
[REFERENCES]

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Changes in Body Temperature and Basal Metabolic Rate of the Ama—*A Commentary*

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The article entitled “Changes in Body Temperature and Basal Metabolic Rate of the Ama” (ie, Korean pearl diving women) focuses on the thermal and metabolic responses of the remarkable Korean pearl divers (ama) who repeatedly dove into the waters of Pusan, Korea. This classic article demonstrates that the ama women exhibited a type of acclimation termed “metabolic adaptation,” which may occur in individuals who become acclimatized to cold. The oral temperatures and metabolic rates of the Korean diving women described in this article were measured during 4 seasons and compared with their Korean nondiving counterparts who lived in the same community and consumed the same diet.

The oral temperature of Korean diving women was measured before and after they dove for pearls in the waters off the Pusan coast. Resting metabolic rate was also measured under the same conditions. In the summer, the average oral temperature of the women declined to 35°C after 70 minutes of diving into 27°C water. In the winter months, the water temperature averaged 10°C, permitting the women to dive for only 15 minutes. During this time, their oral temperatures declined to 33°C. Because the oral temperature declined with respect to the water temperature conditions, the duration of the work for the women was primarily determined by the water temperature and their ability to endure the extreme cold. The basal metabolic rate of the ama pearl divers varied with the season, implying that in the winter months the elevated (basal) metabolic rate was due to a cold adaptation that was a consequence of repeated bouts of cold water immersion.

The typical ama work was to wade in the water carrying a gourd float that was attached to a net for storing their collection of sea life. They would swim 20–300 yards offshore and dive repeatedly in the general area of their float and would rest between dives. After a work period of 2.5 hours in summer and 15 minutes in winter, the women would return to the beach, change into a dry swimsuit, and be rewarmed either in the sun or by an open fire. This schedule was maintained during the 1963 study. A clinical oral thermometer was held under their tongue for 5 minutes before oral temperature was assessed. In the early 1960s, the Korean diving women would dive year-round into the waters off Pusan, Korea, wearing only a thin cotton bathing suit. Because the cotton suit did not provide any insulation or barrier to the stressor of cold, the ama of the 1960s demonstrated a metabolic adaptation to the cold. This "hypermetabolic rate" that the women exhibited is similar to the acute response that we see in individuals who attempt to maintain core temperature during immersion in cold water. The Korean diving women, however, experienced this high resting metabolic rate as a chronic adaptation to repeated bouts of work in cold water exposure whereby they maintained an extremely low core temperature. The core temperatures demonstrated by the ama pearl divers are lower than the core temperatures reported by the Aborigines and also lower than we are permitted to induce in the laboratory today.

Furthermore, the highest postdive oral temperature in the winter was colder than the lowest postdive oral temperature in the summer. The lowest recorded oral temperature was 32.5°C at the end of the diving period in the month of January. As a result of these core temperatures, the subjects were shivering visibly, even in the summer, as they returned to the beach.

Economic necessity provided a strong motivation for these subjects. The ama had to work in the cold water as long as they could tolerate it. However, nondiving women and men probably could not have tolerated this degree of hypothermia voluntarily. Therefore, the authors suggested that the Korean diving women experienced a hypothermic type of adaptation. Furthermore, the authors suggested that the Korean pearl divers are similar to the Aborigines, because they develop a tolerance to the cold that allows them to maintain lower core temperatures than their nondiving counterparts could withstand. For example, the mean body temperature for the ama was as low as 30°C in January and remained low (34.6°C) even in August. By comparison, the naked Aborigines rarely demonstrated a rectal temperature that fell below 35°C.[1] Furthermore, the lowest recorded oral temperature of the English Channel swimmers was only 34.4°C at the end of the cross-channel swimming.[1] It therefore appears that the Korean ama performing intermittent dives in cold water experience a greater degree of thermal stress than either the Aborigines who are exposed to cold air or the English Channel swimmers who underwent a single bout of cold water exposure. Therefore, the authors suggest that this metabolic response experienced by the Korean ama provides the first unequivocal data that repeated cold exposure can stimulate an elevation in resting metabolism in humans.

Brown et al.[2] have also reported a slight seasonal change in basal metabolic rate while studying the Eskimos. Rodahl[3] attributed this basal metabolic change to their high-protein diet rather than to cold exposure. This high-protein diet would increase basal metabolic rate via the higher thermic effect of feeding needed to digest the protein. This is not a valid explanation for the ama because they excreted well below the average (24 g/day) nitrogen excreted by the Eskimos and also well below the daily nitrogen excretion according to Western normative values.

The article suggests that the increased resting metabolism may be an adaptation to the severe body cooling, which is rarely experienced by modern man via cold air exposure, but is seen in the Korean ama because of the unusual degree of hypothermia and cold adaptation that they experience. Kang et al.[1] speculate that this increase in resting metabolism may be a shift from shivering to nonshivering thermogenesis.

This is a classic article that eloquently discusses the tremendous environmental stress that a population of women endured and the thermal and metabolic response that ensued from this stressor. The Korean ama in the winter demonstrated oral temperatures as low as 32.5°C and skin temperatures as low as 10°C. This central and peripheral cooling was accompanied by an increase in resting metabolism that was 35% higher in the winter than in the summer. This tolerance to cold exposure is evidenced by body cooling similar to that observed in the Aborigines.

Kang et al.[1] also concluded that the increase in basal metabolic rate had no value as a defense against body cooling in water; it simply appeared to be the "long-sought" metabolic adaptation of humans to the cold. The authors continue to suggest that if this metabolic adaptation can be programmed by the cooling of human subjects in water baths, it may yield a new field of studying human temperature regulation.

Kang et al.[1] were able to demonstrate that there is a metabolic change or adaptation that accompanies the individual's response to acute cold exposure. However, one may speculate that the authors may have minimized the role of metabolic rate or shivering thermogenesis and its means of attempting to maintain temperature homeostasis. Glickman-Weiss et al.[4] demonstrated that the difference between low- and high-fat men was the hypermetabolic rate that the low-fat men demonstrated in an effort to maintain rectal temperature, compared with their high-fat counterparts. Therefore, the hypermetabolic rate that the ama experienced should not be minimized as an adaptation that potentially enabled these women to maintain oral temperatures similar (albeit at lower overall values) to the previously studied Aborigines.

Overall, this is an outstanding article that presents the metabolic type of adaptation that the individual may experience due to the process of cold acclimation. It is a seminal article that presents a rather unique group of individuals who have physiologically adapted due to the consequence of their profession.

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