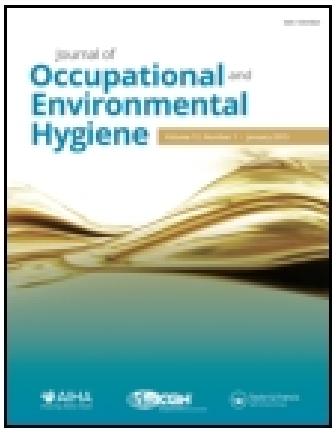

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Loss of Heat Acclimation and Time to Re-establish Acclimation

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Acclimation in a hot environment is one potent means to decrease the heat strain of work in a hot environment. However, with diminished heat exposure, positive adaptations of acclimation may be lost. This rate of loss is equivocal and, once established, could be used to prescribe the time for re-acclimation. The purpose of this study was to determine the rate of loss of heat acclimation over a period of 6 weeks and determine the time needed for re-acclimation after 2 weeks and 4 weeks of de-acclimation in ten healthy participants. All participants first underwent an initial acclimation period (a 3-day plateau in T_{re} was used to signify acclimation). Based on the mean time to acclimate in Phase 1 (mean time to acclimate = 6.1±1.4 days), the loss of acclimation was mapped and participants were randomly assigned to one of two groups: one that underwent one 2-hr heat exposure at 1, 3, and 5 weeks post-acclimation, and one that underwent one 2-hr heat exposure session at 2,4, and 6 weeks. Complete loss of acclimation occurred in 6 weeks and, as expected, work HR and T_{re} increased with increasing time away from the heat ($p<0.05$). Based on the time for total loss of acclimation from Phase 1, participants in Phase 2 ($n = 8$) first underwent acclimation. Then, after either a 2-week or 4-week absence from the heat, participants returned to the laboratory for re-acclimation. While not statistically significant yet practically significant ($p = 0.18$; one-tailed confidence interval), average days for re-acclimation in the 2-week group tended to be fewer than in the 4-week group (days for re-acclimation = 3.8 ± 1.2 and 5.3 ± 1.9, respectively). Based on these general trends, for occupational settings, a re-acclimation period of 4 days is recommended after 2 weeks absence from the heat, 5 days for 4 weeks absence from the heat, and complete acclimation (6 days) after 6 weeks absence or more from the heat.

Keywords acclimation, decay, heat, re-acclimation

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INTRODUCTION

Acclimation, by exposing workers to work in a hot environment for at least 2 hours over sequential days, can have a major influence on reducing occupational heat strain. The National Institute for Occupational Safety and Health (NIOSH) criteria document for occupational exposure to heat [(1)] notes that heat acclimation occurs with increased heat exposure over about 7–14 days. New workers should acclimate with a schedule starting with 20% of a normal exposure (work day) on day one, with a 20% increase in exposure over time the following days. NIOSH [(1)] further recommends that workers with previous work experience in the heat should begin with 50% of anticipated heat exposure time on day one, 60% on day two, 80% on day three, and 100% on day four in recognition of the increased work capacity that acclimation confers. Goldman suggested that acclimation was not linear, but asymptotic with most of the benefits of acclimation occurring early (within 3 to4 days), and full acclimation accruing in about a week [(2)].

Complete acclimation is demonstrated by physiological adaptations in HR and T_{re} and is generally believed to occur after 7 to 10 days with 75% of the adaptations evident from approximately 4 to 6 days of exposure to heat. [(3)] Cardiovascular adaptations of reductions in work-related HR occur relatively rapidly and begin in the first few days of acclimation.[(3–5)]The major cardiovascular adjustments of acclimation are an increase in plasma volume and stroke volume and a resultant decrease in HR for a given work rate which can reduce cardiovascular strain and enable greater convective heat transfer. [(4)] An acclimation period of 6 to 7 days results in an intermediate plateau in work HR[(6,7)] for a fixed workload, with a greater decrease in HR seen with a longer duration of the acclimation process.[(8,9)] In contrast, Weller et al.[(10)] found no further reductions in HR after 5 to 7 days of acclimation in recreationally active men. However, the study by Gill, Phed, and Sleivert used small sample sizes[(8)] and the results of Givoni and Goldman are based on prediction equations. [(9)]

Because HR is influenced by work demands, thermal load, and other factors, core temperature is also used as an indicator of heat strain. With work in the heat, core temperature rises. Under compensable heat stress conditions, core temperature eventually plateaus signaling a new steady state. This plateau in core temperature and new lower steady state core temperature for a given environment and work rate has been suggested as

the major criterion used for complete acclimation.[11,12] Results by Weller et al. [10] and Garrett et al.[5] suggest reductions of 0.4 and 0.3°C in core temperature for a given work rate and environment are evident after approximately 5 days of acclimation under controlled hyperthermia (T_{re} = 38.5°C) in both hot-dry and warm humid-conditions.

Once acclimation is achieved, absence from work in hot environments will result in a gradual loss of the favorable physiological adjustments of acclimation. Early studies evaluating the loss of heat acclimation found equivocal results due to incomplete acclimation, differing modes of acclimation, limited time evaluating the loss of acclimation, or brief re-acclimation periods. [13–15] There are several better-controlled studies that have examined the question of loss of heat acclimation. Pandolf et al. [7] found no significant loss of acclimation after 3, 6, 12, and 18 days in 24 fit soldiers. Weller et al. [10] found no loss in T_{re} response to a constant work rate in the heat after 12 or 26 days away from the heat in 16 fit men but noted increased HR (7 bpm) in both groups.

In contrast, Williams et al. [12] examined the loss of acclimation in 60 South African mine laborers for periods of 1, 2, and 3 weeks and determined that the physiological adaptations in HR vanished after 3 weeks of no heat exposure and adaptations of reduced rectal temperature incurred a 50% loss after 3 weeks. Stephens and Hoag [16] observed a loss of 45% in HR adaptations after 4 days absence from the heat and a 68% loss after 8 days away from the heat in six women. The adaptation in core temperature showed a greater rate of loss of 66% after 4 days absence from the heat and a loss of 77% after 8 days of absence.

These results differ from those of Garrett et al. [5] which suggest that the first adaptations to heat acclimation to occur (decreased HR) are also the first to be lost. The rate of loss of heat acclimation provided by Stephens and Hoag [16] was faster than that suggested by Williams et al. [12] The reason for the discrepancy may have been the difference in fitness of the participants. Physical fitness and heat acclimation confer similar physiological adaptations (increased sweat rate, decreased threshold for onset of sweating, increased plasma volume, increased stroke volume, and resultant decreased HR and decreased core temperature and skin temperature for a given thermal load) with a shorter acclimation period and greater retention of acclimation in fit participants. [2,3,7,17] Because they were soldiers, the men in the studies by Pandolf and colleagues [7] and Williams and colleagues [12] were likely more accustomed to performing physical activity conferring a greater degree of physical fitness than the small group of six women reported by Stephens and Hoag. [16]

Givoni and Goldman [9] suggested that the rate of loss of heat acclimation is approximately 1 day for each 2 days away from work in the heat. Based on the Occupational Safety and Health Administration's (OSHA's) judgment, there is a complete loss of acclimation in two weeks and OSHA recommends a 5-day re-acclimation period. [18] However in the study of Weller et al., [10] at 12 days post-acclimation, participants re-acclimated in 2 days, and at 26 days after acclimation, participants re-acclimated in 4 days. For their fit participants, the apparent loss was about 1 day of re-acclimation needed for 6 days away from work in the heat.

Due to the lack of studies of participants more similar to industrial workers and the equivocal results of previous studies on loss of acclimation and time for re-acclimation, the primary purpose of this study was to establish the time necessary to re-establish acclimation in participants representative of the occupational population. The rate of loss of acclimation was also examined.

METHODS

General Methods

Participants

The study protocol was approved by the local Institutional Review Board. Participants were recruited via word of mouth. Prior to testing, participants provided written informed consent, and were examined by a licensed physician and approved for participation.

All participants underwent a test of maximal aerobic capacity on a treadmill using the Bruce protocol. [19] During the test, HR was monitored continuously and recorded every minute. Expired gases were collected continuously and were analyzed for a plateau in oxygen consumption in two consecutive stages of the Bruce protocol. Leveling off of oxygen consumption despite an increase in intensity was taken as evidence that the participant reached his or her maximal oxygen consumption. Heart rate within 10 bpm of the age-predicted maximal heart rate as well as rating of perceived exertion of 19 or 20 on the Borg 6–20 point scale were also used as evidence of achieving $VO_{2\,max}$. Because most participants (80%) were not able to achieve the goal of a plateau in oxygen consumption despite an increase in workload, $VO_{2\,peak}$ was used to indicate aerobic capacity.

Equipment

Experiments were conducted in an environmental chamber. Work was performed on a motorized treadmill and the speed and grade were adjusted to control the metabolic rate. Heart rate (HR) was monitored using a HR monitor (Polar Electro Inc., Lake Success, NY). Rectal temperature (T_{re}) was measured using a flexible thermistor (401, Yellow Springs Instruments, Yellow Springs, OH) inserted 10 cm beyond the anal sphincter muscle. Assessment of oxygen consumption was used to establish metabolic rate using open circuit spirometry (Vacumed Vista Mini-CPX Metabolic Measurement System, Vacumed, Ventura, CA).

Trial Protocols

To simulate industrial situations, each participant underwent an acclimation period of up to 10 consecutive days (excluding weekends) by walking on a motorized treadmill in the climatic chamber. Environmental conditions of the chamber

were set at 50°C and 20% rh (WBGT = 35°C). The treadmill speed and grade were set to elicit a moderate metabolic rate of approximately 40% VO_{2peak}. Treadmill speed and grade for the workload were established and confirmed during the first 2 days of acclimation.

During each acclimation trial, metabolic rate was assessed at 30, 60, and 90 min in each trial to confirm metabolic rate. HR and rectal temperature (T_{re}) were monitored continuously throughout the trial and recorded every five min. Each experimental trial lasted approximately 120 min unless one of the termination criteria was met: T_{re} equal to 39.0° C, sustained HR greater than 90% of the maximum HR, or participant wished to stop. In accordance with industrial practice, during the acclimation trials, participants were provided water or an electrolyte-replacement beverage and were encouraged to drink freely. During the trials, participants wore shorts, a t-shirt (and/or a sports bra for women), socks and athletic shoes.

A plateau in average T_{re} over the last 30 min (change of no more than 0.1° over 30 min) of the trial on 3 consecutive days was used as the criterion for complete acclimation. [12,16,20] Full acclimation was considered to be the earliest day of the 3-day plateau. Experimental trials for each participant were at the same time of day.

The loss of acclimation (Phase 1) was assessed after the acclimation process described previously. Then, the time for re-acclimation (Phase 2) after absence from the heat following the acclimation process described previously was assessed.

Phase 1: Loss of Acclimation

Thirteen participants began the experimental protocol, but due to participant attrition, ten healthy adults (five men and five women) completed the experimental trials in this phase. Pre-acclimation heat exposure status of the participants is not known. Because the trials took place in Florida, it can be assumed that the participants had at least some exposure to the heat. Three participants were lost due to noncompliance with the experimental protocol. After the initial acclimation period, participants were asked to refrain from strenuous physical activity in the heat for the prescribed period. To estimate the time of complete loss of acclimation, a hierarchical linear model using restricted maximum likelihood estimation was used. First, the time it took participants to become acclimated in Phase 1 was considered (mean = 6.1 ± 1.4 days). Using the mean days to acclimate and the estimates of the coefficients for T_{re} from the hierarchical linear model, it was estimated that on average complete loss of acclimation occurs in approximately 42.5 days (6 weeks).

Participants were randomly assigned to one of two loss-of-acclimation groups. Participants in Group O (odd) underwent one 2-hr heat exposure at 1, 3, and 5 weeks post-acclimation to evaluate decay of acclimation. Group E (even) underwent one 2-hr heat exposure session at 2, 4, and 6 weeks post-acclimation. Two weeks between heat exposures was selected to minimize re-induction of acclimation during the assessment of the loss of acclimation. This design allowed identification of the loss of acclimation with an accuracy of 1 week.

The average and standard deviation of participant physical characteristics by group are presented in Table I. There were no significant differences between groups. Three participants withdrew from the study due to non-compliance after assignment to Group E.

Phase 2: Time for Re-acclimation

Twelve participants began the experimental protocol, but due to participant attrition, eight healthy adults (five women and three men) completed the trials. Pre-acclimation heat exposure status of the participants is not known. Because the trials took place in Florida, it can be assumed that the participants had at least some exposure to the heat. Again, participants withdrew due to non-compliance (not refraining from activity in the heat) and loss of interest. After the acclimation period, participants were randomly assigned to one of two re-acclimation groups based on the estimated complete loss of acclimation developed in Phase 1. Group 2wk was asked to refrain from physical activity in the heat for 2 weeks before returning to the heat stress laboratory for the re-acclimation process following the same protocol as that used for initial acclimation. Group 4wk was asked to refrain from physical activity in the heat for 4 weeks. Following the same criteria for acclimation as before, a 3-day plateau in mean T_{re} over the last 30 min of the trial was used as the criterion for complete acclimation. [12,16,20] The measurement of days-to-acclimate was again the earliest day of the 3-day plateau in T_{re}.

The average and standard deviation of participant physical characteristics by group are provided in Table II. There were no significant between-group differences ($p > 0.05$).

Data Analyses

Differences in Phase 1 and Phase 2 group participant characteristics were examined via analysis of variance (ANOVA) procedures. A repeated measures ANOVA was used to evaluate potential changes in tolerance time, ending HR and ending T_{re} with acclimation.

The expected trends for the loss of acclimation were based on the total time for acclimation and were analyzed using a hierarchical linear model using restricted maximum likelihood estimation. Repeated measures ANOVA was also used to analyze the differences in tolerance time, ending HR and T_{re} in Phase 1 to examine the loss of acclimation as well as in Phase 2 to examine the time for re-acclimation. Statistical significance was set at $p < 0.05$.

RESULTS

Mean acclimation data by phase and by group for each phase are presented in Table III. In approximately 70% of the trials, the first day of acclimation was stopped due to participant fatigue. The duration for the remaining trials (30%) was 120 min. As evidenced in Tables III and IV, ending T_{re} dropped as expected during the acclimation phase and rose as expected during the decay phase.

TABLE I. Demographic Data for Loss of Acclimation (Phase 1) by Gender and by Group[A]

Participants	Age	Ht (m)	Wt (kg)	BSA (m^2)	Peak VO_2 (ml/kg/min)	Days to Acclimate
Group O (n = 7)	31.3 ± 9.8	1.7 ± 0.1	86 ± 21	2.0 ± 0.3	32.4 ± 7.4	6.1 ± 1.3
Group E (n = 3)	30 ± 3.5	1.7 ± 0.1	61 ± 7	1.7 ± 0.1	37.5 ± 2.7	6.0 ± 1.7
Total (n = 10)	30.9 ± 8.2	1.7 ± 0.1	79 ± 22	1.9 ± 0.3	33.9 ± 6.7	6.1 ± 1.4

Note: mean ± standard deviation

[A] Group O (odd weeks group returned for one heat exposure at 1,3, and 5 weeks post-acclimation); Group E (even weeks group returned for one heat exposure at 2,4, and 6 weeks post-acclimation)

Loss of Acclimation

Although there was variability among individuals, there was a significant increase in tolerance time and a general tendency for a decrease in HR with acclimation. Decay of acclimation data is shown in Table IV. For each group (O and E) separately, there was a general trend for ending HR and $T_{re,}$ to be higher and work tolerance time to be shorter with increasing time away from the heat.

Time for Re-acclimation

Re-acclimation data by group are presented in Table V. HR for the 2-week group was significantly greater than the 4-week group for all re-acclimation trials ($p < 0.05$). The average days for re-acclimation (n = 3.8 and 5.3 for the 2-week and 4-week groups, respectively) were less than the 6.4 days for acclimation ($p < 0.05$). There were no significant differences ($p > 0.05$) in days for re-acclimation between the groups returning for re-acclimation at 2 weeks and those returning at 4 weeks ($p = 0.18$; one-tailed confidence interval). However, average days for re-acclimation were lower for the 2-week re-acclimation group. In addition, Cohen's d = 1.3, suggesting a large effect size and thus a high level of practical significance in days for re-acclimation between the groups.

DISCUSSION

The mean and range of peak VO_2s were 31.6 and 22.4 to 43.3 ml kg^{-1} min^{-1}, respectively. Aerobic capacities of industrial men and women vary from 25 to 46.6 ml kg^{-1} min^{-1}.[21–23] In this regard, the sample in the current study was an appropriate representation of the industrial worker population.

The present study assessed the amount of time to acclimate to hot-dry conditions among 18 participants (ten in Phase 1 and eight in Phase 2) of aerobic fitness representative of a working population. Acclimation occurred in approximately 6 days of exposure to hot-dry conditions (mean for both phases = 6.3±1.3 days). The observed acclimation time requirement was based on a convenience sample and there was no attempt to control prior heat stress exposures to assure that the participants were fully unacclimated to heat. Because this study took place in Florida (Phase 1 took place between February and August and Phase 2 took place November through May), it is unlikely that participants were not at least somewhat acclimated, similar to some industrial situations. Nonetheless, the 6-day acclimation period in the present study was in the range of previous reports of 5 to 10 days. [1,5,8,10,16,18,24]

Because acclimation is attenuated if work in the heat is discontinued, the rate of loss is important. Present results regarding loss of acclimation, based on data from 10 participants (Phase 1), suggest that complete loss of acclimation occurred around 6 weeks absence from work in the heat. As expected, with increasing time away from the heat, both HR and T_{re} increased during the heat-exposure trials for each group for a fixed work rate and environment. Although not significantly different, the participants in Group E (even-week group) had systematically higher T_{re}s and HRs than those in Group O (odd-week group). This might be attributed to the small sample size of Group E due to participant attrition (n = 1-3) and/or a systematic difference in participants between groups. For a fit population of men, Weller et al. [10] did not find a significant decay in T_{re} and only minimal loss (5%) in HR with 18 and 26 days away from the heat after a 10-day acclimation period. Also, Garrett et al. [5] observed no loss in short-term (5 days)

TABLE II. Demographic Data for Re-acclimation Data (Phase 2) by Gender and by Re-Acclimation Group

Participants	Age	Ht (m)	Wt (kg)	BSA (m^2)	Peak VO_2 (ml/kg/min)	Days to Acclimate
Group 2[A] wk (n = 4)	26.2 ± 6.6	1.6 ± 0.1	74 ± 25	1.8 ± 0.3	27.9 ± 4.7	6.5 ± 1.5
Group 4[A] wk (n = 4)	31.8 ± 10.4	1.8 ± 0.1	86 ± 13	2.0 ± 0.2	31.0 ± 8.1	6.3 ± 1.3
Total (n = 8)	28.4 ± 8.2	1.7 ± 0.1	79 ± 21	1.9 ± 0.3	29.2 ± 6.02	6.4 ± 1.3

Note: mean ± standard deviation

[A] Group 2 week underwent re-acclimation after 2 weeks away from the heat. Group 4 week underwent re-acclimation after 4 weeks away from the heat.

TABLE III. Beginning of Acclimation and Attainment of Acclimation

Participants	Acclimation day 1 Tolerance Time (min)	Acclimation day 1 End HR (bpm)	% MHR	Acclimation day 1 End Tre [°C]	Days to Acclimate	End of Acclimation Tolerance Time (min)	End of Acclimation Mean HR (bpm)	% MHR	End of Acclimation Mean Tre [°C]
Phase 1:									
Group O (n = 7)	102.1 ± 23.2	151 ± 15.0	83	38.1 ± 0.3	6.1 ± 1.3	114.7 ± 14.0	141 ± 15.9	77	38.1 ± 0.3
Group E (n = 3)	81.7 ± 33.3	161 ± 30.6	83	38.5 ± 0.2	6.0 ± 1.7	116.7 ± 5.8	149 ± 25.5	77	38.3 ± 0.3
Total Phase 1 (n = 10)	96 ± 26.5[A]	154 ± 19.6	83	38.2 ± 0.3	6.1 ± 1.4	115.3 ± 11.8[A]	144 ± 18.1	77	38.2 ± 0.3
Phase 2:									
Group 2wk (n = 4)	85 ± 15.8	165 ± 14.2	85	38.7 ± 0.4	6.5 ± 1.5	120.0	139 ± 13.7	72	38.3 ± 0.2
Group 4wk (n = 4)	91.3 ± 19.3	152 ± 12.8	80	38.6 ± 0.3	6.3 ± 1.3	120.0	136 ± 7.1	72	38.3 ± 0.3
Total Phase 2 (n = 8)	88.13 ± 16.7[A]	159 ± 14.4[A]	83	38.6 ± 0.3[A,B]	6.4 ± 1.3	120.0[A]	138 ± 10.2[A]	72	38.3 ± 0.2[A]
Total all groups (n = 18)	92.5 ± 22.45	156 ± 17.2	83	38.4 ± 0.4	6.3 ± 1.3	117.4 ± 8.9	141 ± 15.1	75	38.2 ± 0.3

Notes: mean ± standard deviation; Acclimation = a 3-day plateau in mean T_{re} over the last 30 min of the trial [12,16,20]

[A] Significantly different between beginning and ending of acclimation, $p < 0.05$.

[B] Significantly different between Phase 1 and Phase 2, $p < 0.05$.

TABLE IV. Loss of Acclimation

Loss Trial (weeks)	Tolerance Time [min]	No. of Trials lasting 120 min	Ending HR [bpm]	Ending T_{re}, [°C]
1 week (n = 6)	113 ± 18	5	141 ± 26	38.0 ± 0.2
2 weeks (n = 3)	105 ± 13	1	149 ± 27	38.0 ± 0.6
3 weeks (n = 7)	116 ± 11	6	150 ± 24	38.1 ± 0.4
4 weeks (n = 2)	120 ± 0	2	149 ± 25	38.4 ± 0.3
5 weeks (n = 6)	103 ± 36	4	145 ± 21	38.1 ± 0.3
6 weeks (n = 2)	68 ± 32	0	172 ± 1	38.4 ± 1.0

Note: mean ± standard deviation

heat acclimation after 1 week away from the heat but did observe a loss of acclimation 2 or 3 weeks away from the heat.

Based on the loss of acclimation in Phase 1, the time for re-acclimation was examined after 2 weeks and 4 weeks away from the heat. Participants who returned for re-acclimation at 2 weeks had consistently higher HRs than those who underwent re-acclimation at 4 weeks. HR for both beginning of acclimation and end of acclimation as well as beginning and end of re-acclimation were higher in the 2-week group than the 4-week group. This suggested a systematically greater heat tolerance for the 4-week group. As expected, after 2 weeks and 4 weeks away from the heat, both groups lost some degree of acclimation as evidenced by an increased tolerance time and reduced HR at the end of re-acclimation vs. the first day of re-acclimation. There was a shorter time for re-acclimation in the group that was away from the heat for 2 weeks versus that unexposed to the heat for 4 weeks (3.8 and 5.3 days, respectively). Although not statistically significant, the results are practically significant and suggest a re-acclimation period of 4 days is sufficient after 2 weeks away from the heat, re-acclimation of 5 days for 4 weeks away from the heat, and complete re-acclimation (6 days) necessary after 6 weeks away from the heat. These data suggest a general trend for most of the loss of acclimation occurring in the first 2 weeks of absence from the heat and requiring a longer re-acclimation period relative to absence from heat. This was in agreement with the results of Williams et al. [12] who recommend a re-acclimation period of 1 day for each week away from the heat. The fit participants of Pandolf et al. [7] experienced a faster re-acclimation (2 days after an 18-day decay period) (max VO2 = 49.5 ± 1.2 ml.kg.min). Weller and colleagues [10] found 2 days and 4 days sufficient to re-acclimate their fit participants after 12 and 26 days away from the heat (max VO2 = 51.3 ± 6.4 and 52.5 ± 3.9 ml.kg.min, respectively). Fit participants typical of the Pandolf et al [7] and Weller et al. [10] studies generally required a shorter acclimation period and experienced an attenuated loss of acclimation, thus explaining the longer acclimation period required for participants in the current study.

The results of this study should be generalized with caution. This study did not control for acclimation status of participants prior to beginning the trials because in industrial settings, workers begin with different levels of acclimation as well. As such, some participants were likely more acclimated than others at study enrollment. The participants were asked to refrain from physical activity in the heat between heat

TABLE V. Re-acclimation Data by Group

		Beginning of Re-Acclimation			Days to Acclimate	End of Re-acclimation		
Group	Tolerance Time [min]	No of Trials Lasting 120 min	HR^A [bpm]	T_{re} [°C]		Tolerance Time [min]^B	$HR^{A\,B}$ [bpm]	T_{re} [°C]
2wk (n = 4)	85 ± 21	0	172 ± 15	38.6 ± 0.3	3.8 ± 1.2	120 ± 0	141 ± 11	38.0 ± 0.1
4wk (n = 4)	108 ± 18	2	137 ± 4	37.7 ± 1.3	5.3 ± 1.9	120 ± 0	119 ± 1	38.1 ± 0.4
All participants (n = 8)	93 ± 22		160 ± 22	38.3 ± 0.8	4.4 ± 1.6	120 ± 0	134 ± 14	38.1 ± 0.2

Note: mean ± standard deviation

[A] Significant difference between groups, $p < 0.05$

[B] Significant difference between beginning and end of re-acclimation

exposures. However, it is unknown if all participants actually did refrain from physical activity in the heat between experimental trials. As many of the participants were students, normal daily activities included riding their bikes or walking. These periodic incidental exposures to heat stress should not have been enough to induce acclimation, but may have been enough to slow the loss of acclimation.

CONCLUSION

In summary, acclimation to heat in participants with below-average to average fitness required about 6 days, using a plateau in increased T_{re} for a fixed environment and workload as the criterion for acclimation. With time away from the heat, full acclimation was lost over a period of 6 weeks. For periods less than 6 weeks, a shorter time for re-acclimation is appropriate. Based on the general trends observed in the present study, prudent periods for industrial workers would be 2 days of re-acclimation for 1 week away, 4 days for 2 weeks, 5 days for 4 weeks, and 6 days for 6 or more weeks.

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