

# Do the ECG Axis and Intervals Depend on the Heart Rate and on the Body Habitus?

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## Abstract

*It is known that the QT interval of the electrocardiogram (ECG) is heart-rate-dependent. Due to physiological aspects, the same can be expected for the PR and the QRS interval. Moreover, it can be hypothesized that the electrical axes are influenced by the body habitus. We wanted to know if these effects can be found in a well defined study group such as young males of a certain age category or whether there is another important correlation.*

## 1. Introduction

Different proposals of correction the QT interval have been proposed with more or less success to overcome its heart rate dependence [1-4]. Heart rate dependence can as well be expected for the other global electrocardiogram (ECG) parameters such as PQ and QRS. Further, the frontal heart axis (P, QRS and T) may be dependent of the body habitus such as the body mass index (BMI). In order to reduce false positives as false negatives such dependencies might have to be described in order to prevent false decisions.

It is not an easy task to find these correlations and interpret them the right way as has demonstrated Malik's group in several papers [5-8] discussing the QT/RR relationship. One needs a well defined database including a high number of normal subjects. Such studies are costly not therefore not often performed. We designed a multi-centre study where we analysed retrospectively the 10s resting ECGs acquired during a pre-defined time period of Swiss Army conscription.

## 2. Materials and methods

Every Swiss male is obligated to undergo compulsory conscription for the Swiss army at the age of about 18 years. In every conscript, medical history is obtained, physical examination performed and a 10s resting ECG is

acquired in order to assign the status of "medically fit for military service", "medically fit for civil service or "medically unfit". We analysed 41'812 consecutive ECGs (AT-104 PC, SCHILLER AG, Switzerland) of persons being included to Swiss Army conscription during the time period of March 1<sup>st</sup>, 2004 and July 31<sup>st</sup> 2006. The data have been acquired with a sampling frequency of 1kHz with a hardware signal bandwidth of 0.05 to 350Hz. For beat measurement, we used the automatic measurement software of the device manufacture. Data were manually interpreted using SEMA200 (SCHILLER AG, Switzerland). All abnormal ECGs reviewed by two independent cardiologists were excluded. All ECGs for which no automatic measurement was possible or body habitus not available or the conscript was a female were excluded, too. ECG subgroups were reviewed and global measurement parameters manually adopted were needed. The remaining 33'551 resting ECGs constituted our database for heart rate/interval and heart axis/body habitus relationship investigation.

## 3. Results

The statistical values of the height, weight and the Body Mass Index (BMI) are shown in Tab. 1 as well Fig. 1 to 3. We already have postulated that there is a good measure for body habitus description [9].

	Mean+/-std (minimal, maximal value)
Height	178+/-7 (118,207) cm
Weight	73+/-12 (40,187) kg (R <sup>2</sup> =0.16)
BMI	23+/-5 (13,58) kg/m <sup>2</sup>

Table 1. Statistical values of the Height and weight distribution.

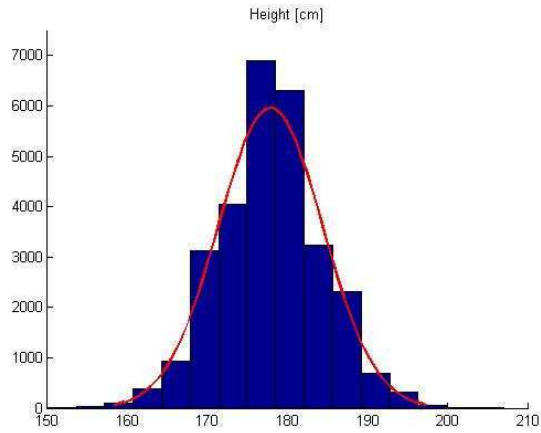


Figure 1. The histogram of the height [cm] distribution of the investigated 33'551 ECGs.

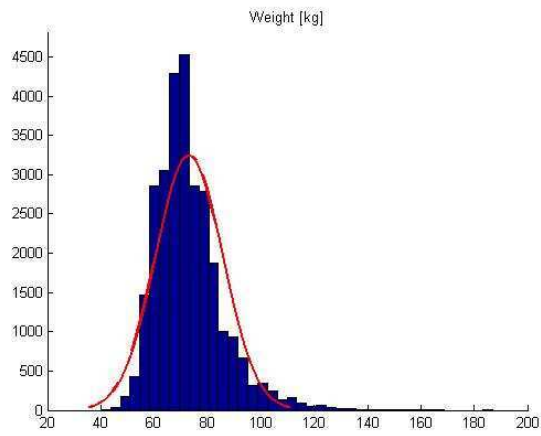


Figure 2. The histogram of the weight [kg] distribution of the investigated 33'551 ECGs.

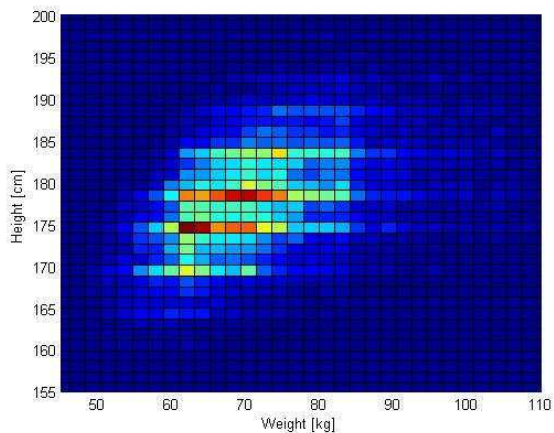


Figure 3. The contour map describing the relationship between the weight [kg] and height [cm] for the investigated 33'551 ECGs.

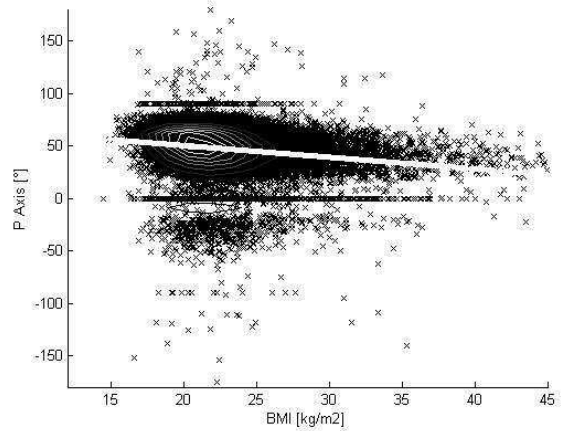


Figure 4. The distribution of the Paxis [°] of the frontal plane in relationship to the body habitus [BMI].

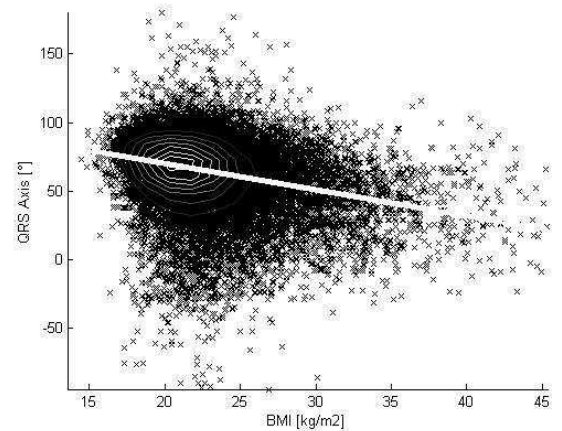


Figure 5. The distribution of the QRSaxis [°] of the frontal plane in relationship to the body habitus [BMI].

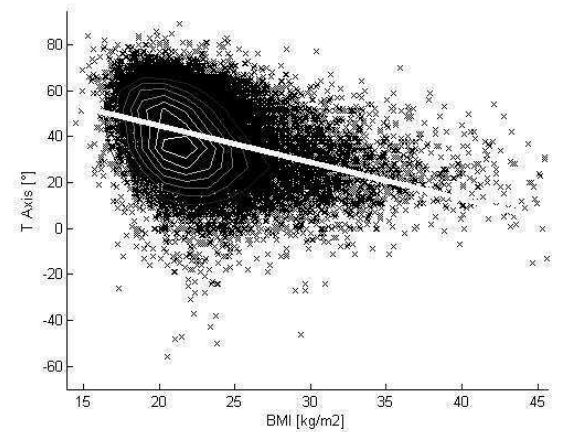


Figure 6. The distribution of the Taxis [°] of the frontal plane in relationship to the body habitus [BMI].

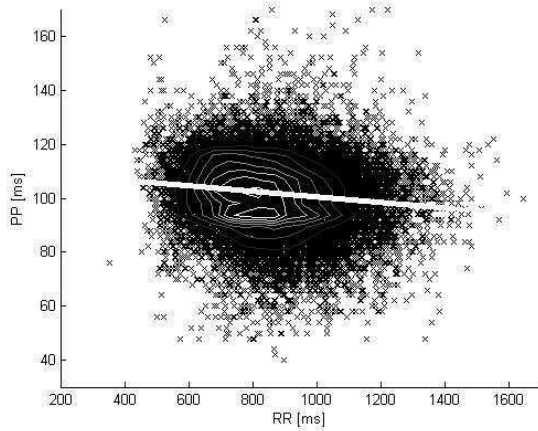


Figure 7. PP interval [ms] in relationship of the RR interval [ms].

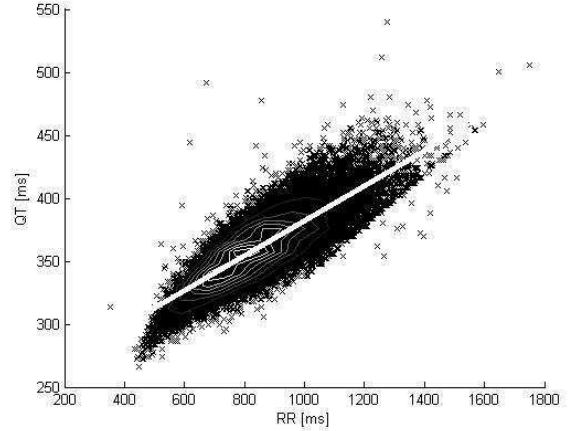


Figure 10. QT interval [ms] in relationship of the RR interval [ms].

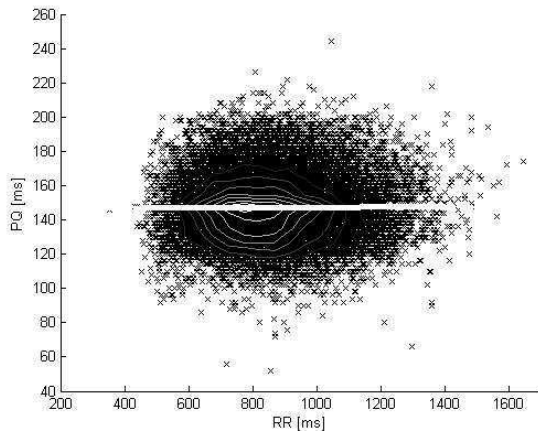


Figure 8. PQ interval [ms] in relationship of the RR interval [ms].

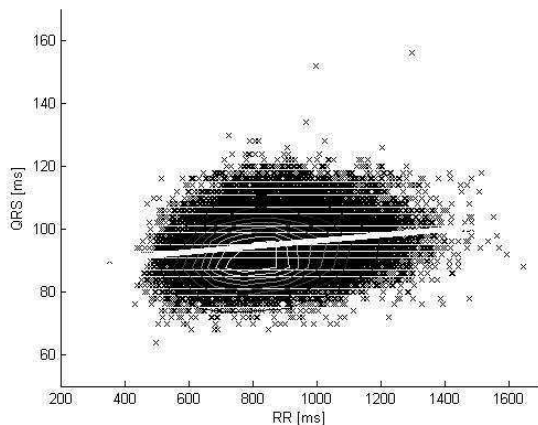


Figure 9. QRS duration [ms] in relationship of the RR interval [ms].

The linear relationship between BMI and Paxis, QRSaxis and Taxis was  $-1 \cdot \text{BMI} + 71$  ( $R^2=0.03$ ),  $-2 \cdot \text{BMI} + 108$  ( $R^2=0.07$ ) and  $-1.5 \cdot \text{BMI} + 76$  ( $R^2=0.13$ ) as shown in Fig. 1 to 6. The linear relationship between RR (351, 859+-162, 1751 ms) and PP, PQ, QRS and QT interval was  $0 \cdot \text{RR} + 110$  ( $R^2=0.02$ ),  $0 \cdot \text{RR} + 146$  ( $R^2<0.01$ ),  $0 \cdot \text{RR} + 89$  ( $R^2=0.02$ ) and  $0.1 \cdot \text{RR} + 248$  ( $R^2=0.65$ ) as shown in Fig. 7 to 10.

#### 4. Conclusions

Although no relevant correlation was found between RR and PQ, QRS and PP, a correlation was detected between QT/RR (known) as well as for local amplitude-duration couples. The measured values corresponding to the difference between the maximal and minimal value are 14 ms, 2 ms, 11 ms and 188 ms for the PP, PQ, QRS and QT interval focusing on heart rate dependency. Absolute values between 3.5 and 3728 mV can be found focusing on local amplitude and duration correlation couples. The regressed Paxis values range from  $57^\circ$  down to  $8^\circ$  for minimal and maximal BMI,  $83^\circ$  down to  $-2^\circ$  for the QRS axis and from  $55^\circ$  to  $-16^\circ$  for the T axis. Therefore, a single measurement parameter such as Sokolov-Lyon index or QRS axis is not really a good way of interpreting the ECG. Things are a slightly more complicated but still logical.

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