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ORIGINAL ARTICLE
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Wristwatch pulse wave monitoring: assessing daily activity post-catheter ablation for atrial fibrillation

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Aims Atrial fibrillation (AF) leads to impaired exercise capacity, and catheter ablation (CA) for AF improves exercise capacity. However, the precise changes in daily activities after CA for AF remain unclear. The authors aimed to evaluate the changes in daily activities following CA for AF using a wristwatch-type pulse wave monitor (PWM), which tracks steps and exercise time, estimates burnt daily calories, and records sleep duration, in addition to establishing the rhythm diagnosis of AF or non-AF.

Methods and results One hundred and twenty-three patients with AF (97 paroxysmal, 26 persistent) wore a wristwatch-type PWM for 1 week duration at three time points: before, 1 month after, and 3 months after ablation. Daily activity data were compared. Steps did not change in both groups, and the number of burnt daily calories and total exercise time increased after CA in patients with paroxysmal AF (burnt daily calories: before, 1591 kcal/day; 1 month, 1688 kcal/day; and 3 months, 1624 kcal/day; $P < 0.001$ and exercise time: before, 45.8 min; 1 month, 51.2 min; and 3 months, 56.3 min; $P = 0.023$). Sleep hours significantly increased (paroxysmal AF: before, 6.8 h; 1 month, 7.1 h; and 3 months, 7.1 h; $P = 0.039$ and persistent AF: before, 6.0 h; 1 month, 7.0 h; and 3 months, 7.0 h; $P = 0.007$).

Conclusion Using a wristwatch-type PWM, we demonstrated changes in daily activities after CA in patients with AF.

Trial registration number jRCT1030210022.

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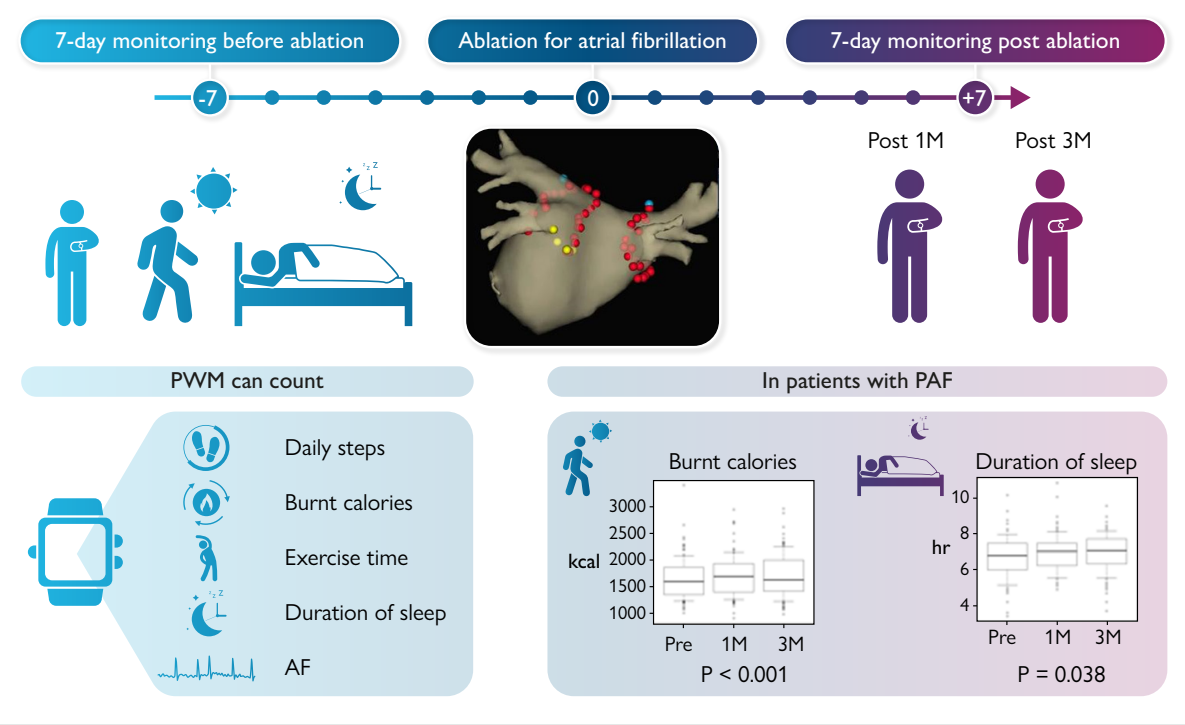
Graphical Abstract



Keywords Daily activity • Catheter ablation • Atrial fibrillation • Wristwatch-type pulse wave monitor • Photoplethysmography

Introduction

Atrial fibrillation (AF) is the most common arrhythmia, especially in the elderly, and its prevalence has sharply increased over time.[1] Atrial fibrillation is associated with twice higher mortality and a five-time higher risk of stroke.[2,3] Patients with AF have significantly impaired quality of life (QoL) or exercise tolerance.[4,5] Catheter ablation (CA) for AF is more effective than antiarrhythmic drugs in maintenance of sinus rhythm.[6–8] However, the precise changes in daily activities after CA for AF remain unclear.

To evaluate CA outcomes, electrocardiogram (ECG) monitoring is often performed using a Holter ambulatory monitor, implantable loop recorders, and, recently, consumer devices. Consumer devices allow AF detection with good sensitivity along with daily activity, exercise time, and sleep duration.[9–11] Catheter ablation improves QoL in patients with AF.[12–14] Cardiopulmonary exercise testing before and after CA for AF showed that exercise tolerance significantly improved in those who maintained sinus rhythm following CA.[12,15–17] Although only in a small number of patients, Yanagisawa *et al.*[18] reported a significant increase in maximum daily steps following CA for AF, evaluated using a uniaxial accelerometer. This study demonstrated the potential use of consumer devices for the follow-up of patients who underwent AF ablation.

A wristwatch-type pulse wave monitor (PWM), PS-300R, is a wristwatch-type photoplethysmography (PPG) device capable of recording pulse waves, and pulse wave data can be analysed offline for further evaluation, similarly to that using a PWM (D-440),[10] as described in our previous report. The PS-300R collects daily activity data, that is, daily steps, burnt daily calories, exercise time, and sleep duration per 24 h, in addition to diagnosing AF/non-AF. We aimed to evaluate changes in daily activity and sleep duration using a wristwatch-type pulse monitor after CA for AF in relation to AF recurrence.

Methods

Study design and population

This prospective single-centre study was conducted at Kyorin University Hospital, Tokyo, Japan. The study protocol was reviewed and approved by the Institutional Research Ethics Committee (approval number: R02-248). Consecutive patients with paroxysmal AF (PAF) and persistent (Per) AF with or without prior AF ablation who were scheduled to undergo CA for AF at Kyorin University were recruited. Patients with impaired mobility were excluded. Written informed consent was obtained from all the patients. Information on medical history and medication was carefully reviewed from the medical records.

Data collection

Clinical data were extracted from the patients' medical record to evaluate Kyorin AF risk score variables, including age, height, weight, medical history of hypertension, heart failure, diabetes mellitus, cerebral infarction, vascular disease (peripheral artery disease or aortic plaque), coronary artery disease (myocardial infarction or angina pectoris), hyperthyroidism, being overweight [body mass index (BMI) $\geq$ 25 kg/m^2], chronic obstructive pulmonary disease, sleep apnoea syndrome, chronic kidney disease, history of smoking, and amount of daily alcohol consumption. Chronic kidney disease was defined as an estimated glomerular filtration rate <60 mL/min/m^2. Creatinine and serum N-terminal pro-brain natriuretic peptide levels were measured at baseline. The $CHADS_2$ score is calculated with one point each for heart

failure, hypertension, age ≥75 years, and diabetes and two points for stroke. The CHA_2DS_2-VASc score is calculated with one point each for heart failure, hypertension, age 65–74 years, diabetes, vascular disease, and female sex and two points each for age ≥75 years and stroke.

Wristwatch-based pulse wave monitor: PS-300R

The participants wore a PWM (PS-300R; Seiko Epson Co., Ltd, Suwa, Japan) for 8 consecutive days before ablation (within a month before CA), 1 (between 2 and 6 weeks), and 3 (between 8 and 16 weeks) months after CA.

The details of the PWM have been described elsewhere.[19] Briefly, the wristwatch-based PWM is capable of full 7 days (~176 h) of continuous recording with an automatic AF diagnosis algorithm using frequency analysis of pulse wave.[10,19] For this study, rhythm diagnosis of AF, that is, 'PWM-diagnosed AF', was established when the AF episode lasted for ≥30 min. If significant motion noise is detected during AF episodes, AF labelling is deferred, and once the noise is reduced, AF labelling is restored. Therefore, a continuous AF episode can be labelled as several episodes of AF. In addition to diagnosing AF, PWM can record daily steps (steps/day), daily burnt calories (kcal/day), exercise time (min/day) and strength (low- or high-intensity exercise), and sleep duration (h/night).[20–22] Burnt calories are calculated taking into account changes in pulse rate as well as age, gender, height, and weight. Exercise strength is calculated by pulse rate and its change from baseline and divided into low- or high-intensity exercise. These data were recorded within the PWM and analysed offline.

Daily activity data were recorded for 8 days. For the analysis, daily activity recordings of the first and last days were excluded, and the average of the rest was calculated and represented as the patients' daily activity data. The obtained data were compared before, 1 month, and 3 months after ablation.

Symptom diary

Patients kept a symptom diary while they wore PWM. They were instructed to write the time and their symptoms, such as palpitation, shortness of breath, dizziness, and chest pain, and wake-up and bedtime times in their diary.

Follow-up and atrial fibrillation recurrence

Patients were seen at 1 (2–4 weeks) and 3 months (8–16 weeks) after CA. An ECG was recorded at the outpatient clinic. Twenty-four hour Holter monitoring was performed at 3 months after CA. Atrial fibrillation recurrence was evaluated using medical records and compared with PWM diagnosis. Atrial fibrillation recurrence was defined as follows: ECG at the outpatient clinic, implanted cardiac device (including loop recorders, pacemakers, and implantable cardiac defibrillators), any external ECG monitor, including 24 h Holter ambulatory monitoring or event monitor showing AF.

Ablation procedure

All patients who underwent index ablation for AF underwent pulmonary vein isolation. Cavotricuspid isthmus ablation was performed in patients with documented atrial flutter (AFL). Additional ablation was performed according to the physicians' preference. For repeat procedures, following the confirmation of PV isolation, additional ablation was performed, in which the ablation strategy was left to the physicians' preference.

Statistical analyses

Continuous data are presented as the means ± standard deviations for normally distributed data or medians [interquartile ranges (IQRs)] for non-normally distributed data. Categorical data are presented as numbers (percentages). The Fisher's exact test or Mann–Whitney *U* test was used to compare the differences between patients with PAF and those with Per AF. Friedman's test was used to compare the differences among the daily activity data before and 1 and 3 months after ablation. A *P*-value <0.05 was considered statistically significant. The analyses were performed using EzR version 1.54 (https://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/download.htm).[23]

This study was registered in Japan Registry of Clinical Trials (registration number: jRCT1030210022).

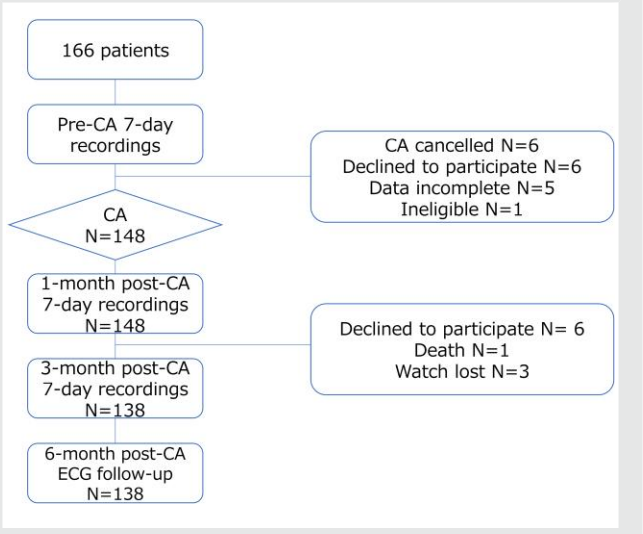


Figure 1 A flow chart of the study is shown. In total, 138 patients completed the 8 day recordings of pulse wave monitoring thrice.

Results

We recruited 166 consecutive patients with PAF or Per AF who were scheduled to undergo CA for AF. All 166 patients wore a PWM before CA. Of these patients, 12 decided to leave the study after the pre-ablation 8-day recordings ($n = 6$) or post-ablation 8-day recordings ($n = 6$). Catheter ablation was cancelled in six patients, five patients had an insufficient recording of PWM due to technical issues, one patient was ineligible for this study, three patients lost their watches ($n = 3$), and one patient died due to a non-cardiac cause at 2 months after CA. Thus, 138 patients completed the planned three-time recordings (*Figure 1*).

The baseline characteristics of the 138 patients are shown in *Table 1*. Weight, BMI, and the prevalence of heart failure and diabetes mellitus were higher in patients with Per AF than in those with PAF. Medication changes are summarized in *Table 2*.

Daily activity and sleep

The changes in daily activities are shown in *Figure 2*. In patients with either PAF or Per AF, the number of steps performed did not change. The steps in patients with PAF were as follows: before, 4245 (291–6979) steps/day; 1 month, 4573 (3261–7183) steps/day; and 3 months, 4739 (3107–6824) steps/day ($P = 0.873$). The steps in patients with Per AF were as follows: before, 4758 (3726–6660) steps/day; 1 month, 4857 (3571–6411) steps/day; and 3 months, 5456 (4038–6697) steps/day ($P = 0.746$). Total exercise time increased in patients with PAF, but not in patients with Per AF. The total exercise times in patients with PAF were as follows: before, 45.8 (28.7–83.7) min/day; 1 month, 51.2 (33.3–85.7) min/day; and 3 months, 56.3 (32.5–88.8) min/day ($P = 0.023$). The total exercise times in patients with Per AF were as follows: before, 61.3 (41.5–89.2) min/day; 1 month, 57.5 (44.2–70.7) min/day; and 3 months, 65.2 (42.2–86.0) min/day ($P = 0.217$). The exercise was further divided into low intensity or fat-burning high intensity. Low-intensity exercise duration did not change in patients with PAF and Per AF [patients with PAF: before, 41.8 (24.8–77.6) min/day; 1 month, 45.2 (27.7–76.4) min/day; and 3 months, 45.1 (26.5–72.0) min/day; $P = 0.063$ and patients with Per AF: before, 50.1 (36.7–65.0) min/day; 1 month, 50.3 (38.3–67.8) min/day; and 3 months, 55.2 (36.3–72.3) min/day; $P = 0.350$]. High-intensity exercise duration did not change in patients with PAF [before, 3.2 (0.8–8.8) min/day; 1 month, 2.7 (0.8–7.8) min/day; and 3 months, 4.0 (1.2–9.8) min/day; $P = 0.091$] and decreased 1 month after ablation in patients with Per

Table 1 Patient characteristics

Variables	PAF ($n = 97$)	Per AF ($n = 41$)	*P*-value
Age (years)	68.0 ± 10.9	67.5 ± 10.4	0.644
Male	62 (63.9%)	32 (78.0%)	0.114
Height (cm)	165.1 ± 8.9	167.3 ± 8.2	0.181
Weight (kg)	63.9 ± 14.0	70.2 ± 12.7	**0.006**
BMI (kg/m^2)	23.3 ± 3.8	25.0 ± 3.9	**0.017**
History of heart failure	5 (5.2%)	8 (19.5%)	**0.021**
Hypertension	73 (75.2%)	35 (85.3%)	0.259
Diabetes mellitus	9 (9.3%)	11 (26.8%)	**0.015**
Cerebral infarction	5 (5.2%)	2 (4.9%)	1.00
Valvular heart disease	1 (1.0%)	4 (9.8%)	**0.027**
Ischaemic heart disease	3 (3.1%)	1 (2.4%)	1.00
Hyperthyroidism	3 (3.1%)	3 (7.3%)	0.362
Overweight (BMI ≥ 25 kg/m^2)	30 (30.9%)	20 (48.8%)	0.054
Chronic obstructive pulmonary disease	2 (2.1%)	0 (0%)	1.00
Sleep apnoea syndrome	30 (30.9%)	18 (43.9%)	0.172
Chronic kidney disease	43 (44.3%)	25 (60.1%)	0.094
Smoking	35 (36.1%)	22 (53.7%)	0.061
Excessive alcohol consumption	1 (1.0%)	2 (4.9%)	0.210
Kyorin AF score	4.3 ± 1.8	5.3 ± 1.5	**0.002**
$CHADS_2$ score	1.3 ± 1.0	1.7 ± 1.0	**0.008**
CHA_2DS_2-VASc score	2.4 ± 1.5	2.6 ± 1.3	0.438
LAD (mm)	36 ± 7	42 ± 5	**<0.001**
LVEF (%)	61.6 ± 9.5%	57.1 ± 10.0	**<0.001**
NT-proBNP (pg/mL)	527 ± 1080	1235 ± 806	**<0.001**
Number of ablation procedure (first session)	64 (66.0%)	31 (75.6%)	0.264

Values in bold indicate statistically significant difference ($P < 0.05$). Excessive alcohol consumption: if an individual consumed >60 g of absolute alcohol per day, it was considered excessive alcohol intake.
AF, atrial fibrillation; BMI, body mass index; LAD, left atrial diameter; LVEF, left ventricular ejection fraction; NT-proBNP, N-terminal pro-brain natriuretic peptide.

Table 2 Medication changes

			P-value
Beta-blockade			
Before ablation	53 (54.6%)	25 (61.0%)	0.493
Post 1 month	33 (34.0%)	18 (43.9%)	0.272
Post 3 months	25 (25.8%)	18 (43.9%)	**0.036**
Antiarrhythmic			
Before ablation	25 (25.8%)	8 (19.5%)	0.431
<pilsicainide/amiodarone/ bepridil/others>	<8/2/10/5>	<0/1/7/0>	
Post 1 month	24 (24.7%)	12 (29.3%)	0.580
<pilsicainide/amiodarone/ bepridil/others>	<9/2/12/1>	<0/2/10/0>	
Post 3 months	17 (17.5%)	11 (26.8%)	0.214
<pilsicainide/amiodarone/ bepridil/others>	<5/2/9/1>	<0/2/9/0>	

Values in bold indicate statistically significant difference ($P < 0.05$).

AF [before, 5.6 (4.0–10.5) min/day; 1 month, 3.8 (1.0–8.0) min/day; and 3 months, 4.7 (1.3–10.7) min/day; $P = 0.004$]. Number of burnt daily calories increased after CA [before, 1591 (1342–1857) kcal/day; 1 month, 1688 (1395–1925) kcal/day; and 3 months, 1624 (1408–1990) kcal/day; $P < 0.001$] in patients with PAF, but not in patients with Per AF [before, 1766 (1526–2052) kcal/day; 1 month, 1852 (1549–2101) kcal/day; and 3 months, 1864 (1588–2052) kcal/day; $P = 0.169$]. Both patients with PAF and Per AF slept longer after CA [before, 6.8 (6.0–7.5) h/night; 1 month, 7.1 (6.3–7.5) h/night; and 3 months, 7.1 (6.4–7.7) h/night; $P = 0.039$ in patients with PAF and before, 6.0 (5.0–7.2) h/night; 1 month, 7.0 (6.1–7.4) h/night; and 3 months, 7.0 (6.2–7.8) h/night; $P = 0.007$ in patients with Per AF]. Additionally, we compared the first session patient vs. redo ablation patients. Results are shown in Supplementary material online, *Figures S1* and *S2*. Total exercise time and sleep duration increased only in patients with first procedure in patients with PAF. Sleep duration increased in patients with per AF in redo procedure.

Atrial fibrillation diagnosis

The number of episodes for each patient is shown in Supplementary material online, *Figure S3A* (patients with PAF) and *S3B* (patients with Per AF).

In 97 patients with PAF, PWM found 185 PAF episodes in 36 patients before ablation [median, 4 (IQR, 2–6) episodes in 36 patients]. One

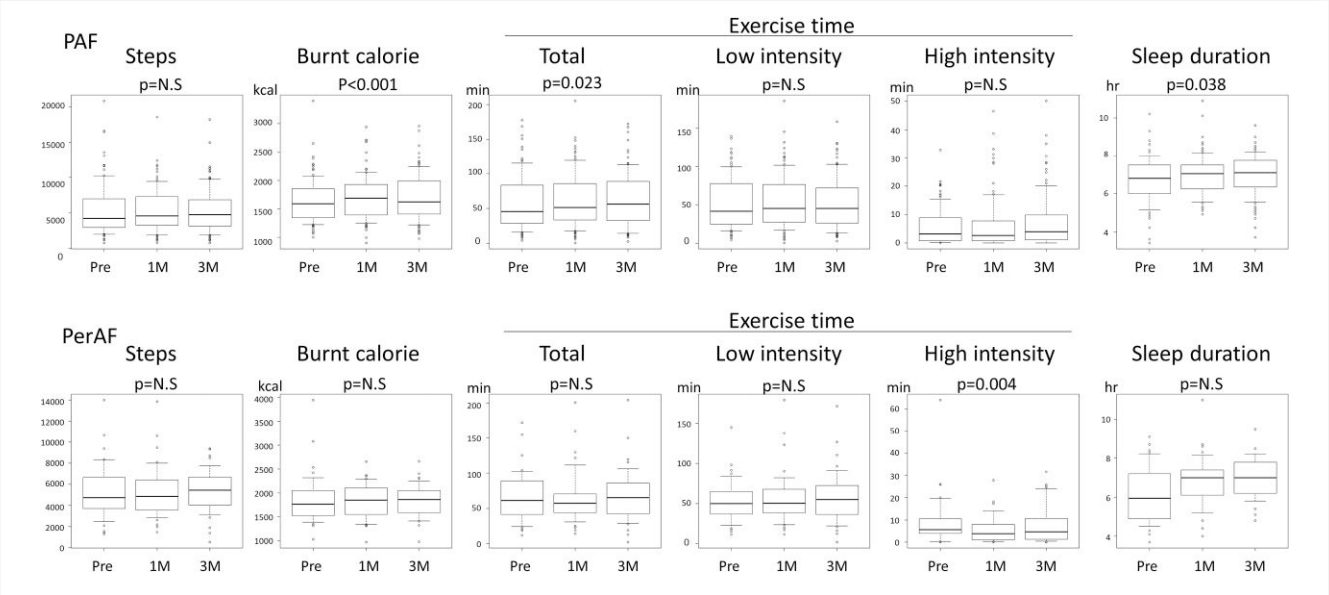


Figure 2 Changes of daily activities are shown. Upper panels: changes of patients with paroxysmal atrial fibrillation; lower panels: changes of patients with persistent atrial fibrillation.

Table 3 Atrial fibrillation diagnosis after catheter ablation

	Clinically judged AF +	Clinically judged AF −	
AF diagnosis 1 month after ablation			
PWM-diagnosed AF	12 (8.7%)	28 (20.3%)	40 (29.0%)
PWM-diagnosed non-AF	2 (1.4%)	96 (69.6%)	98 (71.0%)
	14 (10.1%)	124 (89.9%)	138 (100%)
AF diagnosis 3 months after ablation			
PWM-diagnosed AF	11 (8.0%)	17 (12.3%)	28 (20.3%)
PWM-diagnosed non-AF	1 (0.7%)	109 (79.0%)	110 (79.7%)
	12 (8.7%)	126 (91.3%)	138 (100%)

AF, atrial fibrillation; PWM, pulse wave monitor.

month after ablation, 2 patients had Per AF, 26 patients had PAF with 130 episodes using PWM [median, 2 (IQR, 1–6) episodes in 26 patients]. Three months after ablation, 12 patients had PAF with 70 episodes [median, 2 (IQR, 1–8.25) episodes].

In 41 patients with Per AF, 1117 AF episodes were detected using PWM. At the 1-month follow-up, PWM found 41 PAF episodes in 7 patients [median, 6 (IQR, 3–8) episodes] and Per AF in 5 patients. At 3-month follow-up, PWM found 43 PAF episodes in 10 patients [median, 4 (IQR, 2–6.25) episodes], and six patients had Per AF.

The durations of AF episodes in patients with PAF were 103 (median: IQR, 60–248) min before ablation, 79 (IQR, 42–140) min 1 month after ablation, and 65 (IQR, 40–123) min 3 months after ablation.

Relationship between clinical atrial fibrillation recurrence and pulse wave monitor–based atrial fibrillation recurrence

The relationship between clinically judged and PWM-based AF recurrence is shown in *Table 3*. One month after ablation, 14 patients were clinically judged to have AF recurrence using a 12-lead ECG, a 24 h Holter ambulatory monitor, or an implantable loop recorder. However, PWM found AF in 12 of the 14 patients during the 8-day recordings. Of these two patients without detection using PWM, one underwent cardioversion and remained in sinus rhythm during the subsequent PWM recordings, and the other developed rate-controlled AFL, which was not diagnosed as AF due to its regularity. Three months after ablation, 12 patients had an AF episode on 12 lead ECG, Holter ECG, or ILR. Pulse wave monitor detected AF in 11 of them. The remaining patient had ILR, and she had no episode while she wore PWM.

Symptoms

The patients kept a diary and documented their symptoms while wearing the PWM. Of the 14 patients with clinical AF recurrence, only one patient was symptomatic with AF at 1-month follow-up. At 3-month follow-up, only 3 of the 12 patients with clinically documented AF recurrence were symptomatic. Pulse wave monitor detected AF recurrence in these asymptomatic patients.

Discussion

In this study, we demonstrated the changes in daily activity after CA for AF using a non-invasive PWM, and this is the first study to investigate both daily activity and episodes of AF simultaneously using a PWM.

Daily activity changes after catheter ablation

The number of steps did not change in patients with PAF and Per AF, the number of burnt daily calories and total exercise time increased after CA in patients with PAF, and sleep duration was significantly prolonged in patients with PAF and Per AF. The greatest advantage of wearable devices is the continuous acquisition of data, including the pulse rate, exercise time, steps, and daily burnt calories. With good accuracy in detecting AF, a wearable device can facilitate the early detection of AF recurrence and monitor exercise time, exercise intensity, and sleep. As exercise duration and sleep are both closely related to AF, this information will be helpful in lifestyle management.[4]

Our usual practice discharges patients on the day following the procedure, and patients are advised to avoid vigorous exercise for 1 week and then return to regular activity levels. Our study demonstrated that daily steps did not change from baseline after 1 and 3 months, which is consistent with the results of previous studies. Peigh *et al.*[24] evaluated the effects of CA for AF on activity minutes per day using continuous accelerometer data from cardiac implantable electronic devices (CIEDs) with AF detection. Four hundred and nine patients with CIED who underwent AF ablation were analysed in the study. Despite the decrease of AF burden by $75.1 \pm 53.2\%$ ($P < 0.001$), no significant change in activity minutes per day after CA in the entire cohort or subgroups based on CIED, season of ablation, quartile of AF burden change, and quartile of age at the time of ablation was found. Proietti *et al.*[25] evaluated daily activity levels using an implantable loop recorder following CA for AF in 50 patients. They found that the average daily activity was 244.63 ± 119.75 min and correlated with daily atrial tachycardia/AF burden; daily activity started decreasing after a daily burden of 500 min of AF and significantly decreased after 1000 min. Thus, CA for AF has no significant effect on daily activities in patients with a relatively small AF burden. In our patients with Per AF who remained in sinus rhythm after CA, we did not find any difference in exercise time. This may be due to the small number of patients. Additionally, the follow-up period was up to 3 months, and the exercise time might have increased after the blanking period.

Daily burnt calories were calculated using pulse rate. The baseline heart rate (HR) usually increases after CA for AF,[26] and HR increases more with exercise, which would have caused an increase in daily burnt calories after CA in addition to the increased exercise time in patients with PAF. In addition, the use of beta-blockade was decreased after CA in patients; this might have influenced the changes in pulse rate and burnt calories. In patients with Per AF, their HR in sinus rhythm might be slower after ablation, which was not evaluated in our study, and this might explain the lack of significant difference in the amount of burnt daily calories after CA in patients with Per AF. In addition, because more patients were maintained on beta-blocker, the change in HR may have been less and may have influenced the calories burnt.

The number of ablation procedures had a greater impact on total exercise time and sleep duration in patients with PAF. This might be due to the degree of AF burden reduction. In patients with Per AF, sleep duration increased in patients with repeat procedures. The recurrence rate was similar between those with the first ablation and those with redo procedures; thus, it is difficult to explain the reason.

Sleep and atrial fibrillation

Healthy sleep patterns are associated with a lower risk of AF and bradyarrhythmia.[27] Khawaja *et al.*[28] found that in a large cohort of US male physicians, shorter duration of sleep was associated with risk of future development of AF in patients with sleep apnoea but not in the overall cohort. The Multi-Ethnic Study of Atherosclerosis study also found no association between sleep duration and AF prevalence.[29]

Data from previous studies have shown that sleep quality (SQ), as a component of QoL, may also deteriorate in patients with AF.[13] Kayrak *et al.*[30] examined the relationship between SQ and AF and the effect of sinus rhythm restoration with direct current cardioversion (DCCV) on SQ among patients with Per AF using the Pittsburgh SQ Index (PSQI). The PSQI is a scale used to assess the degree of sleep disturbance and consists of seven components: SQ, time to fall asleep, sleep duration, sleep efficiency, sleep difficulty, sleep medication use, and difficulty waking during the day. They reported that the PSQI score of patients with AF was higher than that of those without AF and that PSQI scores significantly decreased with sinus rhythm restoration following DCCV. The version of the PWM used in this study did not allow depth of sleep, but the current version can evaluate them. As sleep duration was included in the SQ score in their report, our results coincided with those of their study. The mechanism by which AF ablation affects sleep duration remains unclear; however, our patients could sleep longer after CA, and ablation might have positively affected their sleep patterns.

Discrepancies between clinical atrial fibrillation recurrence and pulse wave monitor–diagnosed atrial fibrillation recurrence

We observed a discrepancy between clinical AF recurrence and PWM-diagnosed AF. Considering the accuracy of PWM with a sensitivity of 98.0% and a specificity of 90.6%, PWM had detected true AF, which was either asymptomatic or not detected during the ECG recording.[10] Following the PWM detection of AF, ECG recording is recommended to establish AF diagnosis by longer ECG recordings, such as an event monitor, home-based ECG, or smartwatch capable of ECG recording.[4,31]

In our study, follow-up PWM data were obtained only at 1 and 3 months after ablation within a blanking period. However, AF recurrence within the blanking period is associated with late recurrence.[32–35] Thus, patients with PWM-judged AF recurrence required careful follow-up.

Additionally, several patients with AF recurrence were asymptomatic during their PWM recordings; however, PWM detected asymptomatic AF in these patients. Thus, PWM is feasible for detecting asymptomatic AF.

Comparison with other wearables

Apple Watch and Fitbit are major wearables that can detect irregular heart rhythms in addition to assessing daily activity. However, neither of them continuously checks the irregularity of the pulse wave. Apple Watch occasionally checks the pulse for 1 min, and pulse intervals (tachograms) were calculated. Tachograms were classified as regular or irregular based on the variation in the pulse interval. However, irregular pulse notification was enabled, when 5/6 tachograms were classified as irregular.[9] Apple Watch measures weekly AF burden with daily activities (exercise time, sleep duration, weight, alcohol consumption, and mindfulness time). Fitbit is able to detect irregular pulse waves through the FibriCheck App. Data from FibriCheck's intermittent PPG measurements are analysed. However, they can be made available to physicians.[36,37] This system seems very promising for patient care. Our PWM, PS300-R collects PPG data all the time, and this has to be analysed offline at the moment because it is a research application, but it will give us the notification immediately when it detects irregularities in the rhythm. However, it can be used with smartphones in the near future.

Limitations

First, this was a single-centre study, and the number of participants was small; however, to the best of our knowledge, this is the first study to investigate both daily activity and episodes of AF simultaneously using a non-invasive wristwatch-type PWM. Second, the change in steps after CA for AF was not significant; however, the timing of the recordings may have influenced the results. Follow-up recordings at 6 months or 1 year after CA may show different results. Future studies focusing on changes in daily activity long time after CA are needed. In addition, the patients wore PWMs and wearing them may have affected the patients, which may have changed the patients' daily activity. However, they continued to wear it for a week, during which time, they would have gotten used to wearing it, and they would have spent time as usual. Also, changes in medication, especially the use of beta-blockers, could have affected the calories burnt, as they are calculated based on the changes in pulse rate.

In addition, as users of wearable devices favoured sharing wearable device data with their clinicians to improve care, the use of PWM for management of AF would improve routine medical care.[38]

Conclusions

Using a wristwatch-type PWM, we found that the number of steps did not change after CA for AF in patients with PAF and Per AF, the number of burnt calories and exercise time increased in patients with PAF, and patients with PAF and Per AF slept longer. We collected the data of daily activity at 1 and 3 months after CA for AF. However, these periods are within the blanking period of CA. Acquisition of the data at 6 or 12 months might reflect the eventual effect of CA on daily activities.

Supplementary material

Supplementary material is available at *European Heart Journal – Digital Health*.

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Author contributions

All authors (i) made substantial contributions to the study concept or the data analysis or interpretation, (ii) drafted the manuscript or revised it critically for important intellectual content, (iii) approved the final version of the manuscript to be published, and (iv) agreed to be accountable for all aspects of the work.

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Data availability

The data utilized in this article cannot be shared publicly due to privacy requirements of the organization that provided access to these database.

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