# Prevalence of long and short QT in a young population of 41,767 predominantly male Swiss conscripts

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**BACKGROUND** Abnormally long and short QT intervals are recognized to be associated with an increased risk for life-threatening ventricular arrhythmias. It is therefore important to define the upper and lower border of the normal QT.

**OBJECTIVE** The aim of this study was to describe the normal distribution of the QT interval in a contemporary population of young conscripts and to define long and short limits of the QT interval.

**METHODS** In Switzerland, all young male citizens must undergo compulsory conscription for the Swiss Army at the age of 18 to 19 years. In every conscript, an electrocardiogram (ECG) is performed. Retrospectively, 41,767 consecutive ECGs of Swiss citizens who underwent conscription for the army between March 1, 2004, and July 31, 2006, were analyzed.

**RESULTS** The mean QTc Bazett interval was 394 ± 22 ms. One percent of the conscripts had a Bazett QTc shorter than 347 ms, and one percent had a Bazett QTc longer than 445 ms, respectively. None of the subjects presented a QTc Bazett < 300 ms; the prevalence of a QTc Bazett < 320 ms was 0.02%.

**CONCLUSION** The present study shows the distribution of QT intervals in an unselected young population. Because none of the subjects presented a QTc < 300 ms, it may be concluded that the short QT syndrome is a very rare entity in the population of young male adults.

**KEYWORDS** QT interval; Corrected QT interval; Electrocardiography; Short QT syndrome; Long QT syndrome; Young population.

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## Introduction

Abnormally long and short QT intervals are recognized to be associated with an increased risk for life-threatening ventricular arrhythmias and sudden cardiac death.[1–7] Presentations of the long QT syndrome are palpitations, presyncope, and syncope. However, in some patients cardiac arrest is the first symptom of the disease. Because the QT interval varies inversely with the heart rate, various formulas have been used to correct the QT interval for the underlying heart rate. In clinical practice, the Bazett formula is used most often.[8]

QTc is considered prolonged when it is more than 0.45 seconds in men, more than 0,46 seconds in children, and more than 0.47 seconds in women.[9-12] There is increasing evidence that a short QT interval may at times be associated with an increased risk of life-threatening arrhythmic events.[5,13] Gaita et al[4] described the link between short QT syndrome and familial sudden death, and Wolpert et al[7] provided the genetic and biophysical basis for the disease. The diagnosis of short QT syndrome should be considered when there is a short QT interval in the absence of extrinsic causes and an electrocardiographic (ECG) documentation of ventricular fibrillation or related symptoms or a positive family history for sudden cardiac death or short QT.[13]

The aim of this study was to describe the normal distribution of the QT interval in a contemporary population of young conscripts and to define the long and short limits of the QT interval. Previous studies have shown that the QTc interval of patients with and patients without mutations for the long QT syndrome have a normal distribution with considerable overlapping between the QTc intervals of these 2 populations.[14] Even more challenging is how to define when the QT is short, because evidence exists that the QTc of healthy individuals and patients with short QTc syndrome may also overlap.[15]

## Methods

In Switzerland, ostensibly healthy men must undergo compulsory conscription for the Swiss Army at the age of 18 to 19 years. Female citizens may volunteer for the army, and the recruitment process is the same. In every conscript, medical history is obtained, physical examination and ECG is performed, and a status "medically fit for military service" or "unfit for military service" is assigned.[16,17]

We re-analyzed the 41,812 consecutive ECGs (AT-104 PC, Schiller AG, Baar, Switzerland) of Swiss citizens who underwent conscription for the army between March 01, 2004, and July 31, 2006. Data acquisition has been per-

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formed with a sampling rate of 1 kHz without digital filtering. The hardware filter was set at 0.05 to 350 Hz. For beat measurement, ERI13-software (Schiller AG) was used and data were down-sampled to 500 Hz.

The measurement of the QT interval is based on the derivative on the ECG signal (3-dimensional absolute spatial velocity) as described in detail by Bortolan et al,[18] i.e., the start of the first deflection of the QRS complex to the point at which the T wave returned to the isoelectric line in the electrocardiographic derivation that registered the longest QT interval.[12,18,19] All ECGs with QT $>$ 440 or QTc $>$ 440 and all ECGs with QT $<$ 350 or QTc $<$ 350, respectively, were reviewed by an electrophysiologist (R.K.) and checked for whether QT measurement was correct. Further, to correlate the automatic and the manual measurement, the global measurement points of the ECG of 8,000 randomly selected ECGs were reviewed manually to correct for global measurement errors; 1,722 of these 8,000 ECGs differed in automatic and manual measurement of any interval (PP, PQ, QRS, or QT interval). A total of 241 of the 8,000 ECGs differed in automatic and manual measurement of the QT interval (3.0%). The mean difference between the automatic and manual QT interval measurement was found to be 0.1 ms (median 0 ms), suggesting no bias between automatic and manual QT-interval measurement. The standard deviation of ±15.5 ms occurs because when an automatic QT-interval measurement differs from the manual review, the error is in most cases large (−80 ms to 240 ms) providing either a very small or very large QT interval. In comparison, the correlation test based on the CSE (Common Standards for Quantitative Electrocardiography) database asked in international standards and norms for diagnostic ECG devices accepts a mean measurement error of ±25 ms (with a standard deviation of ±30 ms).[20] Finally, 45 ECGs were excluded from the analysis for various reasons (artifacts, pre-excitation, and bundle branch block with consecutive QT prolongation); 41,767 ECGs were included in the analysis.

## QT correction formulae

The following 4 commonly used formulae were used in the study:

Bazett[8]: $QTc = QT / (RR/ 1{,}000)^{1/2}$

Fridericia[21]: $QTc = QT (RR/ 1{,}000)^{1/3}$

Framingham[22]: $QTc = QT + 0.154 * (1{,}000 - RR)$

Hodges[23]: $QTc\ QT + 1.75 * (60{,}000/ RR - 60)$

## Statistics

Data were analyzed with the SPSS package for paired and unpaired data. The Student *t*-test for unpaired data was used to compare differences. A value of $P < 0.001$ was considered statistically significant. Quantitative data are presented as mean ± SD.

## Results

A total of 41,767 ECGs were analyzed, 41,609 ECGs of male conscripts (99.6%) and 158 of female conscripts (0.4%). The mean age was 19.2 ± 1.4 years (range: 17 to 38 years); 2,518 (6%) were taking medication daily and 3,382 (8.1%) on demand. Of the 2,518 conscripts who were taking medications, 850 (2.0% of all) consumed some kind of drug that potentially could prolong the QT interval.[24] The ECGs of conscripts not taking any medication and those of conscripts taking potentially QT prolonging drugs were analyzed separately; however, there was no difference in the QT intervals (and all further results) between these groups (Table 1). Distribution of the QTc intervals in all 41,609 men is shown in Figure 1.

**Table 1** QT intervals of all conscripts not taking any medication and of those taking regularly potentially QT-prolonging drugs

| | Drugs | N | Mean | Range | |
|---|---|---|---|---|---|
| QT interval (ms) | No | 40,917 | 364 ± 27 ms | 262–566 ms | |
| | Yes | 850 | 362 ± 27 ms | 286–506 ms | $P$ = NS |
| Bazett QTc | No | 40,917 | 394 ± 22 ms | 303–597 ms | |
| | Yes | 850 | 393 ± 21 ms | 325–464 ms | $P$ = NS |
| Fridericia QTc | No | 40,917 | 384 ± 17 ms | 320–558 ms | |
| | Yes | 850 | 382 ± 16 ms | 339–451 ms | $P$ = NS |
| Framingham QTc | No | 40,917 | 385 ± 17 ms | 296–540 ms | |
| | Yes | 850 | 383 ± 16 ms | 324–450 ms | $P$ = NS |
| Hodges QTc | No | 40,917 | 385 ± 16 ms | 322–543 ms | |
| | Yes | 850 | 384 ± 16 ms | 339–460 ms | $P$ = NS |

A total of 40,917 ECGs of male (40,760) and female (157) conscripts not taking QT-prolonging drugs were further analyzed. The mean QT duration was 364 ± 27 ms in male and 378 ± 24 ms in female conscripts. The mean QTc duration and range using the different correction formulae are shown in Table 1. These values do not change if the 158 ECGs of the female conscripts are excluded.

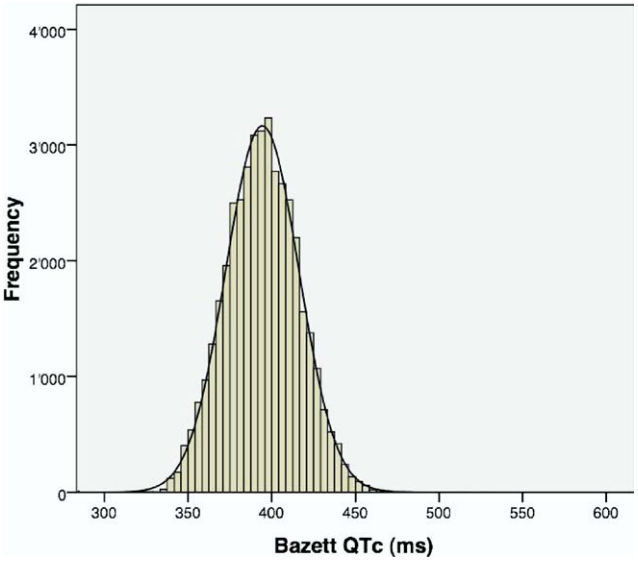


**Figure 1** Distribution of QTc intervals in all 41,609 men. Mean QTc 394.4 ± 21.8 ms.