QRS Score: A Composite Index of Exercise-Induced Changes in the Q, R, and S Waves During Exercise Stress Testing in Patients with Ischemic Heart Disease

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Background: To detect ischemic heart disease, the exercise-induced ST-segment displacement is the most frequently used ECG parameter. However, the value of this marker was proven to be limited with varying sensitivity and specificity. A new parameter, called QRS score, emerged to improve the efficacy of exercise testing.

Methods: Our study aimed at evaluating the diagnostic value of QRS score in ischemic heart disease, investigating males and females separately, and examining the effects of heart rate and antiischemic medication. QRS score and cumulative ST depression were calculated in 212 patients and correlated to the findings of the stress myocardial perfusion SPECT (197 subjects) or coronary angiography (54 subjects).

Results: An inverse correlation could be found between the QRS score and the results of myocardial SPECT and coronary angiography in the whole population, especially in males; females did not show a significant relationship. In patients with conclusive tests (achieving 85% of the maximal predicted heart rate) QRS score correlated significantly with the results of the stress myocardial perfusion SPECT and coronary angiography. The sensitivity, specificity, and validity of the QRS score surpassed those of the cumulative ST depression in the entire population as well as in patients with conclusive tests. The antiischemic medication did not affect correlation values.

Conclusion: QRS score was significantly related to the extent of myocardial ischemia and the severity of coronary heart disease, thus along with the analysis of ST-segment displacement may contribute to the more precise evaluation of exercise testing.

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exercise stress testing; QRS score; cumulative ST depression; stress myocardial perfusion SPECT;
coronary angiography

In developed countries, ischemic heart disease is responsible for a remarkable part of morbidity and mortality.¹ To detect ischemic heart disease in patients with typical or atypical chest pains, exercise stress testing is the most frequently used noninvasive method. The electrocardiographic sign of myocardial ischemia commonly used by most laboratories is the exercise-induced ST-segment displacement.² The value of this marker in the diagnostic process of coronary heart disease is limited

and has been challenged by many investigators.³ A metaanalysis of 147 consecutive studies showed a mean sensitivity of 68% (ranging from 23% to 100%) and a mean specificity of 77% (ranging from 17% to 100%).⁴ Since the late nineteen-seventies, great efforts have been made to improve the efficacy of exercise ECG testing in the identification and quantification of coronary heart disease.⁵⁻¹³

In patients with coronary heart disease (CHD), exercise-induced decrease in Q-wave ampli-

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tude^{3,9,12} and increases in R⁵⁻⁷ and S-wave amplitudes¹³ were found and evaluated in order to determine their diagnostic value either alone or in combination with each other and with ST-segment depression. Since the results regarding the above mentioned studies are conflicting, Michaelides et al. created a new formula called QRS score, in which they incorporated the exercise-induced changes of Q, R, and S-wave amplitudes into a composite index, resulting in higher sensitivity and specificity compared to those of each parameter alone and those of ST depression.³

Our present study was undertaken to relate the QRS score to ST depression and to the results of stress myocardial perfusion SPECT (single photon emission computed tomography) and coronary angiography. We investigated the biological value of the QRS score, determining its use in the assessment of the severity of myocardial ischemia detected by stress myocardial perfusion SPECT and of coronary artery disease detected by coronary angiography, and the diagnostic value of the QRS score determining the threshold best differentiating normals from patients with CHD.

Exercise stress testing regarding ST-segment displacement, unfortunately, has less value in diagnosing ischemic heart disease in females than in males.^{14,15} Thus, the data of males and females concerning QRS score and ST depression were compared to each other and to those of the whole population. Subjects with conclusive test results (reaching 85% of the maximal predicted heart rate) and inconclusive tests were investigated separately in order to judge whether the heart rate has similar impact on the evaluation of the QRS score as on that of the ST segment. The effects of antiischemic medication on the results of exercise testing were also examined.

METHODS

Patients

Two hundred twelve persons (148 males and 64 females, mean age: 52 years) were selected retrospectively to determine the value of the QRS score and the ST-segment depression at the Division of Cardiology of University of Pecs, School of Medicine, Hungary. Within 6 months of the treadmill exercise test, 197 patients underwent stress myocardial perfusion SPECT scintigraphy, 54 were investigated by coronary angiography, provided that

Table 1. Baseline Characteristics of the Study Population

Number of patients	212
Mean age (years)	52
Males	148
Females	64
Stress myocardial perfusion SPECT	197
Coronary angiography	54
Acute myocardial infarction	23
Antiischemic medication	68
β -blocker	39
Ca-antagonist and/or nitrate	64
Digitalis	5
Number of excluded patients	76
Patients with conclusive test results	165
Patients with inconclusive test results	47

in the meantime neither acute myocardial infarction nor revascularization had taken place. Sixty-eight tests were performed under the effect of antiischemic drugs (β -blockers, Ca-antagonists, and nitrates).

Seventy-six subjects of the 212 were excluded from the study because of left bundle branch block, left ventricular hypertrophy, frequent ventricular rhythm disorders, significant ST-segment displacement at rest, or "noisy" real-time ECG at peak exercise (Table 1).

Exercise Testing

All patients performed maximal symptom-limited exercise stress tests on a Marquette Case 15 treadmill according to the Bruce protocol.¹⁶ Blood pressure was measured every 1.5 minutes; 12-lead ECG was continuously monitored during the test and for 5 minutes in the recovery period; ECG print-outs were made at rest, after a minute of hyperventilation, and during the exercise, in erect position. Tests were terminated because of severe angina, shortness of breath, exhaustion, or more than 20 mmHg drop in the blood pressure. When the patient achieved 85% of the maximal predicted heart rate, the exercise was considered conclusive, otherwise inconclusive. The results of conclusive and inconclusive ECGs were evaluated separately. Exercise-induced ST-segment changes were considered ischemic if there was a ≥ 1 mm horizontal or downsloping ST depression, or a ≥ 2 mm upsloping ST depression 60 msec after the J point. The sum of the significant ST depressions in each lead, except for aVR, was given as cumulative ST depression. ST-segment depressions that fulfilled none of the

above-described criteria for ischemic alteration were taken as nonspecific ST-segment changes and thus were not counted in the formula of cumulative ST depression.

The derivation of the QRS score was published by Michaelides et al.³ the postexercise (measured immediately after peak exercise) Q, R, and S-wave amplitudes were subtracted from the preexercise (resting) amplitudes (both measured in upright position), obtaining δQ , δR and δS , respectively. Then the Q and S-wave differences were subtracted from the R-wave difference in leads aVF and V5:

$$\text{QRS score} = (\delta R - \delta Q - \delta S)_{\text{aVF}} + (\delta R - \delta Q - \delta S)_{\text{V5}}$$

QS complexes were treated as either a Q or an S wave. Measurements were taken from the signal-averaged ECG, which was automatically provided by the treadmill computer. The amplitude of the R wave was measured from the isoelectric line (PR segment) to the peak of the R wave; the amplitude of the Q and S waves were measured from the isoelectric line to the notch of the Q and S waves, respectively. The accuracy of the signal averaged beats was supervised by finding an excellent correlation between the mean values of the Q, R, and S-wave amplitudes obtained from five randomly selected consecutive beats and the Q, R, and S-wave amplitude values of the averaged beat ($r = 0.92$, $r = 0.95$, and $r = 0.96$ for Q, R, and S-wave amplitudes, respectively).

Stress Myocardial Perfusion SPECT Scintigraphy

One hundred ninety-seven of our patients underwent stress myocardial perfusion SPECT using ^{99m}Techetium-MIBI for observing the perfusion defects. Two records were made, all in the coronal, sagittal and axial sections: one at rest and the other after a four-minute 0.56 mg/kg dipyridamole stress test. SPECT score was created to evaluate the extent of perfusion defects (Table 2).

Coronary Angiography

Fifty-four patients were examined by coronary angiography. Significant coronary artery stenosis was defined as the presence of more than 75% narrowing of the diameter in either the left anterior descending, left circumflex, right coronary artery, or their major branches. Coronary angiography

Table 2. The Stress Myocardial Perfusion SPECT Score and the Coronary Angiography Score

SPECT Score	
0	No detectable perfusion defect
1	Small, unilocalized transient or permanent perfusion defect
2	Small, multilocalized transient and/or permanent perfusion defect
3	Large, unilocalized transient or permanent perfusion defect
4	Large, multilocalized transient and/or permanent perfusion defect
Coronary Angiography Score	
0	No significant stenosis
1	One-vessel disease
2	Two-vessel disease
3	Three-vessel disease

score was used to describe the severity of coronary artery disease (Table 2).

Statistical Analysis

Statistical analysis was performed by means of mean, standard error of mean, and the Student's *t*-test for paired samples. We gave the values of the sensitivity, specificity and validity of the QRS score and the cumulative ST depression. Finally, the correlation of the following variables was calculated: QRS score, cumulative ST depression, SPECT score characterizing the extent of myocardial ischemia, and the coronary angiography score assessing the severity of coronary artery disease.

RESULTS

The average values of the QRS score and the changes of Q, R, and S waves in leads aVF and V5 at different SPECT and coronary angiography score values can be seen in Table 3. QRS score was significantly lower in patients with detectable myocardial ischemia (SPECT score = 1 - 4) ($P < 0.001$); and there was a decreasing tendency as the extent of perfusion defect increased. The value of QRS score was smaller in patients with coronary artery disease proved by coronary angiography (coronary angiography score = 1 - 3) ($P < 0.01$); and it decreased as the number of obstructed coronary arteries rose.

Table 3. The Changes of QRS Score, Q, R, and S Waves at Different SPECT and Coronary Angiography Score Values (mean $\pm$ SEM)

SPECT Score	QRS Score		δQ	δR	δS
0	5.39 $\pm$ 0.55	aVF:	-0.28 $\pm$ 0.06	1.25 $\pm$ 0.19	-1.44 $\pm$ 0.08
		V ₅ :	-0.52 $\pm$ 0.07	-0.73 $\pm$ 0.31	-2.65 $\pm$ 0.16
1	3.23 $\pm$ 0.71	aVF:	-0.13 $\pm$ 0.10	0.43 $\pm$ 0.28	-1.15 $\pm$ 0.22
		V ₅ :	-0.37 $\pm$ 0.09	-1.51 $\pm$ 0.38	-2.62 $\pm$ 0.22
2	1.50 $\pm$ 2.10	aVF:	0.07 $\pm$ 0.14	0.03 $\pm$ 0.73	-1.14 $\pm$ 0.20
		V ₅ :	-0.14 $\pm$ 0.15	-2.42 $\pm$ 1.13	-2.46 $\pm$ 0.30
3	1.70 $\pm$ 0.92	aVF:	-0.04 $\pm$ 0.13	-0.41 $\pm$ 0.41	-0.79 $\pm$ 0.14
		V ₅ :	-0.31 $\pm$ 0.10	-1.31 $\pm$ 0.55	-2.25 $\pm$ 0.30
4	-0.60 $\pm$ 0.83	aVF:	0.46 $\pm$ 0.13	-0.34 $\pm$ 0.44	-0.69 $\pm$ 0.12
		V ₅ :	0.28 $\pm$ 0.10	-1.28 $\pm$ 0.38	-1.25 $\pm$ 0.29
1-4	-0.60 $\pm$ 0.83				
Coronary Score	QRS Score		δQ	δR	δS
0	4.57 $\pm$ 0.96	aVF:	0.00 $\pm$ 0.13	0.84 $\pm$ 0.40	-1.28 $\pm$ 0.15
		V ₅ :	-0.28 $\pm$ 0.09	-0.86 $\pm$ 0.38	-3.02 $\pm$ 0.36
1	1.35 $\pm$ 1.37	aVF:	-0.30 $\pm$ 0.27	0.75 $\pm$ 0.79	-0.50 $\pm$ 0.24
		V ₅ :	-0.10 $\pm$ 0.26	-1.30 $\pm$ 0.73	-0.90 $\pm$ 0.59
2	0.96 $\pm$ 2.03	aVF:	0.42 $\pm$ 0.16	-0.19 $\pm$ 1.04	-0.84 $\pm$ 0.27
		V ₅ :	0.00 $\pm$ 0.12	-0.65 $\pm$ 0.82	-1.69 $\pm$ 0.41
3	-0.81 $\pm$ 3.72	aVF:	0.68 $\pm$ 0.40	-0.93 $\pm$ 1.32	-0.87 $\pm$ 0.27
		V ₅ :	0.43 $\pm$ 0.23	-1.00 $\pm$ 1.83	-1.37 $\pm$ 0.94
1-3	-0.60 $\pm$ 0.83				

Significant, reverse correlation was found between the QRS score and the perfusion disorders detected by stress myocardial perfusion SPECT, and the severity of the coronary artery disease visualized by catheterization. This correlation was better in males, while females had no significant relationship. In this study, cumulative ST depression did not correlate significantly with the QRS score, stress myocardial perfusion SPECT, nor coronary angiography (Table 4).

The sensitivity and specificity of the QRS score and the cumulative ST depression were determined at different cut-off points referring to the results of stress myocardial perfusion SPECT and coronary angiography (Fig. 1). The optimal cut-off point of the QRS score was 3.5 mm concerning the SPECT findings and 2.5 mm concerning the coronary status. The value of the cumulative ST depression best differentiating normals from patients was 6 mm in both methods. The sensitivity, specificity, and validity of the QRS score and cumulative ST depression are shown in Table 5. QRS score showed higher values than cumulative ST depression in each parameter, not only at the aspect of myo-

cardium perfusion SPECT but coronary angiography.

The separate examination of conclusive and inconclusive results showed that QRS score in persons with conclusive tests was correlated significantly with the results of stress myocardial perfusion SPECT and coronary angiography; nevertheless, in cases of inconclusive tests this issue was not proven (Table 4). The specificity of the QRS score in relation with myocardial perfusion SPECT in the group of inconclusive tests was markedly lower than in the group of conclusive tests and in the whole population; otherwise the diagnostic value of the QRS score concerning the coronary angiography in patients with inconclusive exercise was not markedly different from that of patients with conclusive tests (Table 5).

Similar correlation between the QRS score and the severity of myocardial ischemia was found in subjects under the effect of antiischemic drugs and in subjects without any medication (Table 4). Therefore, QRS score seems to be in line with perfusion defects in patients taking medication, as well.

Table 4. Correlation Values and Level of Significance in Entire Study Population, in Males and Females, in Patients with Conclusive and Inconclusive Test Results, and in Patients With and Without Antiischemic Medication

Study Population	Correlation Coefficient
QRS score – SPECT score	–0.40†
QRS score – coronary angiography score	–0.30‡
QRS score – cumulative ST	0.10
SPECT score – coronary angiography score	0.44†
Cumulative ST – SPECT score	–0.02
Cumulative ST – coronary angiography score	–0.08
Males (n = 148)	
QRS score – SPECT score	–0.43†
QRS score – coronary angiography score	–0.40†
Females (n = 64)	
QRS score – SPECT score	–0.22
QRS score – coronary angiography score	–0.18
Patients with conclusive test results (n = 165)	
QRS score – SPECT score	–0.42†
QRS score – coronary angiography score	–0.36§
Cumulative ST – SPECT score	0.04
Patients with inconclusive test results (n = 47)	
QRS score – SPECT score	–0.31§
QRS score – coronary angiography score	–0.18
Cumulative ST – SPECT score	0.23
Patients with antiischemic medication (n = 58)	
QRS score – SPECT score	–0.40†
Patients without antiischemic medication (n = 139)	
QRS score – SPECT score	–0.38†

† P < 0.01; ‡ P < 0.02; § P < 0.05.

DISCUSSION

A new exercise index called QRS score was recently published by Michaelides et al., which includes the exercise-induced changes in Q, R, and S waves during a treadmill exercise stress test.^{3,17,18} According to our findings, QRS score exhibited the following properties: the score reversely correlated with the extent of myocardial ischemia and with the number of obstructed coronary arteries; it had no significant correlation with the exercise-induced changes in ST segment.

ST-segment displacement has been the most frequently used parameter for anticipating ischemia during exercise stress testing, although its accuracy is challenged by many investigators.^{2,4-6} Several studies tried to improve the diagnostic value of exercise testing applying Bayes's theorem by combining more ECG and non-ECG parameters.^{2,5,6} The basis of these parameters is either upon exercise-induced changes in ST segment (ST/heart rate index, ST/heart rate slope, ST integral, treadmill

exercise score published by Hollenberg et al.),¹⁹ or on multivariate analysis of some ECG (duration of ST depression, changes in R wave, heart rate) and non-ECG data (sex, anginal complaints, systolic blood pressure),⁵ or upon exercise-induced changes in Q, R, or S-wave amplitudes.⁵⁻¹³

Since methods based on ST-segment displacement are complicated and not applicable to patients with CHD not having ST depression during exercise,³ some researchers turned towards the above mentioned changes of QRS complex. Michaelides et al. assumed that the incorporation of the changes of single waves into a compound formula could result in higher sensitivity and specificity.^{3,17} Our present study was undertaken to evaluate the hypothesis that QRS score has its place in the diagnostic process of patients with ischemic heart disease.

Our data are in concordance with those of the literature concerning the individual exercise-induced changes in Q, R, and S waves. The ampli-

Figure 1. Sensitivity and specificity of the QRS score and cumulative ST depression at different cut-off points.

tude of Q wave during exercise mostly increased in normals and failed to increase in patients with CHD. The mechanism of this difference may originate from abnormal septal activation in patients due to the narrowing of left anterior descending artery followed by loss of contraction in the septal region.^{3,9,12}

The R wave decreased in normals and generally increased or remained unchanged in patients.^{3,5-8,10,11,18} The first explanation for this was the so-called Brody effect.²⁰ Accordingly, in patients with reduced myocardial contractility, the intracavitary volume of left ventricle can become bigger and consequently the myocardial mass can increase causing a higher R wave.^{8,10,11} In contrast, experiments with animals showed a biphasic change in the size of R wave during ischemia: a decrease in the first 30 seconds and an increment afterwards. There is a similar biphasic pattern in intramyocardial conduction: in the first 30 seconds the conduction velocity shows an incremental phase and then it slows down. The two phenomena thus have the same tendency and it is thought to be

a causal relationship between them. Moreover, in experimental model after coronary artery ligation, the end-diastolic diameter and pressure of left ventricle increased and cardiac output decreased.⁷

The molecular mechanism of the abovementioned alterations may be a progressive elevation in extracellular potassium concentration, which at first enhances conductivity and later reduces it.^{3,7} In addition, a study on patients with variant angina pectoris suggests that changes in the conductivity of the ischemic zone can be responsible for the R-wave alterations written above instead of the monophasic increase in intraventricular volume.⁸

The amplitude of S wave increased both in normals and patients with CHD, but this change seemed to be bigger in normals. According to literature data, changes in S wave are not in relation with those in R waves, but could be related to those of ST segment, and may be a sign of subendocardial ischemia.^{3,13}

Our findings match those of previous studies;^{3,17,18} QRS score was inversely related to the extent of perfusion defects detected by stress myocardial perfusion SPECT and to the severity of coronary artery disease visualized by coronary angiography. The moderate but significant correlation could be due to the fact that the continuous variable of QRS score was compared with two variables (SPECT score: from 0 to 4 and coronary angiography score: from 0 to 3), which did not allow the subtle classification of myocardial ischemia and coronary artery disease and thus slight differences could be covered. Michaelides et al. found significant correlation between the QRS score and the myocardial ischemia detected by stress myocardial perfusion SPECT, the segmental wall-motion defects shown by radionuclide ventriculography and the number of obstructed coronary arteries proven by coronary angiography. But this correlation was stronger with the results of stress myocardial perfusion scintigraphy and ventriculography than with the angiography.¹⁷

The sensitivity, specificity, and validity of the QRS score surpassed those of cumulative ST depression in relation to stress SPECT and coronary angiography. Therefore the QRS score can differentiate better between normals and patients with myocardial perfusion disorders as compared to cumulative ST depression. QRS score was unrelated to the exercise-induced ST-segment displacement, therefore it can be helpful in finding patients with

Table 5. Diagnostic Values (Sensitivity, Specificity, and Validity) of QRS Score and Cumulative ST Depression Regarding Stress Myocardial Perfusion SPECT and Coronary Angiography in Entire Population, in Males, in Females, in Patients with Conclusive and Inconclusive Tests

QRS Score (Cut-off Point = 3.5 mm)—Stress Myocardial Perfusion SPECT					
	Entire Population	Males	Females	Conclusive Test	Inconclusive Test
Sensitivity %	73.5	75.5	50.0	72.8	76.9
Specificity %	71.3	73.3	71.4	75.0	50.0
Validity %	72.6	74.8	61.5	73.8	68.4
Cumulative ST Depression (Cut-off Point = 6 mm)—Stress Myocardial Perfusion SPECT					
	Entire Population	Males	Females	Conclusive Test	Inconclusive Test
Sensitivity %	49.6	48.9	52.2	54.4	30.8
Specificity %	56.3	60.0	51.4	57.4	50.0
Validity %	52.3	52.5	51.7	55.6	36.8
QRS Score (Cut-off Point = 2.5 mm)—Coronary Angiography					
	Entire Population	Males	Females	Conclusive Test	Inconclusive Test
Sensitivity %	61.3	64.0	50.0	57.9	66.7
Specificity %	65.2	62.5	71.4	61.5	70.0
Validity %	63.0	63.4	61.5	59.4	68.2
Cumulative ST Depression (Cut-off Point = 6 mm)—Coronary Angiography					
	Entire Population	Males	Females	Conclusive Test	Inconclusive Test
Sensitivity %	51.6	56.0	33.3	52.6	50.0
Specificity %	39.1	37.5	42.9	23.1	60.0
Validity %	46.3	48.8	38.5	40.6	54.5

false negative exercise test regarding ST depression. The mechanism of the decrease of QRS score in patients is not clear; however, it shows similar patterns both in patients with and without ST-segment changes, which suggests that besides myocardial ischemia there are some other factors influencing its value, e.g., axis shift, left ventricular dysfunction and enlargement.³

In the current study, the above-mentioned relations were valid primarily in males, on the contrary, the utility of the QRS score—similarly to that of ST depression—is limited in females. Especially in females of 30 to 50 years of age, exercise testing gives false results more frequently than in males of the same age. Numerous studies tried to overcome this problem. Gender-specific criteria in the evaluation of the magnitude of ST depression could not improve the diagnostic accuracy of exercise ECG in

women. Applying heart rate-adjusted modalities, such as ST/heart rate index or ST/heart rate slope, resulted in similar test performances in both sexes; thus ST/heart rate index even without gender-specific criteria can significantly augment prognostication in women compared with standard ST depression criteria. In addition, the use of ST/heart rate slope method with gender-specific criteria provided the best outcome of the clinical decision making in female patients with respect to exercise testing.¹⁴

We found optimal cut-off points for QRS score (3.5 mm) and cumulative ST depression (6 mm) different from those of previous studies (QRS score: 5 mm, cumulative ST depression: 2 mm).^{3,17,18} The latter values resulted in high sensitivity, but low specificity regarding both QRS score and cumulative ST depression. In our study, cumu-

lative ST depression did not correlate significantly with QRS score, stress myocardial perfusion SPECT, and coronary angiography, either. It can be supposed that our study population consisted of patients mostly with severe CHD and only a minority of normals, because patients with positive exercise tests were primarily sent on to more expensive and more invasive examinations (SPECT and coronary angiography) and, on the other hand, a healthy group verified by invasive methods could not be established for ethical principles. For this reason the proportion of subjects with negative test results was relatively low (23%), and a part of subjects with positive test results was false positive, thus stress myocardial perfusion SPECT and coronary angiography were to justify the presence or absence of ischemic heart disease.

In conclusion, our study group represented a more severely symptomatic segment of the workup population for ischemic heart disease without a comparable number of healthy normals. This led to the difference of the optimal cut-off points in QRS score and cumulative ST depression related to previous examinations. This also makes sensitivity and specificity for simple identification of ischemic heart disease less stable and is likely to differ in the less selected overall population. Finally, in clinical practice, the optimal cut-off points for certain variables are to be adjusted in each direction to achieve higher sensitivity or even specificity values as required.

QRS score showed significant correlation with stress myocardial perfusion SPECT and coronary angiography in patients with conclusive test results, but we could not find a similar relationship in patients with inconclusive tests, which is in contrast with the results of Michaelides et al.³ However, the sensitivity of QRS score was unaltered in the inconclusive group, its specificity was much lower, probably because in this group there were only few persons with true negative test results. These patients with inconclusive tests could have more severe disease and the anginal complaints could cause the early termination of the test. In our opinion, the achievement of 85% of the maximal predicted heart rate during exercise stress test is necessary for the proper evaluation of QRS score as well as ST depression.

QRS score exhibited similar correlation with myocardial ischemia both in patients with and without antiischemic medication. The question can arise whether β -blockade increases the number of

inconclusive tests. In our study, out of 47 inconclusive tests, 16 were in β -blockade, and out of 39 tests in β -blockade, 16 resulted in inconclusive outcome. Otherwise, a 1-week treatment with β -blockers, reported by van Campen et al., could improve the value of the QRS score.¹⁸

CONCLUSIONS

According to our findings, the incorporation of the individual changes of QRS complex into a composite expression, called QRS score, can improve the biological and diagnostic accuracy of exercise testing. QRS score correlated inversely and significantly with myocardial ischemia and coronary artery disease, therefore this score along with ST-segment displacement may be of importance in obtaining more precise information from exercise stress testing in identification and quantification of ischemic heart disease.

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