Acclimatization's Importance to High or Low Temperatures

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Abstract
Acclimatization impact in workplace is a key subject to understand workers behaviour in different activities. One of the most efficient ways human beings have to deal with stress by exposure to heat or cold, is through physiological adaptation. This process is known as acclimatization to heat or cold respectively, however humans can not adapt to an unlimited level of heat or cold stress. This study aims to present an analysis that supports acclimatization's importance in work activities. For that, a survey was done with specific keywords resulting in articles analysed according to study objective. The survey was clear about importance of the acclimatization to workplace; But acclimatization time is not consensual. Acclimatization occurs as consequence of heat or cold exposure. Heat acclimatization improves tolerance to higher temperatures and is more effective when it is implemented in warm and wet conditions. In this case, a success indicator is the decrease of core temperature. Cold acclimatization can minimize the risks of cold related injuries. Is settled that acclimatization (to heat orcold) can improve work capabilities and reduce susceptibility to thermal injury.

Keywords: Acclimatization, Cold, Heat, Workplace.

1. INTRODUCTION
Acclimatization plays a key role in human health risks prevention. It occurs in Human body as consequence of a continuous exposure to a thermal environment different than the usual, as physiologic adjustment process.
When Human body is subjected to too stringent environmental conditions, the regulatory mechanisms are no longer effective, occurring then physical and psychological changes which in extreme cases may be irreversible. An prolonged exposition to heat and/or cold can contribute to the emergence of work accidents. At the moment that this balance is threatened, the body reacts (with sweating or tremors) depending on the condition. The heat acclimatization occurs as consequence of heat exposure in order to reduce the core temperature. The acclimatization allows, in general, that people can withstand thermal stress by a series of physiological adaptations. When talking about heat exposure in different work activities can be said that acclimatization is the process of lower cost and greater effectiveness to improve workers' safety and comfort in situations of potential heat stress. Different people as children and adults have similar physiological adaptations during acclimatization to heat. These adaptations involve a lower heart rate, lower core and skin temperature, and reducing the loss of electrolytes in sweat (Naughton, 2008). The acclimatization to heat may take a different course depending if the environment is hot and dry or hot and humid. Nielson *et al*. (1993) in their study induced acclimatization in several subjects and in their protocol they found that with hot acclimatization the sweating increased and the ability to withstand the heat stress is augmented, nevertheless, the skin temperature was not significantly different. Brake & Bates (2002) refer that an excessive heat stress in the workplace can result in heat illness, poor safety, low productivity, poor morale and increased costs. According to NIOSH standard (2002), acclimatized individuals are able to perspire more and more uniformly over their corporal surface and they also start to sweat earlier than no acclimatized individuals, these situations results in lower heat storage and lower cardiovascular strain (lower heart rate). In consequence of working in cold environments, agricultural workers may be exposed to higher risk of cold-related injuries, compared with the general population, so the importance of acclimatization could avoid some undesirable consequences (Geng, 2013). Cold adaptation in humans has been debated and can be used for that, several strategies. Among these strategies there are also different types of cold adaptation, this kind off adaptation include: isolative adaptation in which a person exposed to a constant level of cold exhibits a decrease in skin temperature, without change in core temperature; hypothermic adaptation, in which a person exhibits lower core temperature; isolative hypothermic adaptation, in which a person exhibits both a decrease in skin temperature and lower core temperature and also metabolic adaptation in which thermogenesis is strengthened (Nishimura et al 2012). So, The present study aims to present a theoretical analysis that supports the importance of acclimatization in work activities.

2. MATERIALS AND METHOD
This study was based on a search in different databases and Scientific Journals, according several keywords as acclimatization, cold, heat, and workplace. From survey resulted articles that were analyzed according to the study objective. Were excluded the ones whose methodology was not appropriate to this study.

3. THE IMPACT OF ACCLIMATIZATION
According Nielson *et al*. (1993) daily exercise in dry heat for 9-12 days resulted in approximately double of endurance time. Heat acclimatization is likely to confer an important advantage: a lowering core body temperature in resting about 0.3-0.5°C (Buono 1989). Radakovic (2007) studied the effects of acclimatization on cognitive and physiological performance against heat stress in soldiers, conducting stress tests on forty male soldiers. These soldiers performed trials at temperatures of 20ºC (16ºC globe temperature wet - cold environment) and 40ºC (29ºC globe temperature wet)

unacclimated and after 10 days acclimatization. Temperatures were measured in skin and eardrum and the heart rate measured the physiological strain. Cognitive tests were carried out before and after the stress test. It was concluded that in non-acclimatized soldiers, there was an decrease in the number of correct answers, while acclimatized ones suffered no negative effects of heat stress (Radakovic *et al*. 2007). Brake & Bates (2002) found that acclimatized workers are more efficient to temperatures until 27°C, while not acclimatized ones are more efficient only between 18-21ºC. For other hand a barehanded person exposed to a cold environment experiences pain, cold sensation, and reduced manual dexterity. Both exercise as the cold acclimatization processes, can lessen these negative effects (Muller *et al*. 2013).

3.1 Hot acclimatization

Dry heat acclimatization is different than humid heat acclimatization, because the physiological adaptations are different between conditions, although the literature about this matter is rather scarce, there is evidence to support this expectation (Sawka, 2001). Heat acclimatization is a transient and it gradually disappears if not maintained by repeated heat exposure. Kaciuba Uscilko & Greenleaf (1998) refer that, although heat acclimatization for most individuals begins early in a period of working in the heat and it is also quickly lost if the exposure is discontinued, the loss of acclimatization begins when the activity under those heat stress conditions is discontinued, and a noticeable loss occurs after four days (Niosh 2002). Sawka et al (2001) refers that there is no agreement concerning the rate of decay for heat acclimatization they found in their study different opinions about that, some authors mentioned that the heat acclimatization might be retained for two weeks after the last heat exposure, and then be rapidly lost over the next two weeks, others report some loss of acclimatization in sedentary individuals after one week. The physiologic adjustments of heat acclimatization are: internal and skin temperatures' reduction, decreased heart rate and increased sweating rate. The main alterations that occurs with hot acclimatization are: increase in blood volume, increased blood flow, increased venous tone, increased sweating rate; earlier onset of sweating, production more dilute sweat, sweat with lower sodium concentration, sweating more widespread, less cardiac frequency, lower metabolic rate, lower inner temperature, lower skin temperature, better hydric balance, increased thirst (Sawka *et al*., 2001).

3.2 Cold acclimatization

Human thermoregulatory adaptations to cold exposure are less understood than adaptations to heat (Sawka *et al*. 2001). While heat exposure induces a fairly uniform pattern of thermoregulatory adjustments, cold exposure induces three different patterns: (1) Habituation, with physiological responses during cold exposure characterized by shivering, cutaneous vasoconstrictor, or both; (2) Metabolic adaptations, characterized by enhanced thermogenic responses to cold and (3) isolative adaptations, characterized by enhanced body heat conservation during cold exposure (Swaka et al, 2001). Psychological response to cold could include behavioural reaction, due to increased discomfort and also direct effects on psychological performance in terms of arousal, reduced memory capacity and perception (K Parsons 2003). When exposed to cold environments, human body will respond with vasoconstriction to decrease core and skin temperatures, so as to reduce heat loss from core to periphery by convection, and heat loss from periphery to environment by radiation and convection (Yu et al 2012). Lower skin temperatures during cold air exposure following acclimatization have two implications: (1) at a given air temperature, lower skin temperatures reduce the thermal gradient for heat transfer between skin and air, which improves insulation; (2) in the cold exposure, the magnitude of the acclimatization´s effect on the skin temperature is greater than the effect on core temperature. Therefore, the core-to-skin thermal gradient is enlarged. A larger thermal gradient, between core and skin, favors redistribution of body heat from the core to the subcutaneous muscular shell, while lower skin temperature due to enhanced cutaneous vasoconstriction will limit heat loss through the body's shell. Individual physiological response to cold changes with age and physical fitness (Kaciuba-Uscilko & Greenleaf, 1989) and depends from temperature and exposure time.

3.3 Estimation of acclimatization time

The acclimatization's time is not consensual but 14 days appears to be the minimum recommended, however the benefits of acclimatization begin immediately after the second day. For other hand acclimatization rushes in adults after 5 to 10 days by performing exercise in a hot environment with one or two hours per day of heat exposure (Ribeiro 2010). In 1998, Armstrong refer in his study, that for a complete heat acclimatization is needed more than 14 days but the body's system adjustment to heat exposure changes over time. The first five days (table 1) involve an improvement in cardiovascular functions, including increased plasma volume and heart rate reduction. However, the expansion of plasma volume is temporary, because it decreases between the eighth and fourteenth day of acclimatization.

Table 1 -Number of days until an adaptation in one acclimatization process.

Adaptation	Acclimatization period (days)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Decrease Cardiac rhythm			■	■	■	■								
Increase in plasma volume			■	■	■									
Decrease in body temperature					■	■	■	■						
Normalization of discomfort			■	■	■	■								
Decreasing the concentration of salt in the sweat					■	■	■	■	■					
Increased sweat production								■	■	■	■	■	■	■
Decrease the concentration of salt in the kidneys			■	■	■	■	■	■						

The thermoregulation's adaptation, as for example, increased sweating and perspiration early and the cardiovascular adjustments, result in an internal temperature decrease after 5 to 8 days. For example, the loss of NaCl in the urine and perspiration occurs between the third and ninth day of acclimatization to heat (Armstrong 1998). The acclimatization takes place at different speeds, in the different body segments.

4. CONCLUSIONS

The importance of acclimatization in the workplace is clear, nevertheless the acclimatization time is not consensual. Authors' references for how long this should last, are in a range from one to two weeks. The heat acclimatization improves heat tolerance and is most effective when it is implemented in warm and wet conditions. Buono *et al*. (1998) refer that one indicator of acclimatization success is the reduction of core body temperature. When exposed to heat, the thirst sensation of unacclimatised persons is also lower than that of acclimatised ones. This predisposes unacclimatised people to a much higher probability of dehydration's occurrence, which is one of the most common causes of heat illness (Brake & Bates, 2002). For this reason is very important to assess workers' acclimatization before they start works exposed to heat. Sawka *et al.* (2001) refers that Human adaptations to heat or cold exposure can act to defend core and skin temperature, reducing physiological strain and improving work capabilities and, consequently, reducing susceptibility to thermal injury. Ideally, workers should start by doing half a day's work and climb slowly up to a full day. Heat acclimatization significantly reduces body's core temperature at rest. After short-term acclimatization to humid heat, the workers seem to be able to defend and maintain body temperature around a lower temperature set point. Has already in 1998, Buono asserted, it was found that seven days of humid heat acclimatization resulted in significant decreases core temperature, skin temperature and increased sweat rate (Cheung, 1998). In a cold scenario manual dexterity is important for optimizing work performance and safety (Mullher et al 2013). In the cold, finger blood flow is reduced and manual dexterity ultimately suffers. All the factors like: hands pain, cold sensation, and reduced manual dexterity can lead to injuries in the workplace and hinder performance. ITaken together, these findings confirm and extend the interest to stimulate new research in the area of cold acclimatization and human performance. Even so generally, concerning the cold exposure, it could be said that the long-term exposure to colder indoor environments may induce better physiological tolerance for such environments.

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