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Thus, avid drinkers (D) drank sufficiently such that they lost less than 2% of their initial BW when consuming cool water ad libitum, while reluctant drinkers (RD) lost more than 2% of their BW. When warm water was provided, fluid consumption was reduced by 29% and 54% in D and RD, respectively and BW deficits were comparably increased. Intake of cool water elicited cyclic drinking patterns with higher rates during walking than during rest periods in both D and RD, whereas consumption of warm water produced this cyclic pattern only after food ingestion during the third rest. Food consumption stimulated fluid intake and reduced BW losses in both trials. Compared to pre-prandial (hours 1-2.5) rates, average post-lunch drinking rates during the last 3h increased 14% in D and 19% in RD when consuming cool water, and by 46% and 74%, respectively with warm water. While food consumption has been encouraged to replace electrolytes lost in sweat when working in hot climates, our results indicate that food ingestion also enhances fluid consumption.

PATTERNS OF HUMAN DRINKING:

EFFECTS OF EXERCISE, WATER TEMPERATURE AND FOOD CONSUMPTION

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Running head: Patterns of human drinking

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ABSTRACT

The effects of exercise, water temperature and food consumption on patterns of ad libitum drinking were studied in 33 men during 6 consecutive cycles of 30 min walking (4.8 $km \cdot h^{-1}$, 5% grade) and 30 min rest in a climatic chamber (40°C, 40% relative humidity). On two nonconsecutive days, subjects consumed 15°C (cool) water during one trial and 40°C (warm) water during the other. We previously reported that two groups of drinkers can be identified during work in the heat by the criterion of body weight (BW) loss during the trial. Thus, avid drinkers (D) drank sufficiently such that they lost less than 2% of their initial BW when consuming cool water ad libitum, while reluctant drinkers (RD) lost more than 2% of their BW. When warm water was provided, fluid consumption was reduced by 29% and 54% in D and RD, respectively and BW deficits were comparably increased. Intake of cool water elicited cyclic drinking patterns with higher rates during walking than during rest periods in both D and RD, whereas consumption of warm water produced this cyclic pattern only after food ingestion during the third rest. Food consumption stimulated fluid intake and reduced BW losses in both trials. Compared to pre-prandial (hours 1-2.5) rates, average post-lunch drinking rates during the last 3h increased 14% in D and 19% in RD when consuming cool water, and by 46% and 74%, respectively with warm water. While food consumption has been encouraged to replace electrolytes lost in sweat when working in hot climates, our results indicate that food ingestion also enhances fluid consumption.

Index Terms: heat, exercise, drinking patterns, food intake, rehydration

INTRODUCTION

Dehydration may be involuntary or voluntary. Involuntary dehydration arises when sufficient replacement fluid is not available and drinking is severely restricted. Voluntary dehydration may occur when the individual has access to water but neglects to ingest adequate fluids to maintain euhydration.

Adolph and coworkers (1,2) noted that when living in the desert, man usually does not drink sufficiently to compensate for water losses and may be, therefore, chronically dehydrated. Their research has provided us with knowledge of several factors affecting voluntary dehydration in desert environments: increased sweat rate, elevated work load and/or environmental temperature, and reduced accessibility to water sources (2,10). Additionally, inadequate time allowed for food and fluid consumption (1,7,12), together with increased temperature and poor palatability of drinking water (1,3,7,11,12,14), may also increase the incidence and severity of voluntary dehydration.

In a previous study, we have identified two groups of drinkers: those individuals who maintain body weight loss within 2% of initial body weight when given cool (15^{o}C) water during 6h of intermittent exercise were called avid drinkers (D) and those who lost more than 2% were called reluctant drinkers (RD) (13). In the present experiments, we have examined the effects of 1) water temperature, 2) food intake and 3) treadmill exercise on drinking behavior and patterns during a 6h simulated desert walk.

Patricia C. Szlyk: Research Physiologist

METHODS

Subjects: Thirty-three (33) healthy men volunteered for this study after being fully informed of the procedures and risks. Physical characteristics for all subjects (Ss) (n=33) were (mean $\pm$ S.E.): age= 23.6 $\pm$ 0.5 yr; height= 179.6 $\pm$ 1.5 cm; and weight= 77.13 $\pm$ 1.82 kg. None of the Ss was heat acclimated.

Design: Climatic chamber conditions were 40^{o}C d.b., 40% r.h. with a wind speed of 2.5 $km \cdot h^{-1}$ producing a WBGT of 31^{o}C.

Each individual spent a total of approximately 6h in the climatic chamber on each of two non-consecutive days. During the 6h, Ss walked at 4.8 $km \cdot h^{-1}$ for 30 $min \cdot h^{-1}$, on a treadmill set at a 5% grade. During the 30 min of inactivity, Ss remained standing or sitting. Thus, at the completion of the test day, each had walked 14.5 km and had simulated a climb of 724 m under desert conditions.

During one trial the available drink was cool (15^{o}C) water treated with iodine tablets (16 $mg \cdot L^{-1}$) and during the second, warm (40^{o}C) iodinated water was consumed. Water was iodinated since this procedure is commonly used to disinfect field-acquired drinking water. Water at about 15^{o}C was used because it represents the preferred temperature for consumption in human subjects as measured by fluid intake (2,3,11,12) and palatability (3,11). Ordinarily, the sensation of thirst and the urge to drink occur by a 2% deficit in body weight (1,2,6). The 6h cool (15^{o}C) water trial was selected for differentiating those individuals exhibiting greater than 2% body weight loss (reluctant drinkers, RD) from those exhibiting less than 2% weight loss (avid drinkers, D). Water at 40^{o}C was chosen because during sports events or especially during military operations in hot climates, water is usually supplied at ambient temperature (5). Water was provided ad libitum in canteens which were conveniently accessible to Ss at all times. The temperature of the water was randomized for the 2 sessions.

Measurements: The effects of water temperature, ad libitum food consumption and exercise on patterns of human drinking were assessed through measurements of fluid intake and body weight changes during each walk and rest period.

On each of the two (2) days, Ss reported to the chamber at 0645h whereupon they were fed a light breakfast of cereal, toast and juice. After breakfast, Ss proceeded to a dressing room (21^{o}C) to provide a pretest urine sample for determination of specific gravity and drank 250 ml of cool tap water to insure adequate initial hydration. Initial nude body weight (Sauter, $\pm$10 g), age and height were recorded. Ss then donned shorts, socks and sneakers and a clothed body weight was obtained. Additional clothed body weights were measured at the end of each 30 min walk and rest.

Fluid intake was monitored and canteens were refilled at the completion of each 30 min walk and rest, or sooner if necessary; each canteen was weighed on an electronic balance (Sartorius, $\pm$1 g). Total fluid intake as well as differences in water intake between walk and rest intervals were computed.

Lunch consisting of army rations (Meal, Ready to Eat, Individual) that had been pre-weighed to the nearest gram, was provided ad libitum during the third 30 min rest period (2.5-3.0 h post-start). After lunch, any remaining food was weighed to determine actual consumption.

The classification of individuals as avid drinkers (D) and reluctant drinkers (RD) was a posteriori. Data were analyzed using analysis of variance (ANOVA) with repeated measures followed by the application of Tukey's test. Where appropriate, Student's paired t-test was used. Statistical significance was accepted at $p<0.05$ level.

RESULTS

During the cool (15°C) water trial (Table 1), D replenished 76%, on average, of their total fluid loss, and thus lost only 1.16% of initial body weight (BW) during the 6h of intermittent exercise. Despite similar sweat losses, RD consumed only 69% of the amount of cool water ingested by D, providing a rehydration rate of only 50%. Thus, RD experienced a 6h % BW loss that was nearly 2.3 times greater ($p<0.001$) than that of D. When warm (40°C) water was provided as the drink, 6h fluid consumption significantly decreased ($p<0.001$) by 29% in D and by 54% in RD (Table 1). These marked reductions in fluid intake were accompanied by significantly greater ($p<0.001$) BW losses in both D ($2.43 \pm 0.24\%$) and in RD ($3.84 \pm 0.21\%$). For comparison, 6h intakes of warm water were less ($p<0.001$) and BW losses were greater ($p<0.001$) in RD relative to D.

Drinking rates for each of the six walk and rest periods are depicted for both groups of drinkers in Figure 1 and Table 1. The average fluid intake rate was significantly less ($p<0.001$) in both D and RD when warm water was provided compared to cool water. In addition, the intake rates were markedly higher ($p<0.001$) in D relative to RD. During the cool water trial (Figure 1), both D (upper panel) and RD (lower panel) exhibited a cyclic pattern of drinking, consuming more water when walking than when at rest (D, $p<0.0025$;

RD, $p<0.025$). During the warm water trial, this cyclic pattern of drinking did not emerge until after lunch (R3 or 2.5-3.0 hr post-start) when more fluid was ingested during the walk than rest periods. Figure 2 demonstrates that for the cool water trials the total fluid intake for D and RD was 60% and 53% greater ($p<0.05$) during exercise periods relative to rest; however, during the warm water trials, these differences in intakes during work and rest intervals were not significant. In addition, both D and RD consumed more cool than warm water ($p<0.001$) during the walks (Figure 2), while RD also drank significantly more cool than warm water ($p<0.005$) during the rest periods.

Food consumption (R3, lunch) elicited concurrent increases in the average rate of fluid intake for both D and RD relative to the respective pre-lunch and post-lunch rates (Figure 3). Pre-lunch water intake rates were nearly doubled ($p<0.001$) during lunch in D with either warm or cool water, and for RD were increased during lunch by a factor of 1.4 with cool water (p=ns) and were tripled when consuming warm water ($p<0.02$). Although the quantity of food consumed was approximately equal for both warm and cool water trials in D (0.306 $\pm$ 0.028 kg) and RD (0.168 $\pm$ 0.027 kg), more cool fluid was ingested during lunch by D ($p<0.01$).

Although post-lunch water intakes fell toward pre-lunch values, they remained elevated (Figure 3). Post-lunch fluid intake during cool water trials for both D and RD was increased by approximately 14% (p=ns) and 19% ($p<0.02$), respectively, over pre-lunch intake rates. During warm water trials, this elevated intake rate was even more pronounced as D consumed 46% ($p<0.01$) and RD consumed 74% ($p<0.01$) more fluid post-lunch than pre-lunch. Increased fluid consumption was also reflected in the rate of change in body weight (Figure

4) which demonstrated a significant gain ($p<0.001$) during the 30 min lunch period and a reduced loss following lunch.

DISCUSSION

According to Adolph and coworkers (1) the sensation of thirst usually occurs when body weight lost as body water approaches 2% of initial body weight while Greenleaf and associates (6) maintained that drinking is stimulated at a body weight deficit between 0.5-1.0%. Those individuals who are able to maintain their body weights within a 2% deficit when water is available ad libitum may be at a lesser risk of dehydration and heat illness when working in hot desert-like climates (1,10,12).

In a temperate environment and at self paced work rates, average fluid intake is approximately 3L during a 16h day (6,15). As environmental temperature and/or work rate increase, the amount of fluid ingested hourly should increase to maintain fluid balance. Brown and colleagues (2) reported that soldiers performing strenuous work in desert climates consume about 6 qts per day. Table 1 shows that when given cool (15^{o}C) water, D more than doubled this reported intake and ingested almost 3L in only 6h. Further, RD consumed only 69% of the amount of cool water ingested by D. This was also reflected in the differences in body weight changes seen in the two groups; D lost 1.16% of initial body weight and RD lost 2.65%. In an earlier study (7), we observed intakes of cool (15^{o}C) water ranging from 2.2-3.0L during 6h of intermittent work under similar desert conditions. In similar desert environments, 6h fluid intakes have ranged from 1L in sedentary troops to 1-4L in soldiers marching or performing maneuvers (2,10).

Several investigators have reported that warm water is less acceptable than cool water (3,11), and hence consumption is reduced in both sedentary (3,7,11) and working (1,7,10,11,12,14) individuals. In addition, an increased reluctance to drink warm water has been noted when body temperature is elevated (3,7) or dehydration is prominent (3). In the current study, we have shown marked differences in consumption of warm water in individuals identified as avid drinkers compared to those reluctant to drink. When given warm rather than cool water (Table 1), D reduced their water intake by 29% and consequently lost approximately twice as much body weight as when cool water was available. Moreover, RD consumed 54% less warm than cool water and thus lost a greater percentage of their initial body weight (3.84% vs 2.65%, warm vs cool water trial). Usually during hot-weather athletic events or military scenarios, warm water is available more often than cool water due to logistical constraints in supplying ice, transporting refrigeration units, or maintaining mobile chillers. We believe that the results of this water temperature trial are generally applicable to the existing problem of inadequate fluid intake during outdoor sporting or military events: i.e. the availability of only warm water reduces fluid consumption of both avid and reluctant drinkers leading to increased dehydration, risk of heat illness and performance decrements, especially in the latter individuals.

Unlike dogs and other animals that rehydrate within 2-3 min after water deprivation, man requires at least 30 min (1,8) to attain an 80% rehydration level after being denied access to water. Rolls (9) has shown that maximal drinking in man occurs within 2.5 to 15 min following 24h water deprivation. In the present study, however, water was available ad libitum for the entire 6h period with the exception of short time periods (5 min) during rest.

Thus, if sufficient fluids were not ingested during the 30 min walking periods, the 30 min rest intervals would present ample opportunity for rehydration to the levels (about 80%) observed by Adolph (1,2). Such average rehydration rates were observed (Table 1) in D when they were presented with cool water, but not in RD who averaged only 50% rehydration in the cool water trial. During the warm water trial these percentages were dramatically reduced as D and RD rehydrated to only 50% and 26%, respectively. These results indicate that at moderate work levels in the heat with only warm water available to drink, additional emphasis should be placed on fluid replacement. Also, these data justify the added effort or expense of providing cool water to workers, soldiers, and athletes engaged in hot weather operations.

As seen in Figure 1, both D and RD displayed a cyclic pattern of drinking during the cool water trial, consuming more during periods of walking than rest. A cyclic pattern of drinking was observed only after lunch when warm water was provided. Data for total fluid intake further support the differences in intake rates between walk and rest periods (Figure 2). Total intake of cool water was 60% and 53% greater during the walks than during the rests in D and RD, respectively, most probably as a result of increased sweating during work. This difference in consumption between periods of activity and inactivity was not observed when warm water was provided. While these findings concur with our previous work (7), Rothstein and coworkers (1,10) reported that men in forced marches consumed more water during rest periods, since working individuals may pay less heed to thirst.

Because D consumed approximately the same amount of warm and cool water during the rest periods (1.1L), the difference in total fluid intake between the warm and cool trials was due to the higher consumption of cool water during the walks. The work levels and environmental conditions were nearly identical for the two trials; thus, the higher consumption of cool water by D probably resulted from a greater preference for cool compared to warm water (3,4,7) during work. Differences in intake of warm and cool water during both the work and rest periods by RD might reflect differences in palatability factors (Figure 2). Consumption of cool water during rest periods increased (palatability), and when RD exercised and presumably got warmer, cool water consumption increased even further. These findings suggest that D, with high and nearly equivalent consumptions of cool and warm water during rest periods, might be more sensitive to thirst related factors than palatability, for D may simply recognize the requirement to drink even unpalatable water during exercise in the heat.

In the present study lunch, consisting of a pre-weighed prepared meal, was eaten after the third walk (2.5-3.0 hours post start) and actual food intake was recorded. Rolls (8) has stated that fluid intake in laboratory animals during mealtime may be an anticipatory response to a learned fluid need associated with particular foods: protein demanding a high fluid intake and carbohydrate having a low fluid demand. Ordinarily, individuals should consume approximately equal amounts of fluid when ingesting the same type of foods. These meals contained about 14% protein and 45% carbohydrate, suggesting a relatively low water requirement. However, because these meals are presented in a dehydrated state, their water demand is increased. While D consumed more food and fluid (Figure 3) than RD, the amount of food consumed by each group was approximately equal for both warm and cool water trials. In addition, more cool fluid, as opposed to warm fluid, was ingested during these trials. Thus, palatability may also play a role in the relationship between food and fluid intake.

The data in Figure 3 also show that food consumption should not be neglected as a stimulus to increase fluid intake, particularly while working in hot environments and consuming warm or unpalatable water. Because Ss increased their 30 min water intake rates by 50-200% during lunch, they consumed 11-18% of their total intake in these 30 min and manifested marked gains in body weight (Figure 4) during lunch. These gains in body weight, due both to food and fluid ingestion, represent for D and RD, 64% and 11%, respectively, of the total pre-lunch deficits during the cool water trial, and 25% and 7%, respectively when warm water was provided. Our data agree well with the observations of Adolph and coworkers (1,10) that fluid consumption increases at mealtime and contributes to the reduction in body weight deficits. Although our subjects consumed copious amounts of water with their meals, the pre-lunch water deficit was not compensated as observed by Rothstein and coworkers (10).

After lunch, although average water intake rates moderated toward pre-lunch levels (Figure 3), they remained slightly elevated when compared to pre-lunch rates. During the cool water trials, post-lunch fluid intake rates were 14% greater than those observed pre-lunch for D and 19% for RD. When warm water was consumed, post-lunch fluid intake rates were markedly higher than pre-lunch rates for D (46%) and RD (74%). The subjects may have used the food to mask the non-palatability of the warm water. Hence, the consumption of food at lunchtime may not only reduce the level of dehydration accrued until that time, but may also act as a catalyst for continually increased intakes, particularly if warm water is being consumed.

In conclusion, these data indicate that food consumption may be an important stimulus to increase fluid consumption. Furthermore, the benefits of food consumption in increasing drinking rates may persist for several hours following the actual meal. Fluid intake was reduced and body weight deficits were proportionately increased in both avid and reluctant drinkers when warm water was provided. Avid and reluctant drinkers consumed more cool water during work than rest periods, but this difference in intake disappeared during the warm water trial. Thus, provisions for cool water and adequate rest periods should be made, if possible, during prolonged work in hot environments.

DISCLAIMER

The views, opinions and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other official documentation.

Human subjects participated in this study after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC regulation 70-25 on use of Volunteers in Research. Citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

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REFERENCES

1. Adolph EF, Wills JH. Thirst. In: Adolph EF, ed. Physiology of man in the desert. New York: Interscience, 1947:241-53.

2. Adolph EF, Brown AH. Summary and Conclusions. In: Adolph EF, ed. Physiology of man in the desert. New York: Interscience, 1947:342-52.

3. Boulze D, Monastruc P, Cabanac M. Water intake, pleasure and water temperature in humans. Physiol. Behav. 1983; 30:97-102.

4. Cabanac M. Physiological role of pleasure. Science. 1971; 173:1103-7.

5. Crowdy JP. Drinking water requirements in hot climates. Army Personnel Res. Estab. Rep. 1/68. 1968:16.

6. Greenleaf JE, Brock PJ, Keil LC, Morse JT. Drinking and water balance during exercise and heat acclimation. J. Appl. Physiol. 1983; 54(2): 414-19.

7. Hubbard RW, Sandick BL, Matthew WT, Francesconi RP, Sampson JB, Durkot MJ, Maller O, Engell DB. Voluntary dehydration and alliesthesia for water. J. Appl. Physiol. 1984; 57(3):868-75.

8. Rolls BJ, Wood RJ, Rolls, ET. Thirst: The initiation, maintenance, and termination of drinking. Prog. Psychobiol. Physiol. Psychol. 1980; 9:263-321.

9. Rolls BJ, Wood RJ, Rolls ET, Lind H, Lind W, Ledingham JGG. Thirst following water deprivation in humans. Am. J. Physiol. 1980; 239:R476-82.

10. Rothstein A, Adolph EF, Willis JH. Voluntary dehydration. In: Adolph EF, ed. Physiology of man in the desert. New York: Interscience, 1947: 254-70.

11. Sandick BL, Engell DB, Maller O. Perception of drinking water temperature and effects for humans after exercise. Physiol. Behav. 1984; 32:851-54.

12. Sohar E, Kaly J, Adar R. The Prevention of Voluntary Dehydration. UNESCO/India Symposium on Environmental Physiology and Psychology: 1962:129-35.

13. Szlyk PC, Sils IV, Francesconi RP, Hubbard RW, Matthew WT. Variability in intake and dehydration in young men during a simulated desert walk. Aviat. Space Environ. Med. 1989 (In press).

14. Szlyk PC, Sils IV, Francesconi RP, Hubbard RW, Armstrong LE. Effects of water temperature and flavoring on voluntary dehydration in men. Physiol. Behav. 1989; 45(3):

15. Welch BE, Buskirk ER, Iampietro PF. Relation of climate and temperature to food and water intake in man. Metab. 1958; 7:141-8.

TABLE 1

GROUP	WATER TEMPERATURE (°C)	6H FLUID INTAKE, L	FLUID INTAKE RATE, L/30 MIN	6H BODY WEIGHT LOSS, KG	6H % BODY WEIGHT LOSS	PERCENT REHYDRATION[1]
DRINKERS (n=20)	15	2.98 ± 0.12	0.25 ± 0.01	0.91 ± 0.09	1.16 ± 0.11	76 ± 2
	40	$2.11 \pm 0.21^{*}$	$0.18 \pm 0.02^{*}$	$1.90 \pm 0.20^{*}$	$2.43 \pm 0.24^{*}$	$50 \pm 5^{*}$
RELUCTANT DRINKERS (n=13)	15	$2.05 \pm 0.14^{+}$	$0.17 \pm 0.01^{+}$	$1.98 \pm 0.09^{+}$	$2.65 \pm 0.11^{+}$	$50 \pm 2^{+}$
	40	$0.95 \pm 0.16^{*+}$	$0.08 \pm 0.01^{*+}$	$2.88 \pm 0.21^{*+}$	$3.84 \pm 0.21^{*+}$	$26 \pm 4^{*+}$

Values are Mean $\pm$ S.E.

Number in parenthesis = number of subjects.

1 Percent rehydration = $\frac{\text{fluid intake}}{\text{fluid intake + body weight loss}} * 100.$

* Significantly different from 15°C water by paired t-test ($p<0.05$).

\+ Significantly different from average value for Drinkers ($p<0.05$).

FIGURE LEGENDS

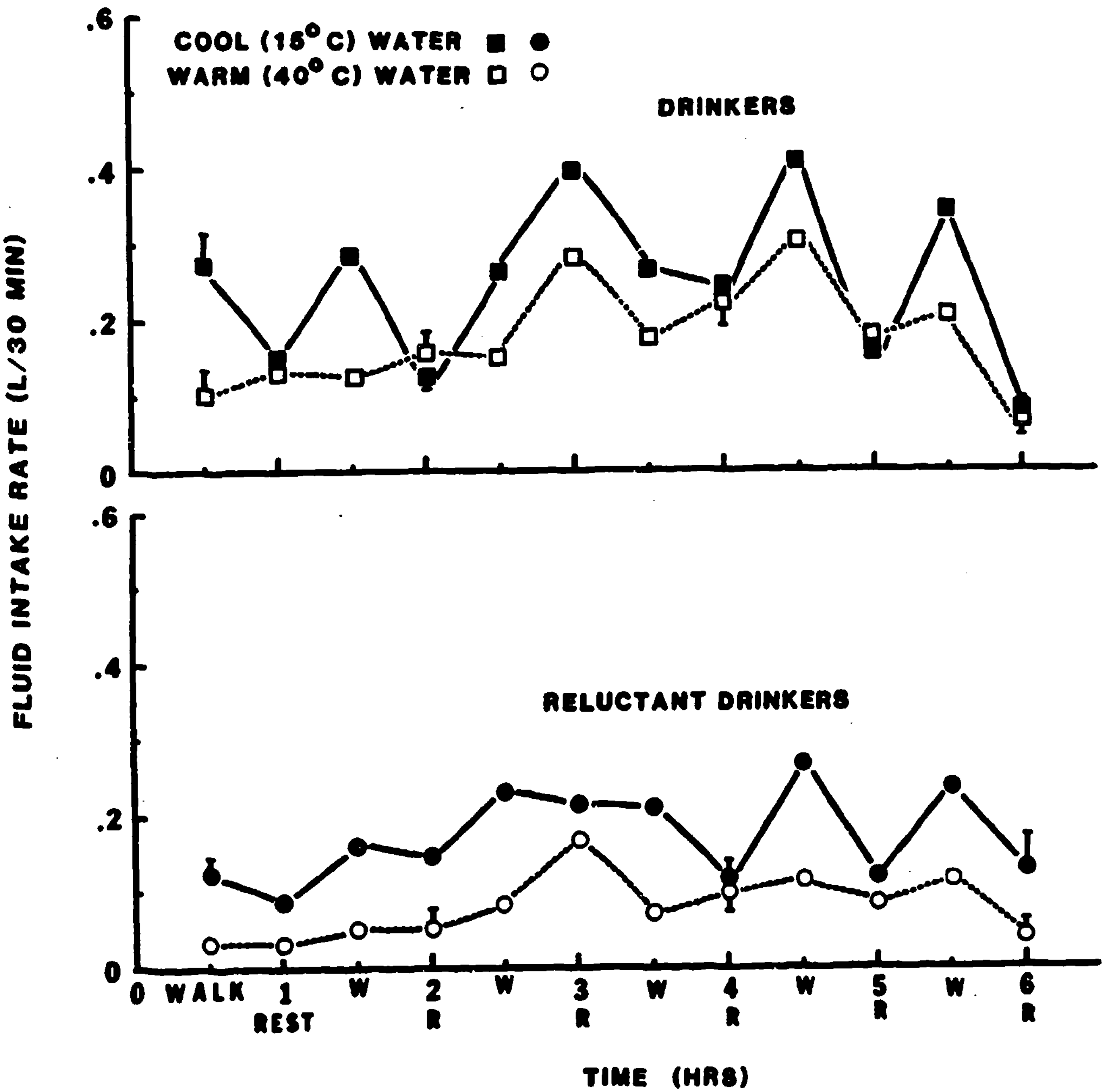
Figure 1 Rate of fluid intake (L/30 min) of avid drinkers (upper panel) and reluctant drinkers (lower panel) during cool ($15^{o}C$) and warm ($40^{o}C$) water trials.

Figure 2 Total fluid intake of avid and reluctant drinkers during walk and rest periods. Only a significance level of $p<0.05$ is indicated on figures. The symbol + represents significant difference from corresponding walk; * indicates significant difference from cool water trial.

Figure 3 Fluid consumption rate (L/30 min) during pre-lunch, lunch and post-lunch during cool and warm water trials. Significant differences ($p<0.05$) between pre-lunch and lunch are indicated by +;between pre-lunch and post-lunch by *.

Figure 4 Change in body weight (kg/30 min) during pre-lunch, lunch and post-lunch for both groups during cool and warm water trials. Statistical significance indicated as outlined in Figure 3.

Figure 1



COOL (15° C) WATER
WARM (40° C) WATER
DRINKERS
RELUCTANT DRINKERS
FLUID INTAKE RATE (L/30 MIN)
.6
.4
.2
0
0 WALK 1 W 2 W 3 W 4 W 5 W 6
REST R R R R R
TIME (HRS)

Figure 2

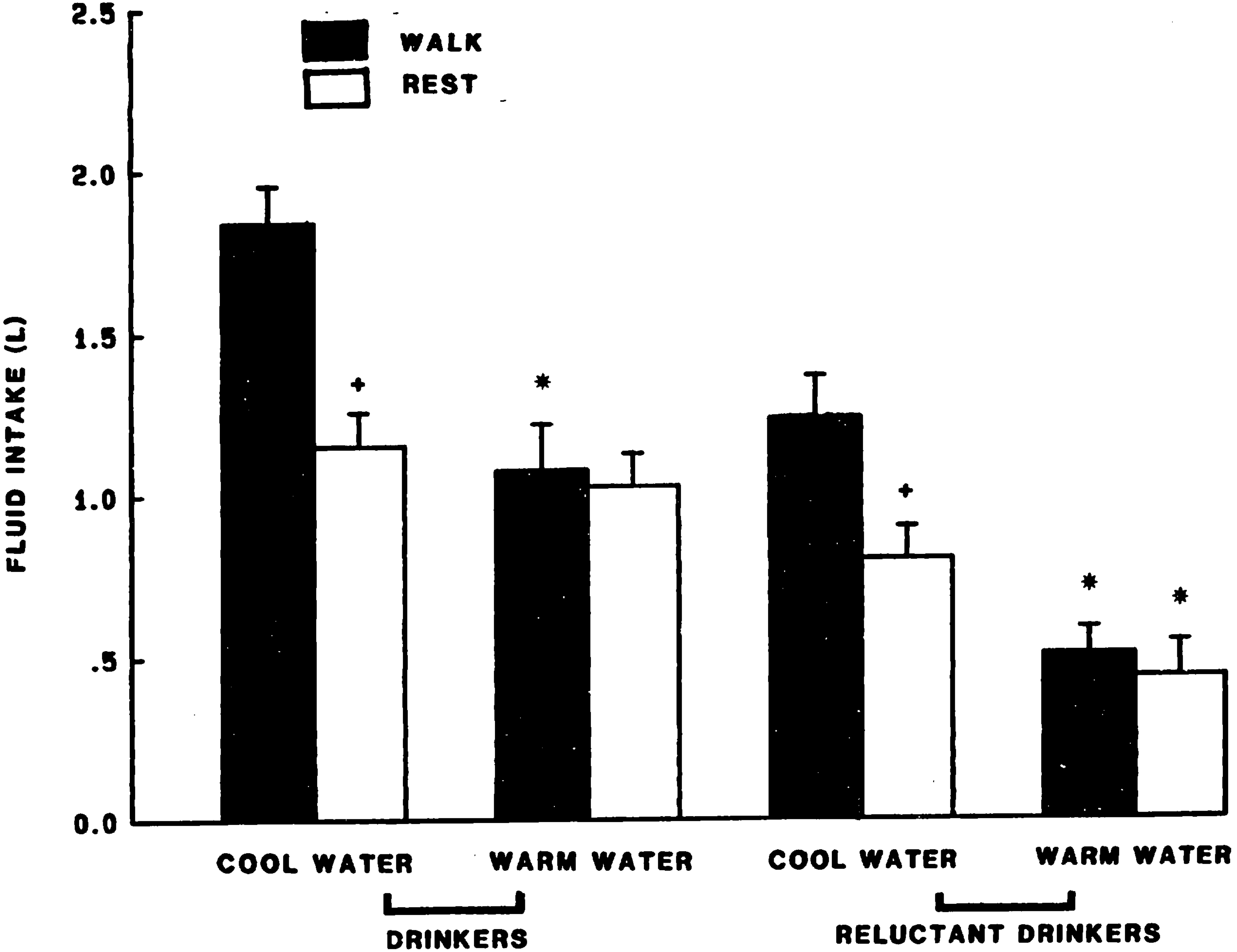

WALK
REST
FLUID INTAKE (L)
2.5
2.0
1.5
1.0
.5
0.0
+
*
+
*
*
COOL WATER
WARM WATER
DRINKERS
COOL WATER
WARM WATER
RELUCTANT DRINKERS

Figure 3.

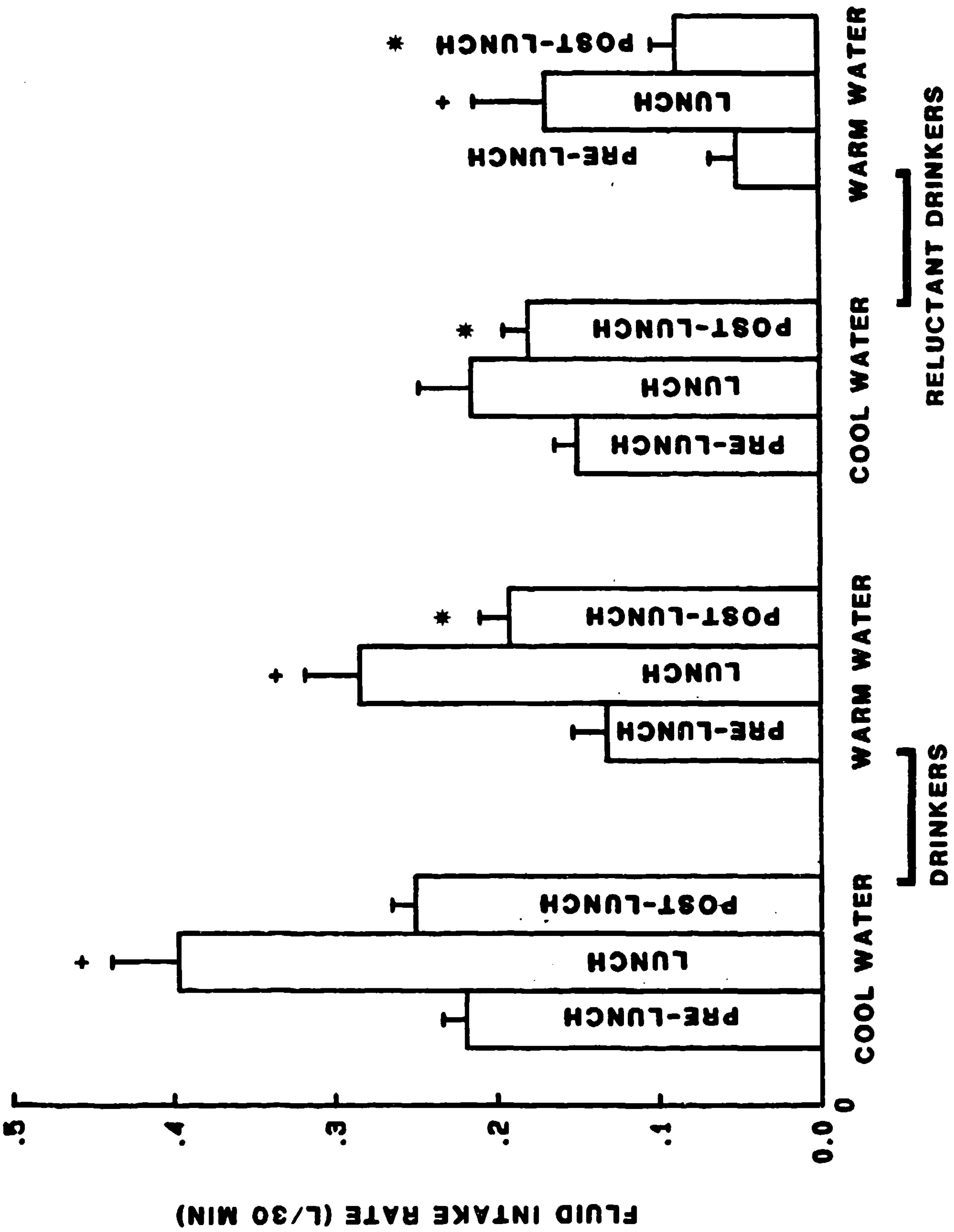
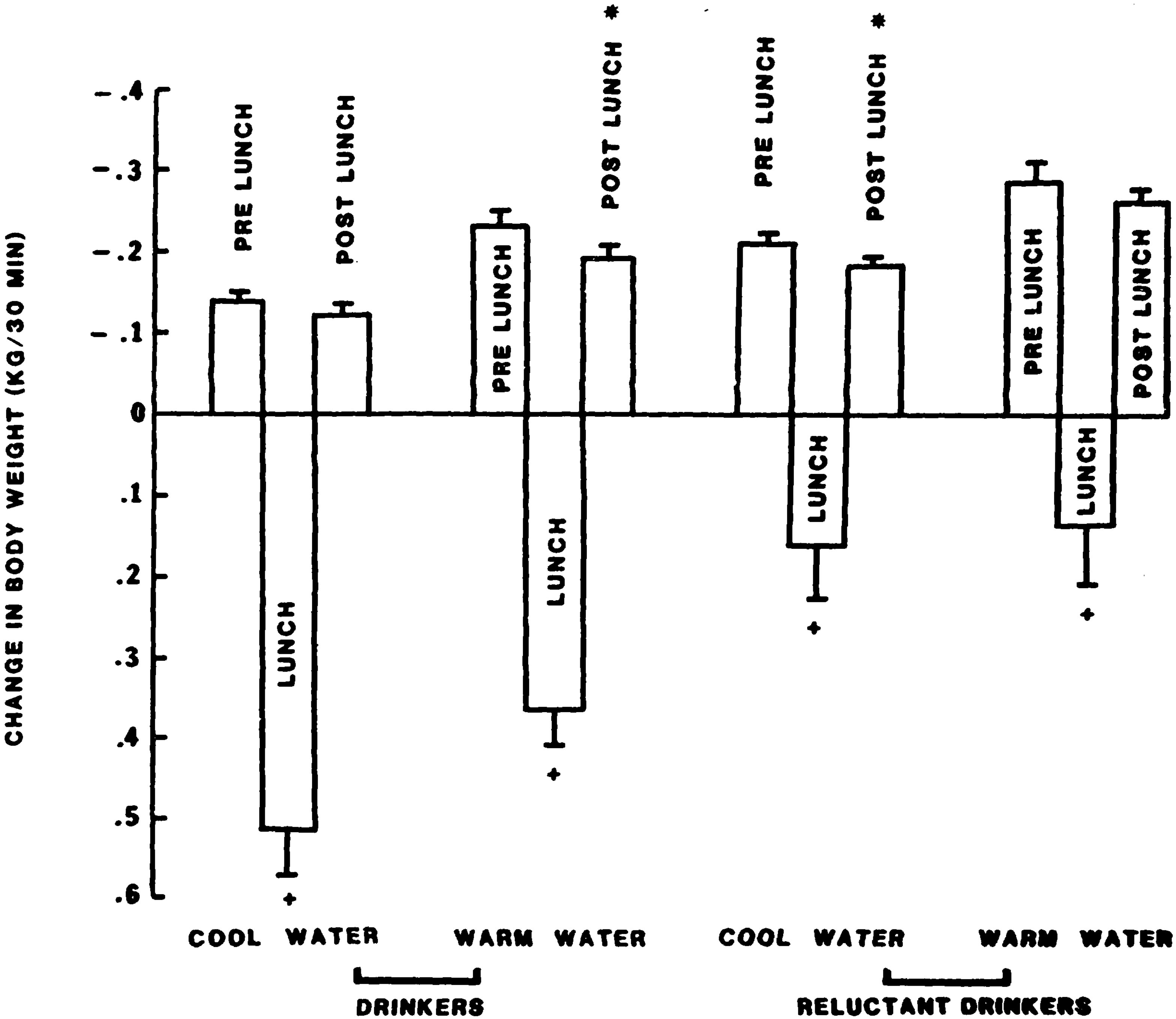

FLUID INTAKE RATE (L/30 MIN)
0.0
.1
.2
.3
.4
.5
0
PRE-LUNCH
LUNCH
POST-LUNCH
PRE-LUNCH
LUNCH
POST-LUNCH
PRE-LUNCH
LUNCH
POST-LUNCH
PRE-LUNCH
LUNCH
POST-LUNCH
COOL WATER
WARM WATER
COOL WATER
WARM WATER
DRINKERS
RELUCTANT DRINKERS

Figure 4



CHANGE IN BODY WEIGHT (KG/30 MIN)
-.4
-.3
-.2
-.1
0
.1
.2
.3
.4
.5
.6
PRE LUNCH
LUNCH
POST LUNCH
*
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COOL WATER
WARM WATER
DRINKERS
RELUCTANT DRINKERS