



AMERICAN
BIODEFENSE
INSTITUTE

REHYDRATION:

TO COMBAT THE IMPACT OF THE COVID-19
PANDEMIC?

INSIDE THIS REPORT

DEHYDRATION AND ITS PHYSICAL AND MENTAL EFFECTS, DEHYDRATION AND COVID-19,
MILITARY PERSONNEL IMPACT, FIRST RESPONDERS, REHYDRATION TOOLS AND MORE.

By James Mayo &
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Rehydration: To Combat the Impact of the COVID-19 Pandemic?

About American BioDefense Institute

The American BioDefense Institute is a Washington, D.C. based Think Tank, dedicated to nonpartisan analysis of U.S. and international biodefense capabilities and strategies, created in response to the COVID 19 pandemic. ABI challenges the conventional boundaries of scientific disciplines by combining expertise in medicine, biology, chemistry, communication, and public policy to provide multidirectional strategies to meet future biosecurity challenges.

ABI Fellows represent some of the most accomplished academic and private sector pandemic and biodefense experts in the world. This highly specialized Institute advises the United States Congressional and Federal Agency community on next-generation tools, tactics, and procedures for effective biodefense and pandemic relief, as well as briefing federal stakeholders on the next generation of biological warfare threats.

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Contents

Introduction.....	5
Dehydration-Its Physical and Mental Effects	7
COVID-19.....	8
Dehydration in Front-line Workers and Medical Professionals	9
Dehydration in COVID-19 Patients.....	10
Military Personnel.....	11
Rehydration Solutions.....	12
Conclusion	14
References.....	15

Introduction

Water is a critical nutrient. All known life forms depend on water; it is considered as one of the best solvents for inorganic matter because it exhibits the highest known polarity. Besides, it also exhibits extremely high heat capacity, making it a superior heat regulator. In the human body, water's role as a solvent – where it dissolves ionic compounds to create solutions that allow transport of metal ions across molecular membranes – is the one with the most significant consequences for our health and well-being.

During day-to-day activities, a person typically loses about two liters of water through breathing, sweat, urine, and bowel movements. This is increased significantly during exercise when fluid loss can be up to two liters per hour. In addition to water, sweat contains different metal ions: mostly sodium (range 10-70 mEq/L) and chloride (range 5-60 mEq/L) (Baker, 2015). During the COVID-19 pandemic, hydration is imperative for well-being. In addition, staying active is critical for both physical and mental health. Physical activity helps our mind and body in many ways (VicHealth, 2020; Health.gov.au, 2020). But it is essential to be careful as increased physical activity can lead to dehydration if one is not adequately prepared.

Physical exertion places a strain on our immune system. At a higher level of physical exertion, our immune system undergoes significant changes: an increase in stress hormones and cytokine concentrations, changes in body temperature, an increase in blood flow, and dehydration (Nieman, 2007). These changes create a window of 3 to 72 hours when the immune system is impaired, potentially allowing pathogens to gain a foothold in the human body. Fluid replacement is the most effective countermeasure against exertion-related immune perturbations. In addition, a study of thermal dehydration has shown that the changes to hematologic parameters during thermal exposure without exercise are remarkably similar to those during physical exercise (Ohira et al., 1981). Dehydration has the same effect on the human body, regardless of the level of physical activity, and it should always be treated with caution.

Many essential workers have had a significant increase in their workload during the pandemic. The use of personal protective equipment requires more exertion to complete any task, and its relative scarcity during the pandemic means that people spend more time using it than they usually

would. COVID-19 patients commonly exhibit fever, diarrhea, and vomiting as symptoms of the disease. If left unattended, it can lead to severe dehydration, exacerbating their symptoms and making their recovery more difficult.

The issue of dehydration is much more common and dangerous, especially when considering the risks that front line medical workers are facing. Therefore, the proper use of rehydration tools, while seemingly small, can make a big difference: it can help front line medical workers, and their patients fight the disease and help everyone else stay healthy during these challenging times.

Oral rehydration solutions (ORS) are specialized formulations, usually in the form of a powder which contains a mixture of essential salts and sugar that are dissolved in water to create a drink that facilitates faster absorption of water in the human body. Their efficacy is based on the ability of sugar to stimulate sodium and fluid absorption in the small intestine via a cyclic AMP-independent process (Binder et al., 2014). The addition of zinc was found to significantly reduce the duration and severity of diarrheal episodes and the likelihood of subsequent infections for 2-3 months (Khan et al., 2011).

ORS was developed in the 1970s to treat severe dehydration resulting from severe diarrhea without the logistical needs of intravenous hydration using sterile solutions. There have been several significant modifications to ORS since, to improve its efficacy and effectiveness. Original formulations were iso-osmolar: they had the same osmolarity of 311 mOsm/kg H₂O as the fluid in the human cells. However, several studies have shown that hypo-osmolar food-based formulations performed better in clinical trials (Gore et al., 1992). It was subsequently determined that hypo-osmolar glucose-based formulations also have superior performance and that this was due to lower osmolarity of these formulations (Duggan et al., 2004). Since then, reduced osmolarity formulations have been adopted by many countries as the standard ORS formulations (Walker et al., 2009).

While ORS has been well established for treating dehydration caused by diarrhea, especially in children, it has not been widely adopted to treat dehydration caused by other medical conditions. Even though ORS is not a drug, it is inexpensive and is ideal for common usage to treat conditions

before drugs are employed. One of the reasons may be that ORS does not alleviate the symptoms of the underlying illness: reduce diarrhea, for instance, but corrects acute dehydration. There is a lack of awareness about the existence of ORS and its ability to prevent dehydration in a variety of conditions. ORS may be used as a preventive tool to avoid dehydration.

Dehydration-Its Physical and Mental Effects

Dehydration represents a deficit of water in our body, which often leads to a disruption of metabolic processes. When we first start to sense thirst, we are already close to 2% dehydrated. This may cause headaches, tiredness, and fatigue, which are further exacerbated without adequate rehydration and rebalancing of electrolytes. The effects of dehydration can be severe: 5-8% loss of water causes dizziness and fatigue, more than 10% loss of water causes severe physical and mental effects, while 15-25% loss of body water is fatal. Dehydration also leads to increased cardiovascular strain, with heart rate increasing by four beats per minute for each percent loss in body weight (José et al., 1997). Furthermore, it leads to an increase in body temperature, and the rate at which glycogen stored in the muscles is consumed.

Recent studies have shown that even small elevations of extracellular sodium within or slightly above the normal plasma range have adverse cardiovascular consequences (Dmitrieva et al., 2015). Also, multivariable analysis of data from Atherosclerosis Risk in Community study demonstrates that serum sodium is an independent predictor in humans of the plasma level of vWF, of the 10-Years Risk of Stroke and the 10-Years Risk of Congenital Heart Defect (Dmitrieva et al., 2014).

Daily water intake tends to decrease with age: thirst and fluid ingestion responses reduce with aging, resulting in higher rates of dehydration among older people (Popkin et al., 2010). This is primarily due to a decrease in thirst, and older people drink insufficient amounts of water following fluid deprivation to replenish their water deficit. Better hydration practices may help prevent sudden hypotension and stroke or abnormal fatigue in older people. A review of clinical tests for identification of impending and current water-loss dehydration in older people found that most of these tests “miss a high proportion of people with dehydration, and wrongly label those who are adequately hydrated.” (Hooper et al., 2015)

Short-term effects of insufficient fluid intake can be wide-ranging. Mild dehydration may lead to impaired cognitive functions such as concentration, alertness, and short-term memory in children (10–12 y), young adults (18–25 y), and the older generation (Popkin et al., 2010). Moderate levels of dehydration can reduce performance on tasks that require the use of short-term memory, perceptual discrimination, arithmetic ability, visuomotor tracking, and psychomotor skills. Diarrheal diseases are a primary cause of death in children in developing countries, resulting in approximately 1.5–2.5 million deaths per year. Diarrheal illness leads to potentially lethal electrolyte imbalances due to water loss. Mortality in such cases can be prevented with appropriate oral rehydration therapy, in which simple dilute solutions of salt and sugar in water can replace fluid lost by diarrhea.

Long-term effects of insufficient fluid intake manifest themselves through chronic diseases. The cause of most chronic diseases is a complex set of factors, and chronic dehydration could be a contributing factor to a number of these diseases. There is strong evidence showing that proper hydration reduces the risk of urolithiasis, the formation of stony concretions in the bladder or urinary tract. Hydration is also correlated with reduced incidence of constipation, exercise asthma, hypertonic dehydration in infants, and hyperglycemia in diabetic ketoacidosis. Proper hydration is associated with a reduction in urinary tract infections, hypertension, fatal coronary heart disease, venous thromboembolism, and cerebral infarct, but all these effects need to be confirmed by clinical trials (Popkin et al., 2010; Armstrong, 2012).

COVID-19

The COVID-19 pandemic presents new challenges related to our physical and mental health beyond the immediate danger posed by the disease. Pandemic countermeasures enacted by most countries include different forms of restrictions on indoor and outdoor gatherings and restricted access to amenities. Several countries introduced temporary lockdowns and curfews on the entire population. Widespread measures also include quarantine and self-quarantine of COVID-19 positive individuals and their contacts. All these measures, coupled with severe economic consequences of the COVID-19 pandemic, have created a high-stress environment for large segments of the world's population. This already has had a profound negative effect on the

collective health and well-being of people, and these effects will persist long after the end of the pandemic.

Exercise plays an essential role in protecting the general health of a population and is an integral part of the convalescence process for COVID-19 patients (UIHC.org, 2020). Additionally, research suggests that exercise can help reduce the risk of some potentially fatal complications of COVID-19 (The Conversation, 2020), due to the beneficial effects of extracellular superoxide dismutase, an antioxidant produced during exercise. Staying physically active can become extremely challenging due to being at home for prolonged periods. Sedentary behavior and low physical activity can have adverse effects on health, well-being, and quality of life. Self-quarantine can cause additional stress and affects the mental health of individuals. Physical activity and relaxation techniques can be valuable tools to help you remain calm and continue to protect your health during this time. World Health Organization recommends 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity physical activity per week, or a combination of both (WHO Europe, 2020).

Dehydration in Front-line Workers and Medical Professionals

Since the beginning of the COVID-19 pandemic, dehydration has been an issue with frontline workers. The lack of personal protective equipment (PPE) and its limited stocks has forced many frontline workers to minimize their water intake during shifts to avoid having to change their equipment (Express & Star, 2020). Also, healthcare professionals and any other professionals required to use PPE face the same issue. As of 23 July 2020, 65% of over 3,200 healthcare providers back in active practice have reported dehydration (DentistryIQ, 2020). This is because most workers were practicing with multiple layers of respiratory PPE.

Out of 3,291 survey respondents, 27% reported using a respirator-level mask covered by a surgical mask, 26% wearing a surgical mask, and a face shield. Meanwhile, 56% used a three-part combination: a face shield, a respirator mask, and a surgical mask. In addition, 62% reported only removing their PPE during their lunch breaks, and 7% never removed their PPE equipment during their entire work shift.

To further increase the potential for dehydration, some workers were not drinking fluids throughout the day, and others were restricting their fluid intake. A study by Johnson stated that more time needs to be allowed for workers performing tasks while wearing respirators as some workers cannot tolerate the breathing demands or the hot, humid conditions created when using a respirator (Johnson, 2016). An increasing number of healthcare professionals reported symptoms consistent with dehydration, and some of these are relatively serious: rapid heartbeat, dark urine, dry and itchy eyes, muscle cramps, and feeling disoriented.

Dehydration in COVID-19 Patients

Dehydration is always an issue in viral infections, where increased body temperature leads to a much faster loss of water through sweating and evaporation. Symptoms of COVID-19 frequently include diarrhea and vomiting, which can further exacerbate the loss of water and make dehydration more severe. Due to the overcrowding of the healthcare system, a relatively large number of people with mild or moderate COVID-19 symptoms are being treated at home. It is recommended, particularly for patients recovering at home without constant medical supervision, to maintain regular hydration and proper nutrition during COVID-19 and in the recovery period after (Nutritioncare.org, 2020).

COVID-19 patients have increased fluid and nutritional requirements during their illness, which is why efficient rehydration is essential. If they experience diarrhea and vomiting, it could be challenging for them to maintain the necessary fluid intake, and in these instances, it is recommended to use oral rehydration therapy.

Military Personnel

Maintaining hydration has always been a challenge for U.S. military personnel. Members of the military are expected to perform physically demanding tasks in a variety of conditions and often have to endure extreme conditions, including extreme heat, in the normal course of their duty, or during their training. This is particularly true for members of the U.S. Army and the U.S. Marine Corps.

A recent study found that nearly one-third of officers attending the U.S. Army Medical Department's Officer Basic Course or Captain's Career Course in San Antonio, TX, suffered from hypohydration before taking the Army Physical Fitness Test (APFT) (Rogers and Cole, 2016). Recently, a sailor collapsed due to extreme heat and dehydration in a public incident. He was a part of the joint military honor guard who had to carry the casket of the late Rep. John Lewis in Washington, D.C. (Yahoo News, 2020).

The military is aware of the importance of proper hydration, including the importance of replenishing nutrients along with water, and the potential danger of hyponatremia or water intoxication if one only drinks water to replace lost fluids (Martin et al., 2020; Health.mil, 2020).

However, their use of oral rehydration solutions is virtually non-existent, with the official recommendations being to hydrate using water. As a result, 7.2 cases of exertional hyponatremia (low serum, plasma, or blood sodium concentration) per every 100,000 military personnel are diagnosed each year (Health.mil, 2019). This amounted to 1,579 cases from 2003 to 2018.

In addition, at least 17 soldiers died of heat exposure during training exercises at U.S. military bases since 2008 (NBC News, 2020). In 2008, 1,766 cases of heatstroke or heat exhaustion were diagnosed among active-duty service members, and that figure increased to 2,792 in 2018. The problem is most pronounced in the U.S. Marine Corps, where the number of cases more than doubled over this time, reaching 0.91 cases per 1,000 personnel annually.

This is especially troubling given the easy availability and affordability of oral rehydration solutions and minimal logistics requirements associated with their widespread deployment. Proper

use of oral rehydration solutions would also mitigate the medical costs of treatment of dehydration related illnesses in the military and prevent dehydration related casualties. Dehydration and its related illnesses are easily preventable, and there is no reason for the U.S. military to lag behind other military forces in the world in this respect.

Rehydration Solutions

Since fluid loss includes not just loss of water, but also of essential electrolytes like potassium and sodium, fluid replacement includes not just replacing lost water, but also replenishing essential minerals. Oral rehydration therapy (ORT) is a fluid replacement strategy that includes drinking water mixed with some types of salts, mostly sodium and potassium, and sugars, like glucose or sucrose. It is used to prevent and treat dehydration, even in extreme cases involving diarrhea and vomiting. Because it is administered orally, it is significantly less invasive than other strategies, like intravenous (IV) fluid replacement. It is well established that ORT significantly reduces the mortality rates of diarrhea illnesses.

Osmolarity or osmotic concentration refers to the number of solute particles in a solution, which determines the solution's osmotic pressure. In a human body, the osmotic pressure allows the transport of ions like sodium and potassium across cellular membranes, effectively determining the maximum intake of ions and nutrients into the cell. This is important for ORT solutions because they would ideally provide just the right number of ions and nutrients to maximize their effect, but also to avoid excess salt and sugar in the body.

The World Health Organization issued guidelines in 2003 and 2006, determining the recommended osmolarity of ORT solutions, reducing the recommended value from 311 to 245 mOsm/L (Houston et al., 2017).

One of the significant issues of ORT solutions is taste, especially with children. Patients will often refuse ORT solution because of its taste, which is a byproduct of salts – sodium gives it a salty taste, while potassium gives it a bitter taste. A study found that remedies looking to alter the taste of ORT solutions to make them more palatable (like apple juice, orange juice, or orangeade) caused

a decrease of sodium (-30 to -53 mmol/L) and chloride (-27 to -47 mmol/L) content. In contrast, osmolarity increased to more than 311 mOsm/kg (Te Loo et al., 2004).

Only tiny amounts of apple or orange juice can be added to the ORT solution without significantly altering electrolyte composition and osmolarity, making the ORT solution less effective. Palatability does not improve compared with commercially flavored ORT solutions, which were preferred by most subjects.

While sports drinks are commonly perceived to offer the same benefits as ORT solutions, this is not the case: a study found that none of the commonly used drinks provides sufficient amounts of sodium, while only a few of them provide sufficient amounts of potassium (Shirreffs et al., 2007). This means that recovery of fluid balance can only be achieved when significant, albeit insufficient, quantities of sodium are ingested in addition to the sports drink after the exercise. Besides, sports drinks tend to contain high sugar content, which is intended to provide energy for physical exertion.

SOS oral rehydration solution has been formulated to minimize the sugar content, taste great, and keep the sodium and glucose balance of 1:1 (SOSHydration.com, 2020). Its osmolarity is 169 mOsm/kg, considerably lower than the WHO levels of 245 mOsm/kg, while still having the necessary amounts of sodium, potassium, zinc, and chloride as well as the addition of magnesium. Low osmolarity accelerates the absorption of fluid in the body and post-exertion recovery, while the addition of magnesium further supports muscle and nerve function and energy production (Mayoclinic.org, 2020).

Conclusion

The issue of dehydration during the COVID-19 pandemic has been much more extensive than one would expect: the pandemic has not shown any seasonal nature and its second wave hit in the middle of the summer; PPE is widely used by front line medical workers on an unprecedented scale; some of the common COVID-19 symptoms are fever, diarrhea, and vomiting, even in relatively mild cases.

While dehydration may seem minor compared to some other issues brought on by the pandemic, it is something that is affecting both the fit and the sick, and it is something that can be resolved efficiently with the use of proper rehydration solutions. ORT has significant advantages over other rehydration methods: it is non-invasive, it can be combined with other essential nutrients (like vitamins) or medication, and it does not require any special equipment to administer.

The most significant advantage of ORT is that when used as a preventative application ORT can save considerable costs (financial, manpower, and resources) which include, cost of ORT itself (allocation of extra resources to treat a dehydration casualty); medical costs (IV therapy, ER admittance, First Responder call out); Time off work for the dehydrated person; allocation of resources to cover the person who is off work with dehydration (recovery can take up to several days); loss of focus (potential for clinical or military mistakes); and allocation of extra resources to treat a dehydration casualty. ORT is proven highly effective in preventing and treating dehydration and its related problems, and in a time of the pandemic, it is a tool that can tip the scales slightly more in our favor.

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