Characteristics of Basal Heart Rate during Daily Life: Relationships with Age, Sex, and Mean Heart Rate

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Abstract

Vast heart rate (HR) data during daily activities are being accumulated with widespread use of wearable sensors. To interpret the meaning of these HR data, the reference point of HR in individual subject is required. Although resting HR has been used for this purpose, the definition of resting HR has not been established and particularly, the effects of time of the day (circadian rhythm) on resting HR have not been considered. One of the other candidates for the reference point may be basal HR, i.e., the lowest HR in the day. In the present study, we therefore investigated the characteristics of basal HR by examining the effects of age and sex on basal HR and the occurrence time of basal HR during 24 h in 113,341 males and 140,332 females extracted from a 24-h Holter ECG database of the Allostatic State Mapping by Ambulatory ECG Repository (ALLSTAR). Although basal HR decreases with age until 20 yr old in both sexes, it increases slightly with advancing age thereafter. Although the clock time to reach basal HR appears between 02 and 05 h on average, it shows progress or delay depending on the time of life. The difference between 24-h mean and basal HR decrease linearly with age, suggesting that age-dependent decline in the

increases in HR with daily activities can be detected by using basal HR as the reference point.

Author Keywords

Heart rate; basal heart rate; resting heart rate; ambulatory monitoring; aging; sex; circadian rhythm; big data; ALLSTAR.

ACM Classification Keywords

J.3. Life and medical sciences: Biology and genetics; and Health.

Introduction

Increase in heart rate (HR) is widely used as an index of physical and mental stresses in laboratory studies [1, 2]. Recently, with widespread use of wearable sensors, vast HR data during daily activities are accumulated [3, 4], and the appropriate interpretation of data is required for their effective utilization. For HR during ambulatory monitoring, however, baseline value of HR is lacking. Consequently, the increase in HR cannot be assessed systematically [5, 6]. HR, even during resting, is known to be affected by body posture [7] and circadian rhythm [8] and to differ with age and sex. To interpret the meaning of HR data, it is necessary to set a value as the reference point for each individual. One of the most promising candidates for the reference point is basal HR, i.e., the lowest HR in the day. In the present study, we therefore, investigated the characteristics of basal HR using big data of 24-h ambulatory electrocardiographic (ECG) recordings.

Methods

We studied 24-h ECG data in 253,673 subjects (median [5-95 percentiles] age, 68 [24-86] yr) including 113,341 males (67 [21-85] yr) and 140,332 females (69 [27-87] yr) extracted from a Holter ECG database of the Allostatic State Mapping by Ambulatory ECG Repository (ALLSTAR) [9].

The ALLSTAR project has started in 2007. The database consists of 24-h ambulatory ECG data that were referred for analysis to three ECG analysis centers (Suzuken Co., Ltd., Japan) located in Tokyo, Nagoya, and Sapporo in Japan. The data were anonymized by the center and stored with accompanying information, including age, sex, and recoding date, time, and location (postal code).

The ALLSTAR project has been approved by the Institutional Review Board of Nagoya City University Graduate School of Medical Sciences and Nagoya City University hospital (No. 709). The purpose and information utilized in this project have been public

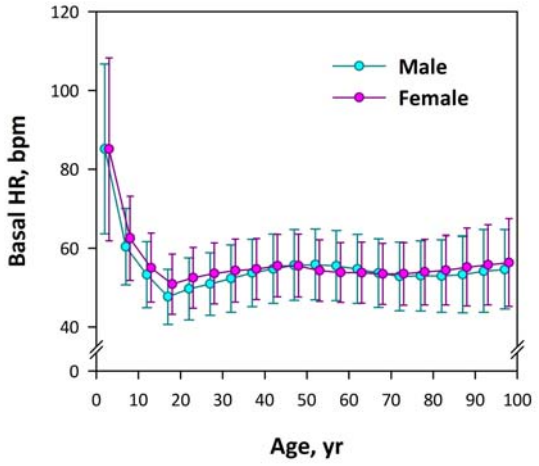

Fig 1. Distributions (mean and SD) of basal HR in subjects with sinus rhythm grouped by age for every 5 years and sex.

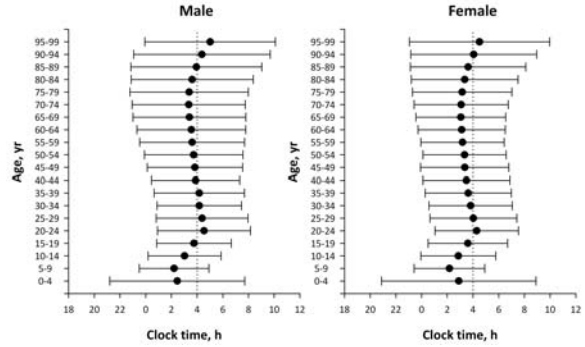

Fig 2. Distributions (mean and SD) of clock time to reach basal HR by age for every 5 years and sex.

through the homepages of the ECG analysis centers (http://www.suzuken.co.jp/product/holter/detail/) and of the ALLSTAR project (http://www.med.nagoya-cu.ac.jp/mededu.dir/allstar/), in which opportunities to refuse the uses of information are ensured for the research subjects.

We defined basal HR as the minimum median value of sinus-rhythm HR within 3-min moving window during the day. We first calculated the median value of sinus interbeat intervals within moving 3-min window over the entire 24 h. Then, we took the maximum median interval and calculated basal HR as 60,000/(the maximum median interval, ms) bpm. We also measured the clock time when basal HR was reached in each subject. Also, we calculated 24-h mean HR only using interbeat intervals with sinus rhythm.

Results

The subjects were grouped by age for every 5 years and sex. In both sexes, basal HR was highest for the age bin of 0-4 yr (85 ± 22 and 85 ± 23 bpm for males and females; Fig. 1). It decreased until 20 yr and

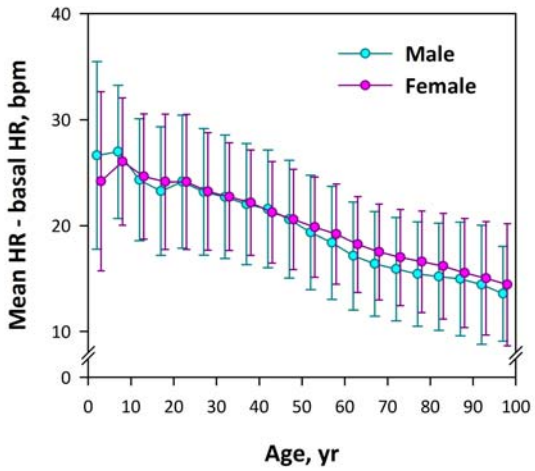

Fig 3. Distributions (mean and SD) of difference between 24-h mean and basal HR by age for every 5 years and sex.

reached a bottom (48 ± 7 and 51 ± 8 bpm); thereafter, it increases slightly with advancing age in both sexes. Although averages of clock times to reach basal HR were observe between 02 and 05 h, the distribution was wide for 0-4 yr and for over 80 yr old (Fig. 2). The average clock time moved from 02 to 04 h during growth between 5 to 20 yr old, moved back to 03 h until 70 yr old, and again moved toward 05 h thereafter. The difference between 24-h mean and basal HR decreased linearly with advancing age from 27 ± 8 bpm (0-4 yr) to 14 ± 4 bpm (95-99 yr) in males and from 24 ± 8 bpm (0-4 yr) to 15 ± 6 bpm (95-99 yr) in females (Fig. 3).

Discussions

Basal HR decreases with age until 20 yr old in both sexes. It then increases slightly with advancing age thereafter. Although the clock time to reach basal HR appears between 02 and 05 h on average, it shows progress or delay depending on the time of life. The difference between 24-h mean and basal HR decrease linearly with age, suggesting that increases in HR with daily activities from basal HR may decline with aging.

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