Association of Age, Sex, Body Size and Ethnicity with Electrocardiographic Values in Community-based Older Asian Adults

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Background	Existing electrocardiographic (ECG) reference values were derived in middle-aged Caucasian adults. We aimed to assess the association of age, sex, body size and ethnicity on ECG parameters in a multi-ethnic Asian population.
Methods	Resting 12-lead ECG and anthropometric measurements were performed in a community-based cohort of 3777 older Asians (age 64.7 ± 9.1 years, 1467 men, 88.8% Chinese, 7.7% Malay, 3.5% Indian, body mass index [BMI] 24.0 ± 3.9 kg/m^2).
Results	Men had longer PR interval, wider QRS, shorter QTc interval and taller SV3. In both sexes, older age was associated with longer PR interval, wider QRS, larger R aVL and more leftward QRS axis, while higher BMI was associated with longer PR interval, wider QRS, larger RaVL and more negative QRS axis. There were significant inter-ethnic differences in QRS duration among men, as well as in PR and QTc intervals among women (all adjusted $p < 0.05$). Findings were similar in a healthy subset of 1158 adults (age 61.2 ± 9.1 years, 365 men) without cardiovascular risk factors.
Conclusions	These first community-based ECG data in multi-ethnic older Asians highlight the independent effects of age, sex, body size and ethnicity on ECG parameters.
Keywords	Age • Sex • Ethnicity • Body size • Electrocardiogram • Asian

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Introduction

The 12-lead electrocardiogram (ECG) is commonly used in day-to-day clinical practice for screening of cardiovascular disease due to its availability, simplicity and low cost. Current ECG reference ranges were largely defined in middle-aged Caucasian populations [1]. However, it is well-recognised that these values are affected by age, sex, body size, and ethnicity [2–5].

Non-Caucasian ethnic groups in which normal ECG parameters have been studied include Black [3,6,7], Hispanic [3] and Chinese populations [2,8,9]. While these prior studies highlighted the need for ethnicity-specific considerations in the interpretation of ECG data, direct inter-ethnic comparisons have been limited by differences in age, sample selection (unselected population-based versus selected referral cohorts), methodology and geography. None included detailed characterisation among different Asian ethnicities. Little is known of ECG reference values in Malays, who constitute almost 28 million of the world's population with large populations in Malaysia and Indonesia. Furthermore, in the largest ECG study in Chinese to date [8], only 16% (857 out of 5360) of participants were $\geq$ 60 years old. Finally, while most prior studies accounted for age and sex differences, few simultaneously accounted for body size differences as well [4,5].

In this community-based study, we aimed to assess the association of age, sex, body size and ethnicity on ECG parameters in a multi-ethnic older Asian population inclusive of Chinese, Malay and Indian ethnicities. We hypothesised that demographic and anthropometric factors (age, sex, body size and ethnicity) would have independent effects on ECG characteristics.

Methods

Singapore is home to 5.5 million inhabitants with a mix of Chinese, Malays and Indians comprising, respectively, 74%, 13%, and 9% of the population. The current study population was derived from the Singapore Longitudinal Aging Study [10], aimed at identifying conditions associated with ageing. Participants were randomly sampled adults from the general community, identified by door-to-door census of all residents in contiguous precincts within five districts in the southeastern region of Singapore. Informed consent was obtained from each patient and the study conformed to the ethical guidelines of the 1975 Declaration of Helsinki. Ethics approval was obtained from the institutional review board.

Demographic and anthropometric data were obtained as part of the original studies and a resting baseline 12-lead ECG was done at the time of recruitment. Body mass index (BMI) was calculated as weight (Kg)/(height(m))^2 and body surface area (BSA) was calculated using the Mosteller formula ($\sqrt{}$(height(cm)x weight(kg)/3600). Waist:hip and waist:height ratios were also obtained. 12-lead ECGs were performed in a standardised fashion across all 10 centres in Singapore. These were done in the morning, between 1030H to 1200H, with participants resting quietly for 10-15 minutes lying on a couch after having their fasting blood samples taken. To further minimise inter-centre variability, the same ECG machine model (GE MAC 5500) was used in all 10 centres. Standard ECG parameters including PR interval, QRS duration, QTc interval and QRS axis were measured from lead II. Further ECG variables of interest including amplitude of R wave in aVL (RaVL) and S wave in V3 (SV3) were measured and recorded by a single, independent trained reader.

In order to define ECG normal limits and associations in healthy Asians, we further defined a ''healthy population'' subgroup as participants without diabetes mellitus, hypertension, hyperlipidaemia, coronary artery disease, cerebrovascular accident (CVA), any smoking history, atrial fibrillation, bundle branch block, anaemia (Hb < 12 g/dL in men, < 11 g/dL in women) or renal impairment (Cr > 120umol/L).

Anthropometric and ECG data were expressed as mean $\pm$ standard deviation and ECG parameters with 5% and 95% confidence limits. One-way ANOVA and Student's T-test were used to compare ECG parameters among ethnic groups and between men and women respectively. Subsequently, sex-stratified analyses were performed: Univariable analyses were performed to assess the association of age and BMI with ECG parameters, and Pearson's correlation coefficients were obtained for each dependent variable in both the overall and healthy populations. In the overall population, multivariable analyses were performed where the dependent variable was the ECG variable of interest, and independent variables included age, BMI, ethnicity, diabetes mellitus, hypertension, hyperlipidaemia and CVA. In the subset of healthy population, multivariable analyses were similarly performed adjusting for age, BMI and ethnicity. Participants with morbid obesity (BMI > 30 kg/m^2) made up only 5% of the overall population, and were adjusted for in the analysis of the healthy population.

Results using different anthropometric measurements (body surface area, waist:hip and waist:height ratio) are included in the online Supplement. A *p* value of < 0.05 was considered statistically significant.

Results

Clinical Characteristics

A total of 3777 (age 64.7 $\pm$ 9.1 years, 1467 men) community-based adults were included, with 1158 (age 61.2 $\pm$ 9.1 years, 365 men) participants in the healthy subset. As shown in Table 1, the study population was predominantly Chinese (88.8%), and older with the expected age-related comorbidities such as diabetes, hypertension and hyperlipidaemia (consistent with Singapore population statistics). Also consistent with a community-based sample, participants generally had normal haemoglobin and renal function.