PERI-NATAL ENVIRONMENT AND PHYSIOLOGICAL RESPONSE TO WORK IN ENCAPSULATING PROTECTIVE CLOTHING IN MILD AND HOT TEMPERATURES

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INTRODUCTION

Plasticity of human physiology is such that there is still much adaptability even after birth. For example, it is believed that nutrient intake in the first months after birth may have life-long impact on adipocyte numbers, which in contrast, is believed to be fixed in adulthood (1). Likewise brain plasticity after birth is widely accepted (2). Humans, even of similar size, body composition and physical fitness, evidence a wide variability of physiological response to work in the same environmental conditions (3,4). It is possible that this variability in heat tolerance could be explained in part by knowing the ambient environmental conditions immediately after birth, considering possible environmental controls such as air conditioning. It was hypothesized that physiological adaptations to the environment shortly after birth might affect tolerance to work in protective clothing (PC) in hot environments as an adult.

METHODS

Healthy males (n=26) wearing Saranex 23P protective clothing, worked continuously at 177 W/m^2 (300 Kcal/hour, VO_2 of 1 L/min) by walking for 15 min at 1.34 m/sec (3 mph) followed by 5 min of arm curls with 14.6 kg of weight, in WBGT's of 18 (T_{db}=21, T_{wb}=17) and 26°C (T_{db}=31, T_{wb}=23, T_{bg}=34), until rectal temperature (Tre), or heart rate (HR), reached a priori limits (38°C or within 10 beats of measured maximal HR) or they were unable to continue. Rectal temperature was monitored with a computer data system, and heart rate with a watch-type heart rate monitor. After removing the upper part of the PC, subjects recovered in the same environment and then repeated work until they were unable/unwilling to continue or 8 hours total experiment time elapsed. Data for the first bout of work (i.e. until a terminating criterion was reached) and the total work time were examined in separate analyses.

Birth environment data were collected via questionnaire. Birth history information was made quantitative by utilizing the following procedures. Subjects were given a score of 1- if they were born in northern climates such as Canada, MN, WI, ME, MT, ND, NH, VT, England, or 2- if born in moderate clime (middle tier states: NC, VA, WV, CA), Northern India, or 3- if born in South: TX, GA, AL, FL, HI, TN, SC, MS, LS, AR, AZ, NM, or Southern India. Subjects were scored 3 for no air conditioning and 1 if it was present. Subjects were scored based on birth month, with June through Aug scored as 3, April or May or Sept or Oct scored as 2; and all others scored as 1 (all participants were from the northern hemisphere). A composite score was derived by multiplying together the three other measures yielding a possible score of 27. Since this was an exploratory study without precedent, scores were arbitrarily assigned such that the highest individual and composite scores were attained for those with the highest theoretical potential for heat exposure at birth.

RESULTS

Twenty-six subjects provided complete data. Subject's mean (± standard deviation) characteristics were: age of 24 years (±4.5), height of 180 (±7) cm; weight of 76 (±11) Kg, and maximal oxygen uptake of 49 (±8) ml/kg/min. Of these, 23% reported birth in a northern climate, 19% in a middle climate and 58% in a southern climate. Availability of air conditioning was reported by 73% of the subjects. Birth month was June through August for 31% of the subjects and April, May or September, October for another 31%. When these three independent measures were multiplied, 8% scored 1 or 2, 23% scored 3, 46% scored 6, and 23% scored 9.

The mean duration of the first walk time (i.e. until a subject reached a stop criterion) at WBGT=18°C was 61 min and mean total work time was 241 (±61) min. At 26°C WBGT, the mean first walk duration was 40 min and total walk time was 118 (±47) min.

Correlations between birth history scores and physiological responses were only significant ($P<.10$) for correlations between birth location and change in mTsk ($r=.36$), and presence of air conditioning and change in Tre ($r=-.36$) and change in mTsk ($r=-.44$) . Predictions of first bout (until initial stopping criterion reached), and total walk time from the independent variables are shown in Table 1.

CONCLUSIONS

In previous work (Bishop et al., paper in this publication) we examined the prediction of work tolerance in the same work and environmental paradigm using physiological responses obtained from a brief bout of work in PC. In that study we were only able to predict with an R^2 of 24% or less. It appears we can account for, in some cases, more variance simply by having subjects report their peri-natal history.

Table 1. Equations predicting first cycle and total work time form peri-natal birth history at two WBGT's, n=26.

WBGT = 18 Work rate = 177 W/m^2

First Cycle work time prediction

Variable	Beta	R^2 (adj)	CV
Location	-24		
A/C	-19		
Month	-24		
Combination	10		
Intercept	137	11 (-6)	39

Total work time prediction

Variable	Beta	R^2 (adj)	CV
Location	-108		
A/C	-132		
Month	-128		
Combination	48		
Intercept	674	32 (19)	23

WBGT = 26 Work rate = 177 W/m^2

First Cycle work time prediction

Variable	Beta	R^2 (adj)	CV
Location	-19		
A/C	-24		
Month	-23		
Combination	9		
Intercept	116	32 (20)	38

Total work time prediction

Variable	Beta	R^2 (adj)	CV
Location	-52		
A/C	-74		
Month	-75		
Combination	27		
Intercept	345	24 (10)	38

Adjusted R^2 is shown as (adj). CV is coefficient of variation.

This was our first attempt to examine these variables, and our sample scored relatively low on peri-natal heat exposure (our highest score was 9 out of a possible score of 27). This greatly constrained the variance on the dependent variables which generally results in low predictive ability. The weightings among the variables were equated, and there are undoubtedly better ways to combine these scores. Individual variables seem to do better than the combination. The presence of air conditioning in the homes of most of our subjects may have greatly hampered our ability to determine the role of peri-natal climate on PC tolerance. We believe these results warrant further study particularly in populations who would not be routinely exposed to extreme environmental controls such as air conditioning at birth. We have observed that Middle Eastern subjects seem to show a greater heat tolerance than matched controls of Northern European descent (unpublished observations). The findings of this study seem to support that possibility.

PC offers an atypical heat stress. It is atypical because the micro-environment of impermeable PC becomes saturated with water vapor from sweat and continued sweating does not allow further evaporation. Therefore the major cooling mechanism for work in hot environments is virtually negated. Given the findings in the present study, further research on the impact of peri-natal circumstances on heat strain in hot macro-environments would be of value.

In view of our very constrained variance (independent variable extended to one third the range), it seems reasonable to expect that a better sample may yield substantially better results. In retrospect, the amount of variance accounted for by such a limited variance in the independent variable, was surprising. At this point, it seems advisable to continue investigation of this hypothesis utilizing subjects with a greater variability in peri-natal history.

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