The Effect of Exercise to P Wave Dispersion and Its Evaluation as a Predictor of Atrial Fibrillation

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Aim: Prolongation of P wave time and increase of its dispersion as an independent predictor of atrial fibrillation. In patients with paroxysmal atrial fibrillation (PAF) as in healthy people, exercise augments sympathetic activity and therefore can cause the development of atrial fibrillation. The aim of this study is to evaluate the effect of exercise on P wave dispersion and to predict the development of atrial fibrillation.

Methods: One hundred and ninety-eight patients (93 women, 105 men, mean age: 59.05 ± 11.01 years) having the diagnosis of PAF were included in the study. The left atrial diameter of all these patients was more than 4.0 cm. One hundred and fifty-five patients (72 females, 83 males, mean age: 58.41 ± 10.79 years), with left atrial diameter more than 4.0 cm and without PAF were taken as control group. Symptom limited exercise test with modified Bruce protocol was performed on all patients. Rest, maximum exercise and recovery, and first, third, and fifth-minute 12-derivation ECG was taken in all patients. The velocity of ECG was adjusted to 50 mm/s; shortest and largest P wave durations were measured and P wave dispersion was calculated.

Results: The mean left atrial diameter was 4.41 ± 0.58 cm in PAF patients and 4.38 ± 0.48 cm in control group. No differences were found between PAF patients with the controls in exercise time (10.38 ± 2.93 vs 10.81 ± 2.75 minutes); METs (6.98 ± 1.72 vs 7.28 ± 1.75 minutes); resting heart rate (79.13 ± 14.86 vs 79.69 ± 10.43 bpm); peak heart rate (146.83 ± 23.21 vs 146.94 ± 16.13 bpm). Maximum exercise P wave duration and P wave dispersion were greater than the rest measurements in PAF group (respectively $P < 0.0001$ and $P = 0.0004$).

Conclusion: In PAF patients, P wave dispersion is significantly longer at rest, maximum exercise and recovery time than in a control group without PAF.

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Atrial fibrillation (AF) is the most common sustained arrhythmia encountered in clinical practice. Barbier¹ reported that a significant relationship between the development of AF in hypertensive patients and increase in the diameter of the left atrium was found. Due to the morphological changes in the left atrium caused by different reasons, especially the increase in the diameter of the left atrium, the electrical stimulation cannot be conducted homogeneously in the left atrium and thus AF develops.^{1–4} The presence of nonhomogenous conduction in the left atrium can be shown with the P wave dispersion.^{5,6}

The duration of the P wave in resting state is less than 0.12 seconds. The sympathetic nervous system becomes active in healthy people during exercise and this causes an increase in the heart rate. As a result of the increase in the heart rate, the duration of the P wave also decreases.⁷ In patients with AF, it is known that the heart rate response to exercise is higher.^{8–10} However, in patients whose rhythm was corrected to the normal sinus rhythm, the heart rate response is similar to the responses of the healthy people. In the studies conducted so far, the relationship between the development of AF and the P wave dispersion has been evaluated

in the resting ECG. The purpose of our study is to investigate the effect of exercise on the P wave dispersion and the value of exercise in anticipating the development of AF.

MATERIALS AND METHODS

One hundred and ninety-two consecutive AF patients (102 male, 90 female, mean age: 59.04 ± 11.01 years), left atrium diameter > 4.0 cm, successfully converted to sinus rhythm, who did not have any physical defects which interfered with exercise and 155 consecutive cases (53 male, 72 female, mean age: 58.41 ± 10.79 years) whose left atrium diameters were again > 4.0 cm and who had never experienced any AF attacks were included in the study. The patients who experienced AF attacks, which lasted less than 48 hours, were excluded. The control group had no evidence of cardiac or other disease due to the absence of significant abnormality at the history, physical examination, ECG, chest radiogram and no evidence of symptomatic tachyarrhythmia.

Echocardiography: All the patients were examined with transthoracic echocardiography by using a 2.5 MHz prop with Acuson Sequa echocardiographic device. The left atrium and the left ventricle diameters, left ventricular ejection fraction, mitral insufficiency, calcification of the mitral ring and the mitral valve were evaluated.

Exercise Test: All the patients underwent treadmill exercise testing using Marquette Case 15 device and to all patients the modified Bruce protocol was applied. The tests were applied 2–3 hours after the last meal and the last cigarette in the patients who continued to smoke. In the resting period before the test, ECG was recorded while the patients were standing on the treadmill. During the exercise test, the V_2 – V_4 – V_6 derivations were continuously observed from the monitor. ECG was recorded after the end of each stage of the exercise. Full ECG was carried out after 1, 3, and 5 minutes, following the exercise. All the ECGs were recorded with the speed of 50 mm/s and with the amplitude of 1 mV/cm. AF patients cardioverted to SR were under antiarrhythmic prophylaxis (4×200 mg quinine). All exercise tests were performed in 2 days after CV. There were 6 patients that experienced AF during exercise test. These patients were excluded from the study.

Electrocardiographical Evaluation: The 12-lead ECG was recorded at a paper speed of 50 mm/s and

1 mV/cm standardization. The P wave duration was calculated in all 12 leads of surface ECG simultaneously recorded. The beginning of the P wave was accepted as the intersection point of the upward deflection of the P wave and the isoelectrical line and the end of the P wave was accepted as the intersection point where the deflection of the wave ends and the isoelectrical line.¹¹ The measurements of P wave duration were performed by two investigators without knowledge of patient assignments by using calipers and magnifying lens (10-fold magnification) for defining the ECG deflections. The difference between the maximum P wave duration and the minimum P wave duration from the 12-lead ECG was defined as the P wave dispersion. The intraobserver and interobserver mean percent error for maximum and minimum measurements were determined in study participants and were $< 2\%$ for P maximum and $< 4\%$ for P minimum.

Statistical Analysis: All numerical values were evaluated using the unpaired Student's *t*-test by calculating mean $\pm$ standard deviation. The comparison of the genders and the etiological factors were made by using the χ^2 test. P value was considered statistically significant if smaller than 0.05.

RESULTS

There were no significant differences between the AF group and the control group with respect to age, gender and the etiological factors. The etiological characteristics of the patients are shown in Table 1. The mean duration of AF which the patients with AF experienced was 93.52 ± 72.63 days.

The mean left atrium diameter that was measured using echocardiography was 4.41 ± 0.58 cm in the AF cases and 4.38 ± 0.48 cm in the control group. No significant difference was found between the two groups with respect to the diameter of the left atrium. The other echocardiographical parameters are shown in Table 2.

P wave durations and P wave dispersions of the study patients during the treadmill exercise test are shown in Table 3. No significant differences were found between the two groups with respect to the length of the exercise period, MET value and heart rates in the resting, maximum exercise, and recovery periods.

When the lengths of the P waves were compared, P-max was significantly longer than in the AF group in all the phases of the resting, maximum exercise, and the recovery periods ($P < 0.0001$ for all). No

Table 1. The Clinical Parameters of the Study Patients

	PAF ^a Patients (n = 192)	Sinus Rhythm Patients (n = 155)	P value
Female/Male	90/102	72/53	NS ^b
Mean age (year)	59.04 ± 11.01	58.41 ± 10.79	NS
Valvular heart disease	34	40	NS
Hypertension	92	88	NS
Coronary artery disease	38	32	NS
Heart failure	29	31	NS
Diabetes mellitus (type II)	10	6	NS

^aPAF: Paroxysmal atrial fibrillation.^bNS: Nonsignificant (P > 0.05).

statistically significant differences were found between the two groups with respect to the P-min values in the first minute of the resting, maximum exercise, and recovery periods. A gradually increasing significant difference was detected in the third and fifth minutes of the recovery period (P = 0.02 and P < 0.0001, respectively).

When the P wave dispersion was examined, it was found to be significantly more in the AF group in both the maximum exercise period and in all the recovery periods (P < 0.0001 for all). Furthermore, when it is compared among itself, the AF group showed a very significant increase in the P-max duration and the P wave dispersion in the maximal exercise period when compared with the resting period in all phases (P < 0.0001 and P = 0.0004, respectively).

DISCUSSION

While the relationship between the diameter of the left atrium and AF development is not clearly known, the disturbance of the homogeneity of the electrical conduction by the dilatation of atrium is shown as the most important reason of the AF de-

velopment. Another explanation for this is that AF causes left atrial dilatation by disturbing the functions of the left atrium.¹²⁻¹⁵ Ökçün et al.² detected a significant relationship between the diameter of left ventricle and the length of sinus rhythm when they converted nonvalvular AF cases that have stayed more than 48 hours to sinus rhythm. Again, in the same study, the short-term recurrence of AF following cardioversion was shown to be related to the duration of AF before the correction. In their studies Dittrich et al.⁴ and Dethy et al.¹⁶ reported that the duration of AF and the left atrium diameter were important parameters in the maintenance of sinus rhythm after cardioversion. Barbier et al.¹ suggested that the left atrium diameters in the hypertensive patients who developed AF were larger and that this dilatation caused P-min to shorten and thus the dispersion of the P wave to increase. Finally, all of these studies support the association between the left atrium diameter and AF.

In some published data the P wave dispersion was reported to be an important parameter in anticipating the development of paroxysmal AF. It is started that it is a significant finding in detecting both the patients with AF and in the patients

Table 2. The Echocardiographic Parameters of the Study Patients

	PAF Patients (n = 192)	Sinus Rhythm Patients (n = 155)	P value
Left atrium diameter (cm)	4.41 ± 0.58	4.38 ± 0.48	NS
Left ventricle diameter (cm)	5.78 ± 0.55	5.75 ± 0.61	NS
Left ventricular ejection fraction (%)	54.04 ± 11.13	55.22 ± 12.05	NS
Mitral valve prolapse	5	3	NS
Mitral annular calcification	22	18	NS

PAF: Paroxysmal atrial fibrillation.

NS: Nonsignificant (P > 0.05).

Table 3. P-wave Durations and P-wave Dispersions of the Study Patients During the Treadmill Exercise Test

	PAF Patients (n = 192)	Sinus Rhythm Patients (n = 155)	P value
Exercise duration (min)	10.38 ± 2.93	10.81 ± 2.75	NS
MET value	6.98 ± 1.72	7.28 ± 1.75	NS
Rest			
Heart rate (beat/min)	79.13 ± 14.86	79.69 ± 10.43	NS
P-max wave duration (ms)	115.05 ± 3.02	94.01 ± 2.30	<0.0001
P-min wave duration (ms)	41.09 ± 1.71	42.04 ± 1.21	NS
P wave dispersion (ms)	75.11 ± 3.10	52.12 ± 2.02	<0.0001
Peak exercise			
Heart rate (beat/min)	146.83 ± 23.21	146.94 ± 16.13	NS
P-max wave duration (ms)	112.30 ± 1.01	92.10 ± 3.00	0.017
P-min wave duration (ms)	44.10 ± 6.00	42.04 ± 2.00	NS
P wave dispersion (ms)	69.00 ± 1.21	53.01 ± 2.31	<0.0001
Recovery 1			
Heart rate (beat/min)	126.35 ± 18.57	127.70 ± 12.91	NS
P-max wave duration (ms)	108.00 ± 3.01	86.01 ± 2.30	<0.0001
P-min wave duration (ms)	41.01 ± 5.40	42.02 ± 1.41	NS
P wave dispersion (ms)	69.02 ± 6.10	45.00 ± 2.00	<0.0001
Recovery 3			
Heart rate (beat/min)	108.97 ± 15.57	107.93 ± 10.30	NS
P-max wave duration (ms)	113.01 ± 2.50	93.00 ± 2.31	<0.0001
P-min wave duration (ms)	37.00 ± 1.50	41.02 ± 1.70	0.02
P wave dispersion (ms)	76.05 ± 2.60	54.00 ± 2.00	<0.0001
Recovery 5 HR (beat/min)			
Heart rate (beat/min)	88.07 ± 12.28	86.33 ± 9.03	NS
P-max wave duration (ms)	111.08 ± 2.71	89.01 ± 2.40	<0.0001
P-min wave duration (ms)	41.07 ± 1.40	34.00 ± 1.10	<0.0001
P wave dispersion (ms)	70.10 ± 2.60	55.00 ± 2.50	<0.0001

PAF: Paroxysmal atrial fibrillation.

NS: Non significant (P > 0.05).

who may develop AF after coronary artery bypass surgery.^{17,18} Chang et al.¹⁹ suggested that in patients who had coronary artery bypass surgery, age, gender and prolonged P wave were independent determinants as AF predictors. Tsikouris et al.²⁰ reported that P-max prolonged significantly after open heart surgery, thus the P wave dispersion increased, this was very significant in the 1–3 days of the operation and this was the period in which AF was seen most frequently. In their study Dilaveris et al.⁵ demonstrated that the resting state P wave dispersion of the patients with a history of AF was longer when compared with the patients who did not have a history of AF and they found that this prolongation was associated with the excessive shortening of P-min in the patients with AF. Similarly, Tükek et al.⁶ reported that in the patients with AF, the P wave dispersion was significantly prolonged when compared with the patients

who had sinus rhythm and that this demonstrated a linear correlation with increase in the left atrium diameter.

In our study, by including the cases with left atrium diameter of >4.0 cm in both groups, its possible effect on the P wave dispersion has been eliminated. When the two groups, which did not show any significant difference in heart rate in the resting state ECG, were compared, P-max and the P wave dispersion was found significantly prolonged in the cases with AF and this was consistent with other data in the literature.^{20,21} In our study, in addition to this relationship, P-max and P wave dispersion showed an extremely significant increase in the maximum exercise period when compared with the values obtained during the resting period, and this was a much more important finding. Because there exist no published data on the exercise P wave dispersion in the literature, it was

impossible to discuss these results. Although, no marked difference was found in the control group during exercise, a significant increase in the P-min values was also observed in the AF group in the maximum exercise period. So with this study the opinion that the determination of P-max and the P dispersion values after the exercise test could be extremely useful in anticipating the development of AF, has arisen. However, we believe that these conclusions should be supported with similar studies, which will be designed in the future.

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