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Relationship between simple electrocardiographic parameter and paroxysmal atrial fibrillation

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Original Article

Abstract

BACKGROUND: Atrial fibrillation (AF) is a prevalent arrhythmia, and predicting its occurrence plays a crucial role in reducing its complications. This study aimed to investigate the relation between simple P wave parameters and paroxysmal AF (pAF).

METHODS: In this case-control study, demographic and laboratory data were gathered by a checklist. P wave parameters were measured in electrocardiography (ECG). The relationship between these parameters and AF in groups was analyzed.

RESULTS: Eighty individuals were included (40 patients with pAF (57.5% female, mean age = 64.9 ± 2.04) and 40 individuals without AF (57.5% female, mean age = 60.3 ± 2.01)). The P wave peak time (PWPT) in leads D2 (p = 0.003) and V1 (p = 0.001) were longer in the case group. In addition, the prolongation of the PR interval (PR) in lead D2, P wave duration (PWD) in lead D2, and P terminal force (PTF) in V1 were associated with an increase in the occurrence of pAF. Adjusted regression analysis showed that two variables, PWPT in V1 (OR, 95% CI: 1.04 (1.01-1.07), p = 0.005) and PWD in D2 (OR, 95% CI: 1.03 (1.00-1.05), p = 0.018), were predictors for AF.

CONCLUSION: Our results underscore the potential utility of simple ECG parameters, especially PWD in lead D2 and PWPT in V1, in predicting and assessing the risk of pAF. These findings provide valuable insights for clinical practice and risk stratification in patients without structural cardiac disease. Additionally, these findings may potentially contribute to the prevention of complications and injuries associated with pAF.

Keywords: Humans; Adult; Heart Diseases; Arrhythmias, Cardiac

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Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia, and about 30 million people suffer from it worldwide[1]. The annual mortality rate in patients with AF is about 23 to 27%, which is considerably higher compared to people of the same age without a history of this disease. It relates to reduced quality of life, increased mortality, left ventricular dysfunction, heart failure, and thromboembolic events[2].

About one-third of the total AF population is asymptomatic. The diagnosis of AF has become crucial in the last decades[3] because identifying people at high risk of AF facilitates screening programs and preventive measures in high-risk individuals[4]. Electrocardiography (ECG) is a simple, cost-effective, and non-invasive modality for diagnosing cardiovascular diseases and has excellent potential to estimate the risk of AF[5,6]. The P wave is the

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most reliable marker of atrial repolarization, and the indices of this wave are considered quantitative indices of atrial electrical activity[7,8].

Based on previous studies, various parameters of the P wave, including P wave duration (PWD), P wave dispersion, P wave terminal force in lead V1 (PTF V1), P wave voltage, and P wave axis, can predict AF[9-12]. Even the PR interval has been used for this purpose[13]. Additionally, P wave peak time (PWPT) has been introduced as a new P wave parameter, and some studies have shown its association with cardiovascular events. Previous research also found that PWPT was longer in patients with paroxysmal atrial fibrillation (pAF) than in the control group[5]. Due to the shortage of evidence and thorough studies on this critical issue, we aimed to compare the potential of P wave parameters, such as PWPT, to detect pAF and predict AF.

Materials and Methods

Study design and patient selection

This case-control study assessed 80 adults from April 2021 to December 2021. Among them, 40 patients with pAF were considered the case group. They were those who had AF for less than seven days during hospitalization at X. AF was diagnosed by the irregular R-R interval and the absence of separate and repetitive P waves in every 12 leads of an electrocardiogram. We only included patients with normal sinus rhythm after an AF attack. The control group consisted of 40 individuals without a history of AF who referred to the heart clinic on an outpatient basis. The groups were matched regarding age and sex.

Participants with electrolyte disorders, uncontrolled thyroid disease, chronic liver disease, acute or chronic infection, moderate to severe valve disorders, congenital heart diseases, inter-ventricular conduction block (QRS more than 120 ms), pre-excitation syndrome, and those taking antiarrhythmic drugs or other drugs affecting the P wave and PR segment were excluded. Data were gathered using a checklist that included demographic characteristics and the medical history of all participants. All blood samples were taken after eight hours of fasting, and laboratory parameters were examined in a single laboratory.

Ethical considerations

The ethics committee of the Vice-Chancellor of Research at Guilan University of Medical Sciences approved this study (Ethical code: IR.GUMS.REC.1400.088, Date: 2021-06-02). This study was part of a thesis for the Degree of MD. Written informed consent was obtained from the participants.

ECG measurements

A 12-lead ECG was taken after calibration at 10 mm/mV and a speed of 25 mm/s, and P wave indices were measured. All measurements were done by a physician twice, after scanning and magnifying the ECG papers and using precision measuring equipment.

In this study, the parameters of the PR interval in lead D2 (PR D2) and lead V1 (PR V1), PWD in lead D2 (PWD D2), PTF V1, and PWPT in lead D2 (PWPT D2) and lead V1 (PWPT V1) were measured. PWD was calculated by measuring the interval between the onset and end of the P wave. The PR interval was defined as the duration between the beginning of the P wave and the QRS complex. PTF V1 is another index calculated by multiplying the depth by the duration of the negative terminal segment of the P wave in lead V1. PWPT is also a new parameter, defined as the interval between the onset of the P wave and the peak of this wave in leads D2 and V1. In lead V1 with negative or biphasic P waves, in which the negative segments were more than 0.1 mV, the interval between the onset of the P wave and the negative peak of the wave was considered (Figure 1).

Statistical analysis

IBM SPSS Statistics for Windows, Version 22.0, was used to analyze the data. Tables and figures were utilized to describe the data. Mean and standard deviation were used to describe quantitative data, and frequency and percent were used to describe qualitative data. To examine the relationship between the normally distributed quantitative variables (checked with the Shapiro-Wilk test), the T-test was used. For non-normal variables, the Mann-Whitney U test was employed. Qualitative data were compared by chi-square and Fisher's exact test. To determine the AF predictors, the logistic regression model (Logistic Backward method) was used. The

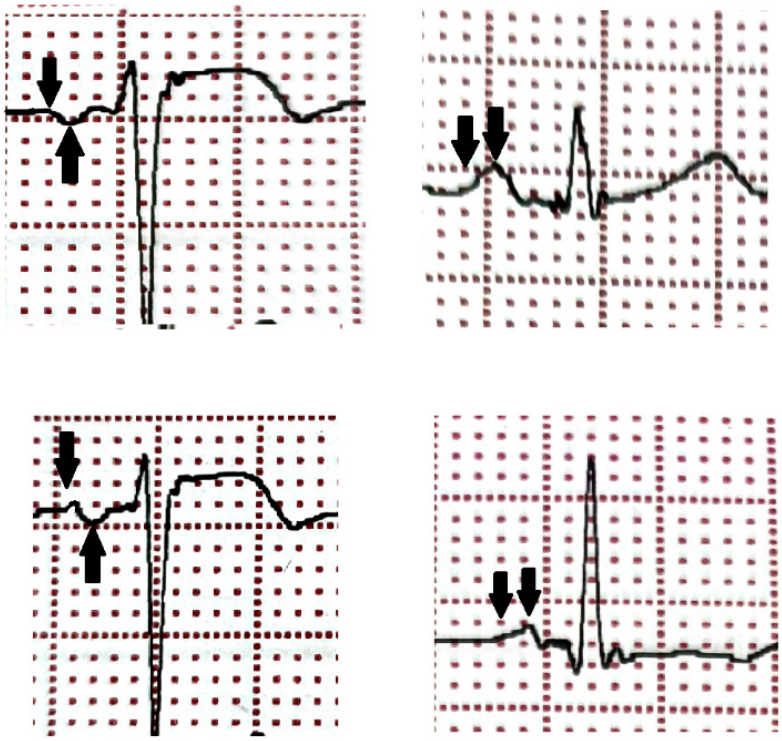


Fig. 1. Measurement of PWPT.

Receiver Operating Characteristics (ROC) curve was designated to determine the area under the curve (AUC) and cut-off point. A P-value < 0.05 was considered statistically significant.

Results

We examined 80 individuals, including 40 patients with pAF in the case group and 40 individuals without a clinical history of AF in the control group. In both the case and control groups, 57.5% were female. The mean age in the AF group was 64 ± 12, and in the control group, it was 60 ± 12 (P = 0.109). Results showed no significant difference between the groups regarding hypertension, cardiovascular events, cerebrovascular events, and smoking. Additionally, laboratory variables were analyzed in both groups (Table 1).

Among ECG parameters, PR D2 (196.00±29.33 vs. 184.00±25.70, p=0.006), PWD D2 (95.60±23.29 vs. 81.25±19.63, P=0.003), PTF V1 (54.35±31.01 vs. 38.25±23.49, P=0.022), PWPT D2 (49.55±20.17vs. 41.25±19.24, P=0.024), and PWPT V1 (45.75±22.83 vs. 30.62±16.37, P=0.001) were significantly longer in the case group. However, the PR V1 was not significantly different between the two groups (Table 2).

PWPT D2 (50.95±23.02 vs. 36.95±16.63, P=0.005) and PWPT V1 (43.30±20.63 vs. 26.73±14.50, P=0.002) were significantly longer in the females' case than the control group. Still, no significant relationship was found between the PWPT and the pAF in males (Table 3).

Based on Table 4, in the unadjusted regression model, only PWPT V1 (OR, 95%CI: 1.03 (1.00-1.05), p = 0.029) was the predictor for AF, but in the adjusted model for all other variables (demographic characteristic, past medical history and laboratory variables), PWPT V1 (OR, 95%CI: 1.04 (1.01 -1.07), p = 0.005) and PWD D2 (OR, 95%CI: : 1.03 (1.00-1.05), p = 0.018) were the predictors (Table 5).

Based on the ROC curve, the AUC was 0.712 for PWPT V1 and 0.684 for PWD D2 (Figure 2). The cut-off point for predicting AF was 38msc for PWPT V1 (sensitivity and specificity of 62.5 %) and 85msc for PWD D2 (sensitivity and specificity of 57.5% and 72.5%) (Table 6).

Discussion

Despite the significantly longer duration of most of

Table 1. Demographic and laboratory characteristics of individuals with and without AF

Variables		Case group (n=40)	Control group (n=40)	P-value
Blood sugar (mg/dl)	**mean±SD**	151.47 ± 73.55	147.27 ± 67.05	0.617****
	median (Q1-Q3)	127.00 (114.00 - 156.50)	124.00 (112.25-154.50)	
Na (mmol.dl)	**mean±SD**	137.77 ± 4.81	137.80 ± 3.69	0.946****
	median (Q1-Q3)	138.00 (136.00 – 139.00)	138.00 (136.25-139.75)	
K (mmol.dl; mean±SD)		3.89 ± 0.47	3.88 ±0.40	0.960****
Ca (mg/dl)	**mean±SD**	9.29 ± 0.53	9.28 ± 0.49	0.889****
	median (Q1-Q3)	9.25 (8.82-9.77)	9.30 (8.80-9.70)	
Mg (mg/dl)	**mean±SD**	2.12 ± 0.48	2.11 ± 0.44	0.903****
	median (Q1-Q3)	2.00 (1.80-2.20)	2.00 (1.80-2.20)	
BUN (mg/dl)	**mean±SD**	20.65 ± 10.73	20.10 ± 9.88	0.776****
	median (Q1-Q3)	18.00 (13.00-22.75)	18.00 (13.00-22.75)	
Creatinine (mg/dl)	**mean±SD**	1.02 ± 0.37	0.99 ± 0.32	0.534****
	median (Q1-Q3)	0.94 (0.80-1.13)	0.93 (.80-1.10)	
HDL-C (mg/dl; mean±SD)	**mean±SD**	44.47 ± 6.36	43.90 ± 6.34	0.706****
	median (Q1-Q3)	45.00 (40.00-49.75)	45.00 (40.00-49.00)	
LDL-C (mg/dl)	**mean±SD**	129.02 ± 26.20	131.32 ± 27.04	0.793****
	median (Q1-Q3)	130.00 (112.50-150.00)	130.00 (112.50-150.00)	
Triglyceride (mg/dl)	**mean±SD**	137.70 ± 48.08	138.97 ± 54.52	0.946****
	median (Q1-Q3)	130.00 (110.00-150.00)	130.00 (110.00-150.00)	
WBC ($\times 10^3.\mu L$)	**mean±SD**	8.45 ± 2.42	8.56 ± 2.34	0.793****
	median (Q1-Q3)	8.00 (7.05-9.75)	8.20 (7.30-9.90)	
Hemoglobin (g.dL)	**mean±SD**	13.24 ± 1.81	13.30 ± 1.75	0.902****
	median (Q1-Q3)	13.05 (12.00-14.00)	13.00 (12.00-14.00)	
Platelets ($\times 10^3.\mu L$)	**mean±SD**	206.70 ± 48.92	209.61 ± 49.41	0.706****
	median (Q1-Q3)	195.00(180.00-240.75)	196.00 (180.00-250.00)	
TSH (mg/dl)	**mean±SD**	1.71 ± 0.74	1.84 ± 0.74	0.173****
	median (Q1-Q3)	1.67 (1.40-1.90)	1.85 (1.60-2.10)	

*t-test, **chi square, ***fisher exact test, ****mann-whitney test.
BUN; Blood Urea Nitrogen, HDL-C; high-density lipoprotein- cholesterol, K: Potassium, LDL-C; low-density lipoprotein cholesterol, Mg: Magnesium, Na: Sodium, TSH; thyroid-stimulating hormone, WBC; white blood cell.

Table 2. Comparing ECG findings in individuals with and without AF

Parameters		Case group (n=40)	Control group (n=40)	P-value
PWD D2 (msc)	**mean±SD**	95.60 ± 23.29	81.25 ± 19.63	**0.003***
	median (Q1-Q3)	100.00 (80.00-120.00)	80.00 (80.00-90.00)	
PTF V1 (msc.mm)	**mean±SD**	54.35 ± 31.01	38.25 ± 22.49	**0.022***
	median (Q1-Q3)	50.00 (30.00-70.00)	40.00 (20.00-60.00)	
PR D2 (msc)	**mean±SD**	196.00 ± 29.33	184.00 ± 25.70	**0.006***
	median (Q1-Q3)	200.00(200.00-200.00)	200.00(165.00-200.00)	
PR V1 (msc)	**mean±SD**	184.25 ± 32.41	174.50 ± 27.16	0.102*
	median (Q1-Q3)	200.00 (160.00-200.00)	180.00 (160.00-200.00)	
PWPT D2 (msc)	**mean±SD**	49.55 ± 20.17	41.25 ± 19.24	**0.024***
	median (Q1-Q3)	40.00 (40.00-60.00)	40.00 (30.00-40.00)	
PWPT V1 (msc)	**mean±SD**	45.75 ± 22.83	30.62 ± 16.37	**0.001***
	median (Q1-Q3)	40.00 (30.00-60.00)	20.00 (20.00-40.00)	

*mann-whitney test.
PWD D2; P Wave Duration in lead D2, PTF V1; P Wave Terminal Force in lead V1,
PR D2; PR interval in lead D2, PR V1; PR interval in lead V1,
PWPT D2; P Wave Peak Time in lead D2, PWPT V1; P Wave Peak Time in lead D2.

Table 3. Comparing PWPT by sex groups

Variables			Case group (n=40)	Control group (n=40)	P-value
PWPT D2 (msc)	**Male**	**mean±SD**	47.64±16.01	47.05±21.43	0.123*
		median (Q1-Q3)	40.00(40.00-60.00)	40.00(35.00-60.00)	
	Female	**mean±SD**	50.95±23.02	36.95±16.63	**0.005***
		median (Q1-Q3)	40.00(40.00-60.00)	40.00(20.00-40.00)	
PWPT V1 (msc)	**Male**	**mean±SD**	49.05±25.78	35.88±17.69	0.123*
		median (Q1-Q3)	40.00(30.00-60.00)	40.00 (20.00-45.00)	
	Female	**mean±SD**	43.30±20.63	26.73±14.50	**0.002***
		median (Q1-Q3)	40.00(40.00-60.00)	20.00(20.00-40.00)	

* mann-whitney test

Table 4. Unadjusted Logistic Regression model for AF

Variables	OR (95%CI)	P-value
PWD D2	0.031 (0.996-1.066)	0.081
PTF V1	1.009 (0.985-1.032)	0.471
PR D2	1.018 (0.998-1.046)	0.221
PR V1	1.000 (0.978-1.022)	0.991
PWPT D2	0.985 (0.947-1.026)	0.473
PWPT V1	1.037 (1.004-1.072)	**0.029**

CI; confidence interval, OR; odds ratio

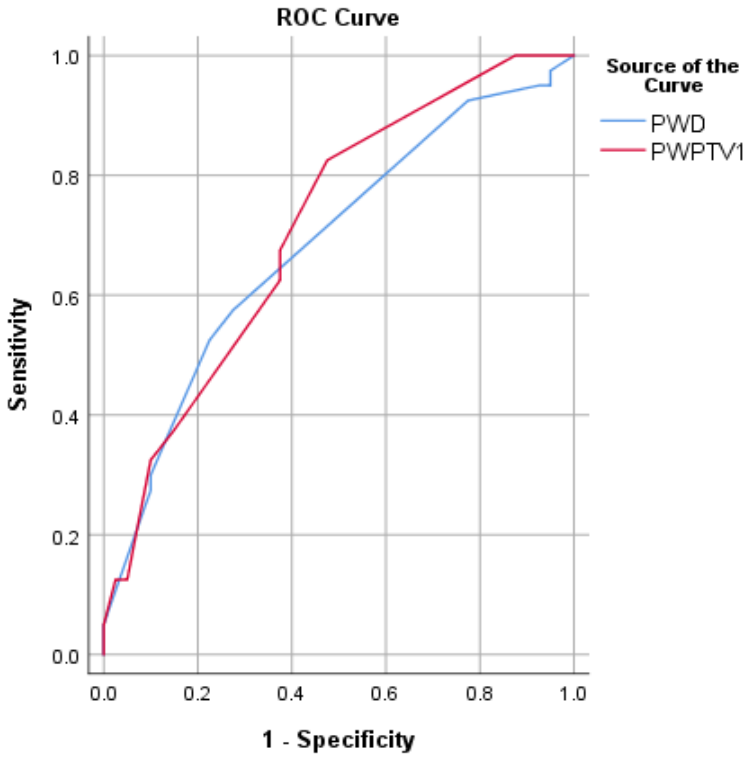
the studied parameters in the AF patients, only PWD D2 and PWPT V1 were predictors of AF.

AF has become one of the most important cardiovascular diseases in the 21st century due to the high mean life expectancy worldwide and the survival of more patients with chronic diseases[14].

Table 5. Adjusted Logistic Regression model for AF

Variables	OR (95%CI)	P-value
PWD D2	1.029(1.005-1.054)	**0.018**
PWPT V1	1.041(1.012-1.071)	**0.005**

In adjusted Logistic Regression electrocardiographic variables with consideration of all other variables (demographic characteristic, past medical history and laboratory variables) were analyzed and predictor variable were obtained.



The AUC was 0.712 for PWPT V1 and 0.684 for PWD D2

Fig. 2. The ROC curves of the PWD D2 and PWPT V1.

Table 6. Cut-off points for PWD D2 and PWPT V1

Variables	AUC	P-value	Sensitivity	Specificity	Cut-off point (msc)
PWD D2	0.684	**0.005**	57.5%	72.5%	85
PWPT V1	0.712	**0.001**	62.5%	62.5%	38

AUC; area under curve, ROC; receiver operating characteristic

The increasing prevalence of AF, the asymptomatic nature of many patients, and the potential to prevent AF-related complications with appropriate treatment have encouraged researchers to find new screening or diagnostic methods for AF. ECG indices were indicated as one of these methods[15]. Our results showed that among ECG parameters, PR D2, PWD D2, PTF V1, PWPT D2, and PWPT V1 were significantly longer in the case group. However, PR V1 was not significantly different between the two groups. In the unadjusted regression model, only PWPT V1 was a predictor for AF, but in the final adjusted model, PWPT V1 and PWD D2 were predictors. The cut-off point for predicting AF was 38 msc for PWPT V1 and 95 msc for PWD D2.

ECG is a convenient, cost-effective, and non-invasive diagnostic tool for diagnosing and determining the prognosis of cardiovascular diseases[6]. The normal heartbeat starts from the sinus node and repolarizes the atrial myocardium, which causes the formation

of the P wave in the electrocardiogram. The indices of this wave are quantitative criteria of the electrical activity of the atria[7,8]. Based on thorough assessments, P wave analysis has become a helpful parameter for predicting AF[5]. Prolonged ECG monitoring (Holter monitoring) can effectively help diagnose patients with pAF, but since it is time-consuming and may sometimes be inaccessible, determining easier parameters predicting AF in ECG can be very helpful[16].

PWD is one of the parameters that is commonly longer in AF patients. Also, more PWD >120 ms[17,18], longer maximum PWD[19], and higher PWD in lead D2[20] may be detected in these patients. However, some studies have reported conflicting results. For example, in one of these studies, although the duration of the unfiltered P wave was significantly longer in AF patients, in the ECG with filtration, PWD was not considerably different between the two groups[21]. In another study, PWD was longer in stroke patients for whom pAF was previously diagnosed. Still, this parameter could not independently predict AF in stroke patients who did not have a previous history of AF[22]. Our study showed that PWD in lead D2 was significantly longer in patients with AF, and this parameter was a predictor for AF. The cut-off point of this parameter for predicting AF was 95 ms with low sensitivity and high specificity.

In our study, despite significantly longer PTF V1 in AF patients, it cannot be used as a predictor for AF. Although some studies have reported longer PTF V1 in patients with AF[5,9], there are conflicting results. The large Framingham Study, unlike the ARIC Study, showed no significant association between PTF V1 >40 ms.mm and the occurrence of AF. Even this difference remained after adjusting for race between the two populations, and this study could not justify the reason for this difference[18]. In another study, long PTF V1 could not independently predict AF in those with stroke and no history of AF[22].

The relation between the PR interval and AF has been examined in several studies. In some studies, a significant association has been reported between the prolongation of this parameter and AF[5,17,18]. Nielsen et al. found that prolongation and shortening of the PR interval were associated with the occurrence of AF in females[23]. Moreover, Smith et al. showed no significant association between a long PR interval and AF. The existence of conflicting results regarding the PR interval might be because it consists of different parameters[17]. In our research, this parameter in lead D2 had a significant association with AF, but in lead V1, there was no significant difference between the two groups, and it was not a predictor for AF.

PWPT is also a new P wave parameter used to predict and diagnose various cardiovascular diseases. However, its association with the occurrence of AF has been examined in only a limited number of studies. Based on their results, the prolongation of this parameter is associated with AF, but these studies have recommended further studies to assess this association[5,16]. Based on our research, PWPT in both D2 and V1 is associated with AF. However, only PWPT V1 was identified as a predictor for this disease. The cut-off point for this parameter was 38 ms with a sensitivity and specificity of 62%.

Conclusion

Based on the results of our study, despite the significantly longer duration of most of the studied parameters in the AF patients, only two parameters, PWD D2 and PWPT V1, can be used as predictors for AF. PWD is an available parameter with a convenient calculation. The cut-off point for predicting AF was 85 ms, which has not high sensitivity, but acceptable specificity. The prolongation of PWPT V1 as a new P wave parameter had a significant association with pAF, and this relationship was more pronounced in females than males. The cut-off point for this parameter was 38 ms with moderate sensitivity and specificity. The measurement of this wave is highly dependent on the morphology of the P wave and its biphasic nature. Thus, the accuracy of the electrocardiograph and the method of measurement were crucial in calculating this parameter. Since this parameter has moderate sensitivity and specificity for predicting AF, it may be a challenging parameter for the diagnosis and treatment of AF. Therefore, further multicenter studies with a larger sample size are recommended on this issue.

limitations

Our study had some limitations. A low sample size, a population with different demographic characteristics, and a retrospective design may have affect the results. The low amplitude of the P wave is

another limitation that may cause a systematic error. This error may occur especially for parameters such as PWPT. Since the morphology of the P wave has a significant effect on its calculation. In our study, we used a single electrocardiogram, but we did not evaluate its sensitivity. Also, the absence of pAF in the control group was ruled out only by taking the history and studying the medical records of the participants. It would be better if we could examine them with a Holter ECG or implantable loop recorder.

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Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

MAR: Conceptualization, Methodology, Project administration, Supervision, Writing - Review & Editing. HS: Data curation, Investigation, Resources, Software, Visualization, Writing - Review & Editing. SK: Data curation, Investigation, Resources, Validation, Writing - Original Draft. HE: Formal analysis, Methodology, Writing - Original Draft. MG: Conceptualization, Project administration, Supervision, Validation, Writing - Review & Editing.

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