



# **Current U.S. Military Fluid Replacement Guidelines**

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### CURRENT U.S. MILITARY FLUID REPLACEMENT GUIDELINES

This paper presents a summary of the process to revise the U.S. Military's Fluid Replacement Guidelines. The "old" fluid replacement guidelines provided recommendations for fluid replacement based solely on climatic conditions without consideration for energy expended (activity level) or without hourly or daily limits on fluid consumption. The "revised" fluid replacement guidelines added activity level and hourly and daily limits on fluid consumption. The revised recommendations to the U.S. Army's fluid replacement guidelines were successful as fluid consumption was better matched to sweat losses during hot weather military training.

# **BACKGROUND**

The primary emphasis of the U.S. Military's fluid replacement guidelines is to avoid dehydration, reduce the risk of heat casualties, and thereby eliminate military performance degradation (2, 3, 9). Unfortunately, during the ten-year period between 1989 and 1999, there were 190 hospitalized cases of hyponatremia (caused by over-drinking) during hot weather military training reported. Sixty-seven of these cases of over-drinking/water intoxication occurred in the military training environment at Fort Benning, GA (4, 11). In 1997, eleven hospitalized cases of hyponatremia were reviewed (11). The common characteristics of these cases were that they: 1) occurred early in a military training cycle, 2) were associated with a large fluid intake, 3) presented with mental status changes, and 4) presented with nausea and/or vomiting. All eleven cases occurred during environmental heat stress and in each case considerably more fluid was consumed than recommended by the existing fluid replacement doctrine (2). The number of cases of hyponatremia suggested the fluid replacement guidelines needed to be adjusted in the training environment to prevent possible over-drinking.

In response to the numerous hospitalized cases of hyponatremia, the fluid replacement guidelines for hot weather military training were reviewed and subsequently revised (9). The "old" fluid replacement guidelines provided recommendations for fluid replacement based solely on climatic conditions without consideration for energy expended (activity level) or without hourly or daily limits on fluid consumption. It

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was assumed that any "modest over-drinking" from this guidance would be balanced by increased urine output, and over-hydration would be minimal. However, since Military Leaders are required to enforce fluid replacement guidelines to avoid dehydration and related heat injuries (2, 3), without specific guidance based on energy expenditure and the environmental conditions, the maximal fluid replacement for any "Heat Category" was often employed to avoid dehydration (Table 1, 3<sup>rd</sup> column). This guidance was further complicated by the commonality between the initial symptoms observed for heat exhaustion and hyponatremia (10, 11) so that water was provided to individuals experiencing dizziness, headache, weakness and nausea often without knowledge of recent fluid ingestion volumes. Unfortunately, it wasn't routinely made known that individuals presenting with heat exhaustion resulting from dehydration respond fairly quickly to fluid replacement, while those with hyponatremia may have their condition aggravated by the oral administration of fluids.

The initial development of the revised fluid replacement guidelines used existing computer model estimates of sweat losses for various activity levels and climatic conditions (9): (1) Computer Simulation – estimated work times and fluid intake from an existing heat stress model; (2) Constructed Table – easy (250W), moderate (400 W) and hard (600 W) military tasks; 70-110°F, 20-100%rh; (3) Collapsed Matrix – WBGT (Heat Category: I-V); sweating rates rounded to 0.25 quart; and (4) 2<sup>nd</sup> Computer Simulation – adjusted matrix for T<sub>core</sub> (38.5°C) and 4 hour sustained training.

The second step revised these estimates utilizing actual data collected from soldiers wearing the hot weather, Battle Dress Uniform during climatic chamber studies at different climatic conditions and activity levels (9): (1) Laboratory Validation —easy, moderate and hard work in three humid climates and moderate work in a dry environment (n=20, men and women); (2) Compared Results — constructed tables with hydration guidance; and (3) Revised Tables — decreased fluid recommendation; added work intensity.

Table 1. WATER AND WORK\REST CYCLE REQUIREMENTS (OLD; FM21-10, November 1988<sup>2</sup>)

CRITERIA		PMM		
HEAT CONDITION/ CATEGORY	WBGT INDEX (°F)	WATER INTAKE QUARTS/HOUR	WORK/REST CYCLE-MINUTES	
1	78° - 81.9°	At least ½	Continuous	
2	82° - 84.9°	At least ½	50/10	
3	85° - 87.9°	At least 1	45/15	
4	88° - 89.9°	At least 1 ½	30/30	
5	90° - above	More than 2	20/40	

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These revised guidelines were then "field tested" and compared to data collected under the "OLD" and "REV" guidelines (7): (1) Field Validation – 550 recruits were studied over two successive summers (1997, 1998); (2) 1997 – Field testing at Fort Benning using the "OLD" Fluid Replacement Guidelines (n=277); and (3) 1998 – Field testing at Fort Benning using the "REV" Fluid Replacement Guidelines (n=273). These studies used heat acclimatized, male basic training recruits during mild to hard work (250-600 W) wearing the battle dress uniform, hot weather (BDU). Serum sodium, body mass and fluid intake were measured pre – post activity. The revised fluid replacement guidance is shown in Table 2 below. This revised guidance applies to the average heat-acclimated soldier wearing the Battle Dress Uniform (BDU), Hot Weather (3, 9). The additional changes to the decreased fluid recommendations were the addition of easy, moderate and hard work (Table 3); limiting the hourly water intake  $\leq 1.5$  quarts; and limiting the daily water intake  $\leq 12$  quarts.

Table 2. Revised Fluid Replacement Guidelines for Warm Weather Training (3,9)

Heat WBGT Index, (°F)	Easy Work		Moderate Work		Hard Work		
	Index,	Work /Rest	Water Intake (Qt/hr)	Work /Rest	Water Intake (Qt/hr)	Work /Rest	Water Intake (Qt/hr)
1	78-81.9	NL	1/2	NL	3/4	40/20 min	3/4
2 (Green)	82-84.9	NL	1/2	50/10 min	3/4	30/30 min	1
3 (Yellow)	85-87.9	NL	3/4	40/20 min	3/4	30/30 min	1
4 (Red)	88-89.9	NL	3/4	30/30 min	3/4	20/40 min	1
5 (Black)	> 90	50/10 min	1	20/40 min	1	10/50 min	1

- The work-rest times and fluid replacement volumes will sustain performance and hydration for at least 4 hours of work in the specified heat category. Individual water needs will vary  $\pm \frac{1}{4}$  qt/hr.
- NL= no limit to work time per hour.
- Rest means minimal physical activity (sitting or standing), in shade if possible.
- Hourly fluid intake should not exceed 1½ qt. Daily fluid intake should not exceed 12 qt.
- Wearing body armor adds 5°F to WBGT Index
- Wearing MOPP over-garment adds 10°F (Easy Work) or 20°F (Moderate or Hard Work) to WBGT Index.

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Specifically, these "revised" fluid replacement guidelines (REV) were compared with the "OLD" guidelines on daily changes in serum sodium concentration (Na+) and body mass (BM) during Basic Combat Training at Fort Benning, GA during two successive summers (1997 and 1998). Data were collected from over five hundred recruits (OLD=277, REV=273). Recruits were tested in the morning before and in the afternoon after, 8-12 hours of hot weather, outdoor, military combat training. The wet bulb globe temperature (WBGT, mean  $\pm$  SD) averaged 26.6  $\pm$  1.7°C and 27.4  $\pm$  0.9 °C for OLD and REV (NS).

Serum Na+ decreased from  $137.5 \pm 1.6$  mEq/L to  $137.0 \pm 2.1$  mEq/L after outdoor, military training in OLD (p<0.05). Twenty-two recruits (8%) had serum sodium fall to below 135 mEq/L during OLD. Serum Na+ increased from  $139.0 \pm 1.7$  mEq/L to  $139.4 \pm 2.1$  mEq/L after outdoor military training in REV (p<0.05). Only two recruits (1%) had serum Na+ fall to below 135 mEq/L during REV. BM increased an average of  $1.3 \pm 1.4$  kg (p<0.05) in OLD and an average of  $0.4 \pm 1.7$  kg in REV (p<0.05). The revised guidelines effectively reversed the decrease in serum sodium, reduced the increase in body mass, maintained hydration and minimized over-drinking during hot weather military training compared to the "OLD" fluid replacement guidelines.

Table 3. Examples of Easy, Moderate and Hard Work for the Revised Fluid Replacement Guidelines for Warm Weather Training

101 Warm Weather Training						
Easy Work	Moderate Work	Hard Work				
<ul> <li>Weapon Maintenance</li> <li>Walking Hard Surface at 2.5 mph, 30 lb Load</li> <li>Manual of Arms</li> <li>Marksmanship Training</li> <li>Drill and Ceremony</li> </ul>	<ul> <li>Walking Loose Sand at 2.5 mph, no Load</li> <li>Walking Hard Surface at 3.5 mph, 40 lb Load</li> <li>Calisthenics</li> <li>Patrolling</li> <li>Individual Movement Techniques. i.e. low crawl, high crawl</li> <li>Defensive Position Construction</li> <li>Field Assaults</li> </ul>	<ul> <li>Walking Hard Surface at 3.5 mph, ≥40 lb Load</li> <li>Walking Loose Sand at 2.5 mph with Load</li> </ul>				

The fluid replacement tables underwent another correction based on soldiers working in mission oriented protective posture (MOPP) Level 1 or Level 4. This process included: (1) Computer Simulation – estimated core temperature in a specific environment using existing model; (2) Laboratory Data – experimental data in PPE (MOPP1; MOPP4); (3) Constructed Table – several WBGT; BDU, MOPP1, MOPP4; low, moderate or hard work; (4) Collapsed Matrix – equilibrium core temperature; low and moderate work; WBGT; (5) Compared Results – constructed tables with clothing guidance; and (6) Revised Tables – adjusted heat category for MOPP4 and moderate and hard work. This iterative process recommended that wearing MOPP at any protective level (1-4) adds 10°F for easy work, and adds 20°F for moderate or hard work. There was no change made for recommendations when wearing of body armor (adds 5°F to WBGT index).

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### **CONCLUSIONS**

The changes to the U.S. Army's fluid replacement guidelines successfully minimized the incidence of significant serum sodium loss without increasing the risk of dehydration for soldiers in the military training environment. Serum sodium concentration provided both a good estimate of hydration status (as it accounts for  $\sim 50\%$  of plasma osmolality) during exercise-heat stress and provided a direct measure of possible hyponatremia. The revised fluid replacement guidelines decreased the number of outliers ( $\pm$  2 SD) tending to be hyponatremic without increasing the number of outliers tending to be marginally dehydrated.

The field validation provided a "snapshot" of fluid replacement during outdoor military training. There were two design issues that may have minimized differences observed between the "old" and "revised" fluid replacement guidelines. The fluid replacement tables were revised because of the increased incidence of hyponatremia reported during military training (4, 6, 11). The revisions, to include activity level (energy expenditure) and upper limits for hourly and daily fluid replacement, were intended to provide safe guidelines that would reduce the incidence of hyponatremia [defined here as serum sodium concentration less than 135 mEq/L] without increasing the incidence of dehydration in a military training environment (9). Dehydration in excess of 3% of total body water markedly reduces military performance and increases the thermal stress of exercise (1, 8, 12). The revised recommendations to the U.S. Army's fluid replacement guidelines were successful as fluid consumption was better matched to sweat losses as indicated by a reversal to a slight increase in serum sodium concentration and a smaller increase in body mass during hot weather military training observed in this study. During the time of this investigation at Fort Benning, two cases of hyponatremia were reported during OLD and no cases were reported in REV. These cases were not associated with the recruits participating in this investigation.

The revised fluid replacement guidelines "field tested" in a training environment provided evidence supporting the laboratory and computer model estimations of sweat losses during hot weather training (9). The large number of recruits during hot weather, military training provided an adequate distribution of serum sodium and body mass changes to assess the utility of the revised fluid replacement guidelines. A follow-up of epidemiological data indicated a significant decrease in hospitalized hyponatremia cases in 1998 and 1999 compared to 1997 (under "old" guidelines), further supporting the success of the revised fluid replacement guidelines (5). The number of hyponatremia cases reported at Fort Benning was reduced from ten in 1997 to four in 1998 to one in 1999 (5). The average changes in serum sodium concentration observed during hot weather military training, although statistically significant, were small. An important observation is the direction change in serum sodium concentration after military hot weather training with the new fluid replacement guidelines.

During military training, water is the primary rehydration beverage and electrolytes are replaced during meals as daily sodium intake for garrison or field diets is sufficient to replace most sodium losses from sweat. Sodium is not the only electrolyte that is lost in sweat (potassium, calcium, and magnesium) and the inclusion of sodium or other electrolytes can be an effective source for electrolyte replacement during prolonged periods of profuse sweating in hot weather, especially when meals are not available. However, the findings from the field study, done in a training environment where most heat injuries occur, indicated the revised fluid replacement guidelines effectively reversed the decrease in serum sodium, reduced the increase in body mass, maintained hydration and minimized over-drinking during hot weather military training compared to the "old" fluid replacement guidelines.

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