Comparative Cardiorespiratory Patterns in Pinnipeds

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When submerged, mammals exhibit a dive response to conserve precious oxygen stores. This physiological condition is characterized by cessation of breathing (apnea), decrease in heart rate (bradycardia), and reduced blood flow to the extremities (peripheral vasoconstriction). As amphibious mammals, pinnipeds are adapted for terrestrial and marine living. However, most of what is known about the cardiorespiratory behavior of pinnipeds has been carried out on actively diving individuals. Further, the majority of available data have been collected with only a few, well-studied species. Here, we explore cardiorespiratory patterns in phocids, otariids, and odobenids resting out of water to evaluate how these patterns differ as a function of evolutionary biology or life history traits. Replicate data sets ($n > 15$) were obtained from harbor, ringed, spotted, bearded, and Hawaiian monk seals, California and Steller sea lions, [NT1] and walruses ($n = 20$ individuals). Individuals were conditioned to position calmly on a conductive surface for > 5 minutes during electrocardiogram measurements, while corresponding spontaneous respirations were recorded to video. All subjects displayed a clear bimodal distribution of heart rate between bradycardic and tachycardic states. Bradycardia was linked to periods of apnea, regardless of apnea duration. Prior work suggests that all pinnipeds "dive" while at rest on land by punctuating extended breath holds with bouts of clustered respiratory events. While each subject in our study exhibited some degree of this apneustic breathing pattern, notable differences were apparent. Some species breathed more regularly and others more intermittently while at rest, driving predictable changes in heart rate. Preliminary [NT2] analyses highlight species- and family-level differences in typical apnea duration, respiratory rate, and absolute and dynamic range of instantaneous heart rate between tachycardia and bradycardia. These data provide an initial comparative framework with which to consider evolutionary adaptations for diving as well as physiological trends related to phylogenetic relationships.