you feel right now?	Not thirsty Very thirsty ________________________

Section IV. *Try to think of an average flight day and then indicate how you feel.*

	1 Fully alert, wide awake	2 Very lively, responsive, but not at peak	3 Okay, somewhat fresh	4 A little tired, less than fresh	5 Moderately tired, let down	6 Extremely tired, very difficult to concentrate	7 Completely exhausted, unable to function effectively
4. At the beginning of shifts	☐	☐	☐	☐	☐	☐	☐
5. At the middle of shifts	☐	☐	☐	☐	☐	☐	☐
6. At the end of shifts	☐	☐	☐	☐	☐	☐	☐

Section V. *The following questions are about your feelings and thoughts during the past few days. For each question, please indicate how often you have felt or thought the way that is described. Although some questions appear may appear similar, there are differences between them and each should be treated as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up actual instances, but rather indicate the answer which seems like a reasonable estimate. Please mark the appropriate response.*

	1 Never	2 Almost never	3 Some-times	4 Fairly Often	5 Very often
15. In the past few days, how often have you been upset because of something that happened unexpectedly?	☐	☐	☐	☐	☐
16. In the past few days, how often have you felt that you were unable to control the important things in your life?	☐	☐	☐	☐	☐

17. In the past few days, how often have you felt nervous or stressed?	☐	☐	☐	☐	☐
18. In the past few days, how often have you dealt with irritating life hassles?	☐	☐	☐	☐	☐
19. In the past few days, how often have you felt that you were effectively coping with important changes that were occurring in your life?	☐	☐	☐	☐	☐
20. In the past few days, how often have you felt confident about your ability to handle your personal problems?	☐	☐	☐	☐	☐
21. In the past few days, how often have you felt that things were going your way?	☐	☐	☐	☐	☐
22. In the past few days, how often have you found that you could not cope with all the things you had to do?	☐	☐	☐	☐	☐
23. In the past few days, how often have you been able to control irritations in your life?	☐	☐	☐	☐	☐
24. In the past few days, how often have you felt that you were on top of things?	☐	☐	☐	☐	☐
25. In the past few days, how often have you been angered because of things that happened that been outside your control?	☐	☐	☐	☐	☐
26. In the past few days, how often have you found yourself thinking about things that you have to accomplish?	☐	☐	☐	☐	☐
27. In the past few days, how often have you been able to control the way you spend your time?	☐	☐	☐	☐	☐
28. In the past few days, how often have you felt difficulties were piling up so high you could not overcome them?	☐	☐	☐	☐	☐

Thank you for participating in this survey.

Once again, I would like to emphasize that your responses are anonymous, and will not be made available to anyone other than the researcher(s) for the purposes of statistical analysis.

For Research use only: Date:

Weather information: Temperature: Humidity:

APPENDIX D. LOW RISK NOTIFICATION

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA

7 May 2013

Odgerel Chagnaadorj
6/359 College Street
West End
PALMERSTON NORTH 4410

Dear Odgerel

Re: Factors Affecting Dehydration in General Aviation Pilots and Air Traffic Controllers

Thank you for your Low Risk Notification which was received on 6 May 2013.

Your project has been recorded on the Low Risk Database which is reported in the Annual Report of the Massey University Human Ethics Committees.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

> *"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.*
>
> *If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director (Research Ethics), telephone 06 350 5249, e-mail humanethics@massey.ac.nz".*

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to provide a full application to one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

John G O'Neill (Professor)
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics)

cc Dr Andrew Gilbey
School of Aviation
PN833

Mr Ashok Poduval, CEO
School of Aviation
PN833

Massey University Human Ethics Committee
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