

PERCEIVED EXERTION DURING EXERCISE IN THE HEAT, COLD OR AT HIGH ALTITUDE

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INTRODUCTION

Since the early 1970s, over 40 full-length reports have been published concerning rated perceived exertion (RPE) during exercise at the environmental extremes of heat, cold or high altitude. More is known about RPE during exercise in the heat than exercise in the cold or at high altitude. The purpose of this paper is to briefly review the key findings from the published literature concerning RPE during exercise at each of the three environmental extremes.

METHODS

All of the reports presently discussed evaluated RPE using the original Borg scale (1). This is a category rating scale from 6 to 20 with every odd number anchored by verbal expressions ranging from "very, very light" at 7 to "very, very hard" at 19. In addition, several of these reports involving heat or cold also studied thermal sensation (TS) using category rating scales (2,3,4).

RESULTS AND DISCUSSION

Exercise-Heat Stress. Table 1 summarizes the findings from previous reports investigating the "plateau day(s)" for heart rate (HR), plasma volume expansion, rectal temperature (T_{re}), RPE and sweat rate during exercise-heat acclimation (modified from 5). During heat acclimation of young individuals, the plateau day(s) for overall RPE are generally after 3 to 6 days of continuous daily heat exposure (2,5). This coincides with the plateau day(s) during heat acclimation reported for HR and plasma volume expansion and overlaps with the

TABLE 1. PLATEAU DAYS (POINT AT WHICH APPROXIMATELY 95% OF THE ADAPTATION OCCURS) DURING HEAT ACCLIMATION

ADAPTATION	DAYS OF HEAT ACCLIMATION													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Heart Rate Decrease														
Plasma Volume Expansion														
Rectal Temperature Decrease														
Perceived Exertion Decrease														
Sweat Rate Increase														

plateau day(s) for T_{re} . Except for HR, none of these physiological adaptations are thought to strongly influence overall WE. Although the absolute and relative exercise intensity may provide important sensory cues to overall WE in certain situations, both do not appear to be major influences during heat acclimation (2,3). Changes in **TS** during exercise-heat acclimation parallel those seen for overall RPE (2). The change with acclimation in **TS** may be related to the significant decrease in skin temperature (T_{sk}) because moderate to high correlations ($r = 0.42$ to 0.71) exist between these two variables (2,3). Overall, these findings suggest a perceptual as well as physiological acclimation occurs during continuous daily exercise-heat exposure (2,3,5). These conclusions for RPE seem to be valid for both hot-dry and hot-wet environments involving exercise intensities ranging from 30 to 70% $\dot{V}O_{2max}$ (2,5,6).

In contrast to continuous daily acclimation (10 consecutive days) where a plateau in WE occurs after 5 days, RPE for intermittent exercise-heat acclimation (10 sessions over 3 weeks) shows no significant change nor indication of a plateau (6). The rate of acclimation is also faster in terms of the reductions in T_{re} and HR for daily, compared to intermittent, acclimation. Thus, daily compared to intermittent exercise-heat acclimation is the more effective acclimation strategy for improvements in RPE, T_{re} and HR (6).

Exercise-Cold Stress. At the same relative exercise intensity ($\sim 70\% \dot{V}O_{2max}$), overall RPE appears to be higher in the heat (31°C) than in the cold (4°C and 11°C, see Figure 1). RPE increases with time for all environments and is significantly higher at 31°C compared to 4°C and 11°C from 20 through 50 min of exercise (7).

At low and high exercise intensities in cool or cold water (4), overall RPE is moderately correlated with HR ($r = 0.68$) and pulmonary ventilation ($r = 0.61$),

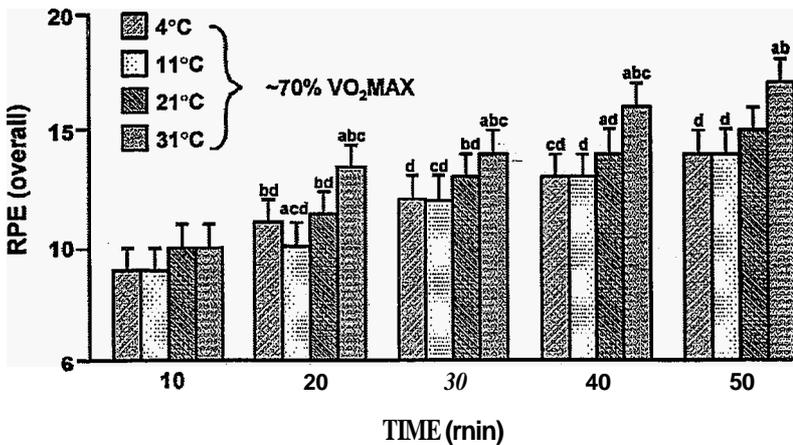


Figure 1. Overall RPE during 50 min of exercise in 4 different environmental conditions, Values are the mean and SEM. $P < 0.05$ for a, b, c, d corresponds to 4°C, 11°C, 21°C and 31°C, respectively (redrawn from 7)

whereas very slight relationships are observed with T_{re} and T_{sk} ($r = 0.20$ and $r = 0.10$). TS is moderately correlated with T_{sk} and T_{re} ($r = 0.64$ and 0.73), but low correlations exist between TS and both HR ($r = 0.32$) and ventilation ($r = -0.12$). The changes in oxygen uptake attributed to shivering during exercise in cool and cold water do not appear to add to the overall RPE (4).

Exercise-High Altitude. The effects of hypoxia combined with exercise seem to have a greater influence on the overall RPE than those related to exercise and normoxia, whether in a thermoneutral or cold environment (8, see Table 2). This same study also suggests a possible relationship between overall RPE and blood lactate concentration during exercise in hypoxic and normoxic conditions.

TABLE 2. MEAN BLOOD LACTATE(mg/100ml) AND RPE FOR NORMOXIA VS. HYPOXIA AND THERMONEUTRAL VS. COLD

	<u>Normoxia</u>	<u>Hypoxia</u>	<u>Thermoneutral</u>	<u>Cold</u>
Blood Lactate	22.3 ± 10.2	58.9 ± 12.3	42.3 ± 11.8	38.9 ± 8.9
P Value	<0.001		NS	
Perceived Exertion	11.5 ± 1.0	15 ± 2.0	13.5 ± 1.5	13 ± 1.5
P Value	<0.001		NS	

VALUES ARE MEANS ± SD. BLOOD LACTATE AND RPE DURING EXERCISE ARE BOTH HIGHER FOR HYPOXIA (NEUTRAL OR COLD) THAN FOR NORMOXIA. HYPOXIA = 12% O₂ in N₂; NORMOXIA = room air; THERMONEUTRAL = 25°C ; COLD = 8°C ; EXERCISE = 50% HR reserve.

Differentiated RPE have been investigated during exercise at high altitude and include a local muscular rating, a central or cardiopulmonary rating and an overall rating (9,10). During acute exposure (< 2 h) to high altitude (4300 m), the local RPE seems to be the dominant rating (9). However, the reduced blood lactate concentration during exercise after 18 days of altitude acclimation appears related to a lowered local RPE with the central RPE now becoming the dominant rating (9). Further, central RPE is reported to be highly correlated ($r = 0.88$) with Acute Mountain Sickness symptoms in low-altitude natives (10).

CONCLUSION

While much is known about the RPE adaptations during exercise in the heat, more research is needed to fully understand the RPE adaptations during exercise in the cold and at high altitude.

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