Actigraphy-derived physical activity levels and circadian rhythm parameters in patients with psoriatic arthritis: relationship with disease activity, functional impairment, mood, age and BMI.

Dr Dylan McGagh[1], Dr Niall McGowan[2], Dr Chris Hinds[3], Prof Kate EA Saunders[4] and Prof Laura C Coates[1]

1. Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford. 2. Sleep and Circadian Neuroscience Institute, Nuffield Department of Clinical Neurosciences, University of Oxford. 3. Oxford Digital Phenotyping Laboratory, Big Data Institute, University of Oxford. 4. Department of Psychiatry, University of Oxford.

Background

Psoriatic arthritis (PsA) is a chronic inflammatory disease occurring in approximately 30% of patients with psoriasis. The disease can manifest as peripheral arthritis, axial involvement, enthesitis and dactylitis and leads to an increased lifetime risk of metabolic syndrome and cardiovascular disease. This association is thought to be mediated by chronic inflammation and reduced physical activity secondary to pain, fatigue and overall disease burden. To date, there have been no accelerometry studies investigating the relationship between objectively assessed physical activity levels or sleep disturbance and disease activity in patients with PsA.

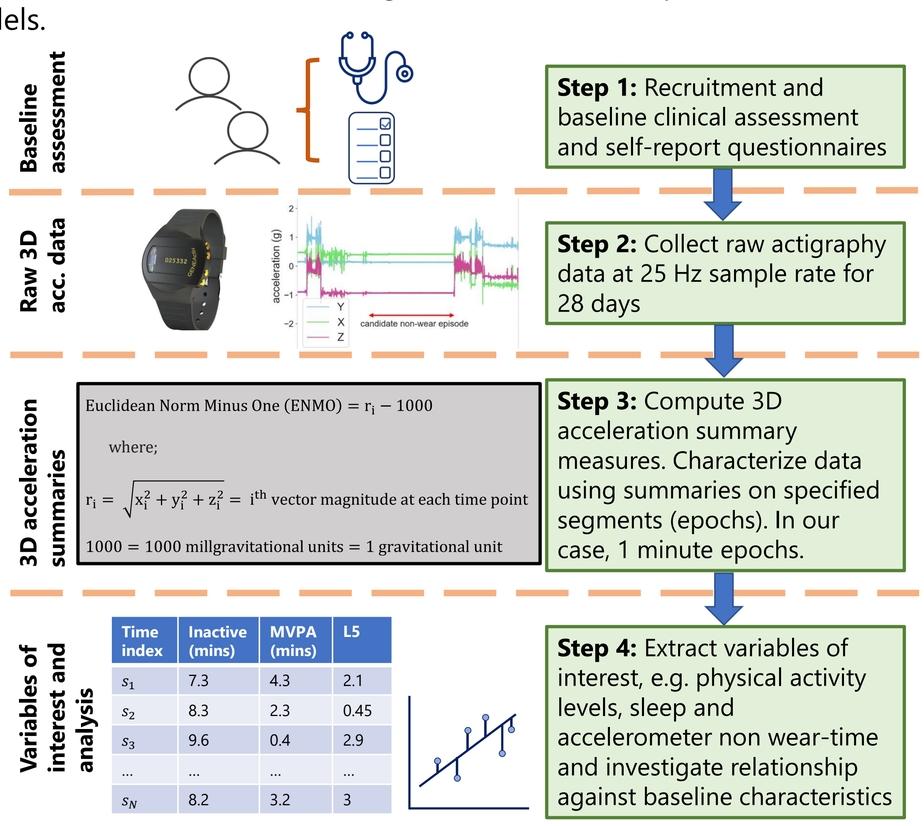
Aims

This pilot study aims to examine the following:

1. To test the feasibility and tolerability of using a smartphone application and wrist-worn accelerometer to collect data on daily symptoms, in patients with PsA.
2. To investigate the relationship between actigraphy measures on physical activity and circadian rhythm and baseline characteristics, including age, BMI, disease activity and functional impairment.

Methods

Participants (n=30) with PsA aged ≥18 and <80 years, meeting the CASPAR criteria for PsA were recruited from rheumatology clinics at a single centre. Disease activity and impact were collected at baseline using the Minimal Disease Activity (MDA) criteria and Psoriatic Arthritis Impact of Disease-9 (PsAID-9) questionnaires, respectively. Participants wore GENEActiv tri-axial accelerometer on their non-dominant wrist for 28 days, which measured time spent in sedentary, light and moderate-to-vigorous physical activity (MVPA). Parameters reflecting the circadian rhythm of physical activity and rest were also estimated, including the onset time of the least active 5-hour (L5) and most active 10-hour (M10) daily periods. A minimum of seven days with ≥21 hours of wear-time per day were included in the analysis. Raw actigraphy data were processed using the GGIR package (version 2.8-0) in RStudio. Participants were also given access to the Mezurio smartphone application which was developed to nest daily symptom and mood questionnaires. We utilized the MoodZoom (MZ) questionnaire to measure daily mood. MZ is a validated 10-item questionnaire collecting items such as feeling cheerful, energetic or anxious on a 5-point Likert scale. The relationship between baseline characteristics, activity levels and circadian measures were assessed using linear-mixed effects (LMER) models. We also investigated the relationship mood and PA levels using LMER models.



Results

Table 1. Participant characteristics at baseline.

	Variables	PsA (*n* = 19)
Demographics		
	Age (yr)	52±11
	Female (%)	42.1
	BMI	29.6 ± 9.0
	Disease duration (yr)	2 ± 1 #
	MDA achieved (%)	47.4
	Co-morbid psoriasis (%)	68.4
Global		
	Patient global activity (0–10)	3.1 ± 2.5
PROMs		
	HAQ	0.46 ± 0.38
	Pain VAS (1-10)	3.3 ± 2.8
	PsAID-9 score (1-10)	2.9±1.9
	PHQ-2 depression (%)	0

#, Median and Interquartile Range

Results

2. Wear-time as marker of feasibility

There was total of 342 eligible person-days (64.3% of the 532 available days). Wear-time compliance for those included in the final analysis was 17.2±4.6 days. The number of valid week days was 12.3 ± 3. The number of valid weekend days was 4.9 ± 1.5. The mean time spent in inactivity per day was 602±77 minutes. The mean time spent in light PA per day was 237±68 minutes. The mean time spent in MVPA was 90.5±40.8 minutes.

3. Impact of disease activity on PA levels in PsA

LMER models controlling for age, BMI, disease duration, and weekday type (weekend vs weekday) identified a statistically significant association between MDA and levels of physical activity (Table 2). Participants with active PsA spent 63.87 minutes (95%CI: 18.52-109.23, p=0.008) more in inactivity and 30.78 minutes (95%CI: 0.43-61.13, p=0.047) less in MVPA per day compared to those in MDA. Age, BMI and disease duration were also associated with physical activity duration (Table 2) within the multivariate models. A one-year increase in age was associated with 2.22 minutes (95%CI: 0.12 – 4.3, p=0.04) more in inactivity and 1.18 minutes (95%CI: 0.45 – 2.81, p=0.014) less in MVPA.

Table 2. LMER model outputs investigating relationship between disease activity, BMI, age, disease duration and weekend effect on physical activity levels

	Inactivity (mins/day)			Light PA (mins/day)			MVPA (mins/day)		
Predictors	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	401.99	280.99 – 522.98	**<0.001**	303.51	151.22 – 455.80	**0.001**	207.38	126.06 – 288.69	**<0.001**
MDA	-63.87	-109.23 – -18.52	**0.008**	34	-22.80 – 90.80	0.225	30.78	0.43 – 61.13	**0.047**
Age	2.22	0.12 – 4.33	**0.04**	-0.78	-3.42 – 1.87	0.546	-1.83	-3.24 – -0.42	**0.014**
BMI	2.99	0.54 – 5.44	**0.019**	-0.58	-3.63 – 2.48	0.697	-1.18	-2.81 – 0.45	0.147
Disease duration	0.63	0.26 – 1.00	**0.002**	-0.42	-0.88 – 0.04	0.074	0.04	-0.20 – 0.29	0.706
Weekend	-8.65	-34.11 – 16.81	0.504	-20.84	-33.49 – -8.20	**0.001**	-7.44	-15.81 – 0.92	0.081

4. Relationship between daily mood and PA levels in PsA

LMER models investigating the relationship between daily mood items collected on the Mezurio smartphone app identified a significant relationship between positive mood items and PA levels for the matched day. There was a non-significant trend between feelings of sadness, anxiety, anger and self-doubt and reduced PA.

Table 3. LMER model outputs investigating relationship between mood and PA

	Inactivity (mins/day)			Light PA (mins/day)			MVPA (mins/day)		
Predictors	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	425.86	271.26 – 580.46	<0.001	304.15	150.79 – 457.50	<0.001	180.59	109.61 – 251.58	<0.001
Energetic	**-41.39**	**-60.21 – -22.58**	**<0.001**	14.91	4.16 – 25.65	0.007	**13.3**	**6.56 – 20.04**	**<0.001**
(Intercept)	438.59	294.70 – 582.47	<0.001	301.83	147.98 – 455.68	<0.001	171.52	98.95 – 244.09	<0.001
Cheerful	**-37.43**	**-55.06 – -19.80**	**<0.001**	12.48	2.40 – 22.55	0.015	**14.22**	**7.91 – 20.53**	**<0.001**
(Intercept)	427.27	287.10 – 567.45	<0.001	307.59	153.62 – 461.57	<0.001	179.41	106.88 – 251.93	<0.001
Elated	**-38.88**	**-58.22 – -19.54**	**<0.001**	11.8	0.28 – 23.32	0.045	**12.81**	**5.61 – 20.00**	**0.001**

All models control for age and BMI. All significant findings were significant within univariate models with age and BMI removed; Accepted α-level of 0.005 to post-Bonferroni correction.

5. Impact of functional impairment on circadian rhythm in PsA

Models investigating the relationship between disease activity and the circadian rhythm of the rest-activity cycle found a non-significant trend between achieving MDA and an earlier M10 onset time. LMER models investigating the relationship between HAQ and M10 onset time controlling for age, BMI, disease duration and weekend effect demonstrated that a 1-point increase in HAQ score was associated with a 1.94 hour (95% CI: 0.49 – 3.39, p=0.011) delayed M10 onset time (table 3).

Table 4. LMER model outputs investigating relationship between disease activity, BMI, age, disease duration and weekend effect on circadian rhythm parameters

	L5 Onset Time			M10 Onset Time		
Predictors	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	24.16	21.33 – 26.98	**<0.001**	9.43	6.52 – 12.34	**<0.001**
HAQ	1.3	-0.10 – 2.71	0.067	1.94	0.49 – 3.39	**0.011**
Age	-0.01	-0.06 – 0.03	0.564	-0.02	-0.07 – 0.03	0.477
BMI	0.02	-0.04 – 0.08	0.536	-0.01	-0.07 – 0.05	0.735
Disease duration	0.01	0.00 – 0.02	**0.029**	0	-0.01 – 0.01	0.518
Weekend	0.46	-0.03 – 0.95	0.065	0.27	-0.16 – 0.70	0.223

Conclusions and future directions

Our study demonstrates a clear relationship between increased disease activity and reduced PA in patients with PsA. Our study has also demonstrated disruption to circadian rest-activity patterns in the form of delayed M10 onset time related to functional impairment in PsA. Delayed M10 onset time may represent morning stiffness, pain and immobility associated with increased disease activity and is worth further investigation as an indication of early morning symptoms. Collectively, these data demonstrate the potential utility of digital phenotyping of mood and daily disease symptoms within PsA cohorts. Remote daily monitoring could have applications in PsA clinical trials to aid efficacy assessment with further validation of these findings needed in larger PsA cohorts.

Acknowledgements

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