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Physical Activity and Atrial Fibrillation: Data from Wearable Fitness Trackers

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Abstract

Background: Regular physical activity is an important determinant of cardiovascular health and quality of life. Previous investigations examining the association between exercise and atrial fibrillation (AF) have been limited by self-reported, retrospectively collected activity data.

Objective: We sought to objectively quantify differences in daily physical activity among individuals with and without AF using electronic wearable activity trackers.

Methods: Daily exercise data was directly obtained from wrist-worn activity trackers (Fitbit, San Francisco, CA) among participants in the Health eHeart (HeH) Study. Average daily step count was compared between individuals with and without AF both before and after adjusting for comorbidities. AF severity was quantified using the Atrial Fibrillation Effect on Quality of Life Survey (AFEQT) questionnaire.

Results: Among 171,284 HeH participants, 3,333 individuals (234 with AF, 7%) submitted activity data. In unadjusted analysis, AF participants ambulated an average of 723 fewer steps/day (95% CI 292 to 1,154, p = 0.001) compared to individuals without AF. After adjustment for demographics and comorbid diseases, participants with AF demonstrated 591 less steps/day (95% CI 149 to 1,033, p = 0.009). Among AF patients, AF severity was associated with less physical activity; for each single point decrease in AFEQT score (corresponding to more symptomatic AF), physical activity decreased by a mean 24 steps/day, 95% CI 1 to 46 steps/day, p = 0.04).

Conclusions: Objective, automatically collected step count data demonstrates that individuals with AF engage in significantly less average daily physical activity. In addition, worsening AF symptom severity is associated with reduced daily exercise.

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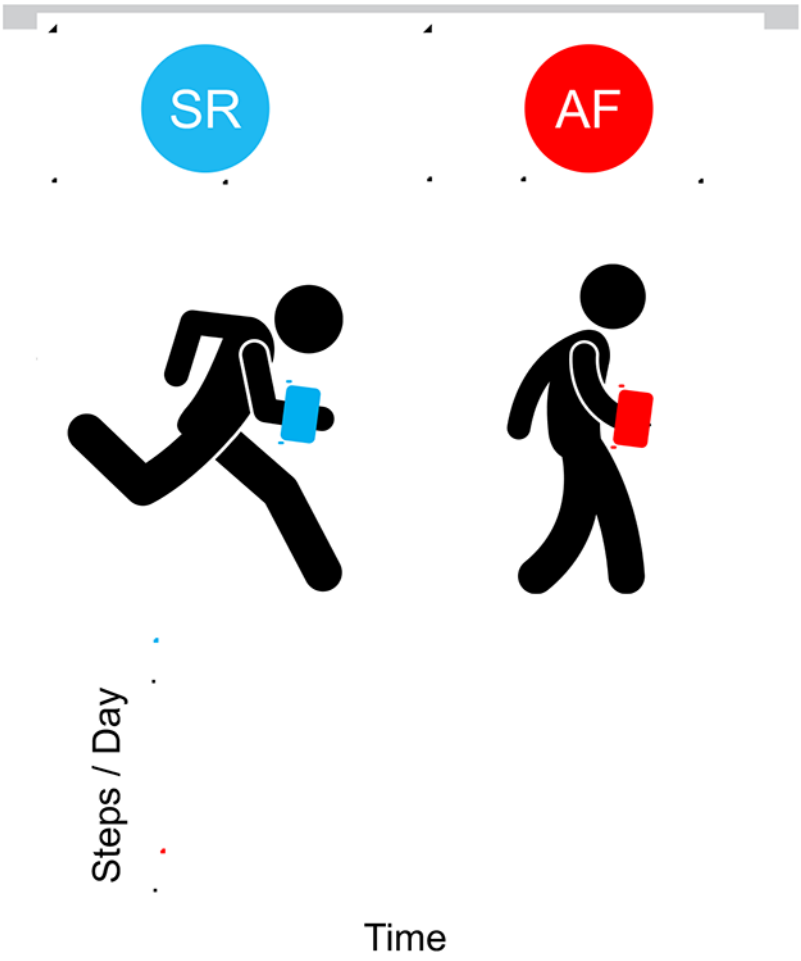
Graphical Abstract



Keywords

atrial fibrillation; physical activity; exercise; step count; fitness tracker

Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia and is associated with increased risk of stroke, dementia, heart failure, and death.[1–3] These adverse outcomes are largely attributed to thromboembolism and arrhythmia-associated hemodynamic abnormalities. However, exercise is an important determinant of overall health, and physical activity influences the progression of many common chronic diseases including diabetes, cancer, and coronary disease.[4] It is therefore possible that a reduction in physical activity among individuals with AF may also contribute to the morbidity and mortality associated with this arrhythmia.

The impact of AF on overall physical activity is incompletely understood. Previous studies investigating the relationship between AF and exercise have exclusively utilized

self-reported activity questionnaires.[5–8] This methodology is prone to substantial bias, as the retrospective recall of daily activities by study participants is likely inaccurate.

Electronic wearable activity trackers continue to grow in commercial popularity and are used by individuals both with and without disease to monitor physical activity. These devices are typically worn on the wrist and can provide objective, accurate, automated, and comprehensive exercise data.[9–13] Measurement of daily step count via wearable devices has emerged as a validated instrument to assess physical activity in the setting of chronic illness; we have recently demonstrated that a reduction in daily activity as assessed by wearable activity trackers correlates with neurologic disease staging.[14] In the present study, we sought to objectively quantify longitudinal differences in daily activity between and among patients with and without AF in a real world, ambulatory population using electronic activity trackers.

Methods

All individuals enrolled in the Health eHeart Study (HeH) between March 2013 and January 2018 were eligible for study inclusion. Details of HeH have been previously described.[15] Briefly, HeH is an internet-based prospective cohort study that continues to enroll individuals ≥ 18 years old. Participants both with and without cardiovascular disease are recruited from medical clinics and via mobile applications, social media, and communications from the American Heart Association. All participants provide baseline demographic and medical information using online surveys and have the opportunity to share additional data, for example by connecting other apps or devices.

Prevalent AF was assessed at study enrollment by asking participants if they 1) have been told by a doctor or nurse that they have AF or 2) have received medical treatment for this arrhythmia. Participants were excluded if they responded “I don’t know.” This methodology of AF ascertainment has been previously validated in HeH and has been found to be 100% sensitive (95% CI 86-100%) and 100% specific (95% CI 80-100%) when compared to medical chart review.[16] All participants with prevalent AF at baseline were asked to complete the previously validated Atrial Fibrillation Effect on Quality of Life Survey (AFEQT) to quantify disease-related symptom severity.[17] The AFEQT score incorporates AF frequency, duration, and degree of AF symptoms, with lower scores representing more severe AF.

After enrollment, all HeH participants were invited to submit electronic activity data via a single vendor wearable activity monitor (Fitbit, San Francisco, California). Monitoring hardware was not provided by the study and the decision to record daily activity was patient-initiated. All available step count data obtained between HeH enrollment and January 1, 2018 were included in the analysis. Consistent with previous studies, individuals with less than 500 steps/day were considered to have missing data for that calendar date.[14] Users with average wear times of less than 10% were also excluded. Duration of monitoring was defined as the number of days between the first and last daily step count measurements.

All participants provided electronic consent for the study, which was approved by the University of California, San Francisco Institutional Review Board.

Statistical analysis

Continuous variables are presented as means ± standard deviations (SD) or medians and interquartile range (IQR). Normally distributed continuous variables were compared using t-tests and categorical variables were compared using the chi squared test. Hierarchical mixed linear regression models were employed to assess the relationship between AF and repeated average step counts (taking clustering by individual into account). We used generalized linear models to examine the association between AFEQT scores and average daily step counts. SAS (SAS Institute Inc., Cary, NC) was used for all statistical analyses. A two tailed alpha of 0.05 was considered statistically significant.

Results

Among 171,284 HeH participants, 3,920 (2.3%) provided step count data via their physical activity tracker. Of these participants, 587 were excluded due to self-reported unknown AF status. AF was present in 234 (7%) of the remaining 3,333 participants. Consistent with the previous AF literature, individuals with AF were more often men, were older, and were more likely to have other medical comorbidities, including smoking status, hypertension, diabetes, chronic obstructive pulmonary disease, coronary artery disease, and congestive heart failure (Table 1).

The mean overall duration of step count monitoring was not significantly different between individuals with and without AF (685 versus 681 days, p = 0.89), although the median number of monitored days per month was slightly higher among participants with versus without AF (27.1 versus 26.0 days/month, p = 0.004). The overall mean step count was 7,585 ± 3,245 steps/day. Participants with AF took, on average, 723 less steps/day compared to those without AF (95% CI 292 to 1,154 less steps/day, p = 0.001). After adjustment for age, sex, race, education, income, smoking status, hypertension, diabetes, chronic obstructive pulmonary disease, coronary artery disease, and congestive heart failure, individuals with AF ambulated 591 less steps/day (95% CI 149 to 1,033 less steps/day, p = 0.009, Table 2).

Among participants with AF, 226 (97%) completed the AFEQT survey. The mean AFEQT score was 80 ± 18. For every 1-point decrease in AFEQT score (corresponding to more symptomatic AF), participants walked on average 34 fewer steps/day (95% CI 14 to 55 steps/day, p = 0.001, Figure 1). After adjusting for the demographics and comorbidities in Table 1, each point decrease in AFEQT was associated with 24 fewer steps/day (95% CI 1 to 46 steps/day, p = 0.04). A sensitivity analysis limited to step data obtained during the first 90 days after AFEQT symptom assessment did not yield significantly different results.

Discussion

Utilizing objective, daily step count data longitudinally collected over an average of more than 1.5 years, we observed that individuals with AF demonstrate a significant reduction

in daily step count, even after adjusting for relevant demographics and other medical comorbidities. Furthermore, more severe, symptomatic AF was associated with lower daily step count.

The association between regular physical activity and a reduced risk of both cardiovascular and overall mortality has been long recognized.[18] More recently, there has been increased interest in the association between exercise and AF. Compared to sedentary or minimally active adults, individuals that engage in moderate levels of exercise experience a significant reduction in AF risk.[19] Notably, however, there is evidence that extreme levels of exercise may promote arrhythmogenesis, especially in men.[5] All of these prior investigations, however, are limited by the use of self-reported physical activity; this methodology is prone to substantial recall and observer bias.

In the present investigation, we found that HeH participants with AF had a significant reduction in average daily step count. This relationship persisted despite controlling for a variety of demographic variables and medical comorbidities that are likely to be associated with both AF and activity level, suggesting that the arrhythmia is primarily responsible for the observed association. In addition, the significant correlation between AF symptoms (assessed via the validated AFEQT score) and daily step count further strengthens the argument that symptomatic arrhythmia is the driver of reduced activity among these patients. These findings are bolstered by our study design, which allowed for objective assessment of physical activity without the need for error-prone recollection and without explicit participant knowledge that daily exercise was being studied in relation to AF symptoms, minimizing recall and observer bias.

The absolute difference in average daily step count between individuals with and without AF was reasonably high (723 steps in unadjusted, 591 in adjusted model). Prior studies have shown that an additional 1,000 steps/day is associated with significant reductions (ranging between 6-15%) in overall mortality.[20] These data suggest that at least part of the overall health impact of AF may be related to a decrease in physical activity. We recognize that our study design does not allow for assessment of causality and we are therefore unable to definitively determine whether reduced physical activity is the result of AF or is instead the cause of this arrhythmia. However, the observed relationship between worsening AF symptoms and decreased daily exercise suggests that the observed reduction in physical activity is the result of the arrhythmia. In addition, these significant relationships persisted after adjustment for other comorbidities that likely confound the relationship between reduced physical activity and AF risk. Catheter ablation is a validated treatment option for symptomatic AF and has been shown to improve AFEQT scores by an average of 25 points.[21] If symptomatic AF is indeed the cause of reduced step counts, our findings suggest that an improvement in AF symptoms of this magnitude could substantially benefit physical activity and long-term health outcomes, although the wide confidence interval surrounding our AFEQT-step count point estimate should limit further extrapolation.

Several potential limitations should be considered when interpreting these study results. Comorbid health conditions were identified via patient-administered surveys using the HeH online platform. Although it is possible that these data are less reliable than data

obtained from direct medical examination or chart analysis, prior analyses have shown a high accuracy between HeH participant self-report and primary medical record review.[16] Furthermore, to result in a false positive finding, misclassification of these comorbidities would need to correlate with step count. In a more likely scenario, non-differential misclassification resulted in underestimation of these observed relationships. Due to the observational nature of our study, incompletely ascertained or unmeasured confounders that are associated with both daily step count (such as musculoskeletal injuries or conditions such as osteoarthritis) and AF risk (such as lifestyle choices or habits inadequately captured by the available data) could have biased our findings. As we were only able to assess for physical activity that was quantified by an accelerometer-based wearable wrist monitor, we recognize that certain forms of exercise (e.g. stationary cycling) may not be accounted for in the present analysis. In addition, AF symptoms were only assessed at study enrollment via the AFEQT questionnaire. We acknowledge that AF symptoms may have improved or worsened over time, either due to the nature of the disease or secondary to medical therapy. However, as a sensitivity analysis limited to the first 90 days after symptom assessment did not yield significantly different results, we believe this does not entirely account for our findings. In addition, this limitation would presumably reduce statistical power and would seem unlikely to explain our positive findings.

Conclusions

Through the use of wearable, accelerometer-based monitoring, we provide the first evidence that AF is associated with a substantial, objectively measured reduction in physical activity, even after taking associated comorbidities into account. In addition, more symptomatic AF is associated with reduced daily exercise. Collectively, these findings raise the possibility that a proportion of the poor health outcomes associated with AF are related to disease-associated inactivity and that alleviation of AF symptoms may help facilitate physical activity among those with the disease.

Conflict of Interest Statement:

Dr. Marcus has received research support from Medtronic, Eight, Jawbone, and Baylis, am a consultant for Johnson & Johnson and InCarda, and hold equity in InCarda.

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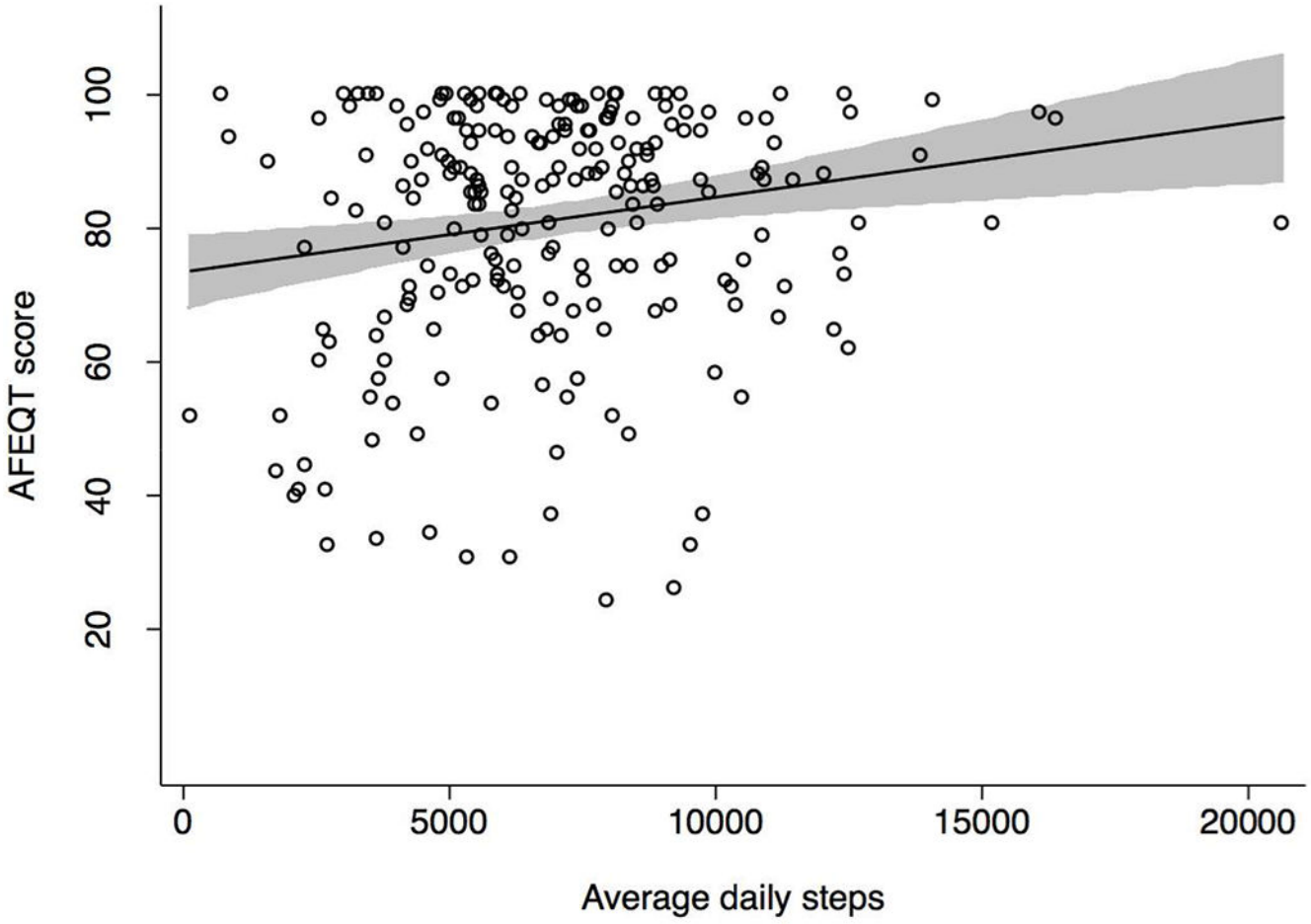

Figure 1.

AFEQT score and Average Daily Step Count.

Linear regression line with 95% confidence intervals (grey shading). AFEQT, Atrial Fibrillation Effect on Quality of Life Survey.

Table 1

Baseline characteristics of participants with and those without prevalent AF

	No AF (n = 3099)	AF (n = 234)	*P* value
Age (y)	49.9 ± 13.6	62.2 ± 12.1	<.0001
Female gender	1836 (59)	106 (45)	<.0001
Race/ethnicity			.07
White	2605 (84)	214 (92)	
African American *	111 (4)	3 (1)	
Asian/Pacific Islander	139 (4)	5 (2)	
Hispanic	204 (7)	10 (4)	
Other	31 (1)	2 (1)	
Education			.70
Some college or less	637 (21)	46 (20)	
BA or higher	1704 (55)	125 (53)	
Unknown	758 (24)	63 (27)	
Annual income			.35
<$50,000	390 (12) *	25 (11)	
$50,000-$100,000	608 (20)	39 (17) *	
>$100,000	1091 (35)	82 (35)	
Unknown	1010 (33)	88 (37)	
History of smoking	738 (24)	81 (35)	<.001
Hypertension	1008 (33)	122 (52)	<.0001
Diabetes	191 (6)	29 (12)	.001
COPD	76 (2)	18 (8)	<.0001
Coronary artery disease	218 (7)	34 (15)	<.0001
Congestive heart failure	48 (2)	34 (15)	<.0001

Values are given as mean ± SD or n (%).

AF = atrial fibrillation; BA = Bachelor of Arts degree; COPD = chronic obstructive pulmonary disease.

Table 2

Unadjusted and adjusted associations between baseline characteristics and average daily step count

	Unadjusted model			Adjusted model*		
	Steps/day	**95% CI**	***P* value**	**Steps/day**	**95% CI**	***P* value**
Age (per year)	−2	−10 to 6	.6	9	0.5 to 18.0	.04
Female gender	−557	−780 to −334	<.001	−628	−851 to −404	<.001
Non-White race	−248	−553 to 57	.11	−265	−567 to 37	.09
Education						
BA or higher	Reference					
Some college or less	−831	−1114 to −547	<.001	−439	−729 to −149	.003
Unknown	3	−263 to 269	.98	−57	−690 to 576	.86
Household income						
>$100,000	Reference					
$50,000-$100,000	−697	−1006 to −388	<.001	−469	−780 to −159	.003
<$50,000	−1381	−1742 to −1021	<.001	−914	−1287 to −541	<.001
Unknown	−353	−618 to −88	.009	−400	−789 to −11	.044
Tobacco use						
Never smoker	Reference					
Active smoker	−352	−621 to −82	.011	−193	−465 to 79	.16
Unknown	152	−123 to 426	.28	195	−419 to 808	.53
Hypertension	−855	−1086 to −624	<.001	−757	−1003 to −510	<.001
Diabetes	−1304	−1746 to −862	<.001	−938	−1383 to −492	<.001
COPD	−1636	−2299 to −972	<.001	−1181	−1842 to −520	<.001
Coronary artery disease	−418	−835 to −2	.049	−77	−501 to 348	.72
Congestive heart failure	−1273	−1984 to −563	<.001	−576	−1294 to 143	.12
Atrial fibrillation	−723	−1154 to −292	.001	−591	−1033 to −149	.009

BA = Bachelor of Arts degree; CI = confidence interval; COPD = chronic obstructive pulmonary disease.

*Model adjusted for all listed variables.