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Characterising mobility and pressure exposure in community dwelling residents with pressure ulcers using monitoring technology and intelligent algorithm

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ABSTRACT

Aim: Individuals in the community with reduced mobility are at risk of exposure to prolonged lying and sitting postures, which may cause pressure ulcers. The present study combines continuous pressure monitoring technology and intelligent algorithms to evaluate posture, mobility, and pressure profiles in a cohort of community dwelling patients, who had acquired pressure ulcers.

Materials and methods: This study represents a secondary analysis of the data from the Quality Improvement project 'Pressure Reduction through COntinuous Monitoring In the community SEtting (PROMISE)'. 22 patients with pressure ulcers were purposely selected from 105 recruited community residents. Data were collected using a commercial continuous pressure monitoring system over a period of 1–4 days, and analysed with an intelligent algorithm using machine learning to determine posture and mobility events. Duration and magnitude of pressure signatures of each static posture and exposure thresholds were identified based on a sigmoid relationship between pressure and time.

Results: Patients revealed a wide range of ages (30–95 years), BMI (17.5–47 kg/m^2) and a series of co-morbidities, which may have influenced the susceptibility to skin damage. Posture, mobility, and pressure data revealed a high degree of inter-subject variability. Largest duration of static postures ranged between 1.7 and 19.8 h, with 17/22 patients spending at least 60 % of their monitoring period in static postures which lasted >2 h. Data revealed that many patients spent prolonged periods with potentially harmful interface pressure conditions, including pressure gradients >60 mmHg/cm.

Conclusion: This study combined posture, mobility, and pressure data from a commercial pressure monitoring technology through an intelligent algorithm. The community residents who had acquired a pressure ulcer at the time of monitoring exhibited trends which exposed their skin and subdermal tissues to prolonged high pressures during static postures. These indicators need further validation through prospective clinical trials.

1. Introduction

Individuals residing in community settings can spend prolonged periods of time in bed or their chair, particularly those with mobility impairments [1]. This can result in the exposure to prolonged pressure and shear forces in vulnerable bony landmarks e.g., sacrum and heels, which can lead to local tissue damage. This damage to the skin and underlying soft tissues is referred to as a pressure ulcer (PU) [2], which can vary in size and severity and have a significant impact on the individual's quality of life [3]. These chronic wounds require extensive treatment, which has been attributed with a high treatment burden in studies around the world [4,5].

Prevention strategies currently focus on pressure relief via periodic repositioning and pressure redistribution [2]. This is typically achieved through support surface selection and self-evoked movements, or where mobility is limited, by clinicians and carers who manually adjust the individual's posture. However, this can be time consuming and labour intensive [6]. Accordingly, in many community settings where resources are limited, the recommended frequency and magnitude of movements are not followed [7], or delivered effectively [8]. In addition, there is a

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lack of robust evidence on the frequency and effectiveness of repositioning to prevent pressure ulcers [9]. As a result, individuals may be exposed to prolonged pressures over time, putting bony landmarks such as the sacrum at high risk of damage. Indeed, seminal research has identified a sigmoid relationship between pressure exposure and time, above which damage thresholds are exceeded [10].

Technologies that can both monitor and promote active mobility, assisting those who are frail and identify detrimental health signs are critical to our future digitally enabled care provision [11]. An example of existing technology to aid clinical decision-making is pressure sensing arrays, which are used to assess individuals whilst lying or sitting [12], providing a visual feedback of the pressure distribution at the body-support surface interface to optimise posture and aid in the selection of support surfaces [13]. These devices have also been used in research to assess the performance of support surface systems [14–16]. However, this is typically performed either at a single time point or averaged over short periods, providing a "snapshot" of the interface conditions. Accordingly, the interpretation of these data provides limited prognostic insight [14].

In recent years, technologies have been adapted to monitor over prolonged periods. These modified continuous pressure monitoring technologies have been evaluated in hospital settings, revealing some positive impact through biofeedback with patients and healthcare professionals [17–20]. In parallel, lab-based studies have explored the use of continuous pressure monitoring as a surrogate for movement, through machine learning (ML) and artificial Intelligence (AI) algorithms [21,22]. Specific features within the pressure data were both sensitive and specific to postural movements [21] and artificial intelligence was used to efficiently analyse posture and movement patterns [22]. This has been translated to assess vulnerable patients during prolonged periods of lying and sitting in specific cohorts, i.e., spinal cord injured [23,24]. To date, however, there has been no studies that have utilised this combination of pressure monitoring and intelligent algorithms on individuals residing in the community. This is despite the known risks of pressure ulcers in community residents, many of whom present with mobility impairments and challenges in care provision. Therefore, the aim of the present study was to evaluate the posture, mobility, and pressure profiles of residents in the community who had acquired a pressure ulcer.

2. Materials and methods

This study represents a secondary analysis of the Quality Improvement project 'Pressure Reduction through COntinuous Monitoring In the community SEtting (PROMISE)' [25], during which 105 community residents (individuals in private, residential and nursing homes) were recruited from four regional healthcare providers based in Southwest England. From this cohort, 22 patients who had received repeat continuous pressure monitoring interventions were selected for further analysis, corresponding to patient with current pressure ulcers from each of the recruitment sites. Individuals were eligible for the PROMISE study if they were deemed at high risk of PU development, had existing pressure ulcers or were reluctant or unable to use their allocated pressure relieving equipment. Informed consent was obtained from each participant prior to the monitoring period, or where appropriate consent via a consultee. Data collection was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

Institutional ethical approval was sought for secondary analysis of the data (ERGO 80625. A1). This included the continuous pressure monitoring data captured when patients were initially assessed (baseline) and corresponding demographics.

2.1. Test equipment

A commercial continuous pressure monitoring system (ForesitePT, Xsensor, Canada) was used in the PROMISE study. The ForeSite PT is a bed sensing array and consists of a fitted mattress cover embedded with 5556 sensor cells, over a surface area of 762 × 1880 mm and spatial resolution of 15.9 mm. The system continuously recorded interface pressure values with a sampling frequency of 1 Hz. Each sensor operates within the pressure range of 5–256 mmHg (0.7 −34.2 kPa), with an accuracy of ±1 mmHg. Sensor arrays were used in each recruitment site, placed on top of the mattress, underneath a bed sheet, with the dedicated monitor showing an image of the pressure distribution. The systems were cleaned between patient usage as per the infection prevention standards of the healthcare institution.

2.2. Data collection

Prior to data collection, the clinical teams implementing the continuous pressure monitoring were trained on how to use the system. Patients and carers were provided with information and a demonstration of how the image on the monitor represented real-time visual feedback of their interface pressures, with cold colours (green, blue) representing low pressures and warm colours (red, yellow) representing high pressure, was given. A tissue viability nurse assessed the skin of each participant and recorded relevant clinical data. These were documented on a standardised data recording sheet, noting their skin status, support surface, mobility, level of frailty, comorbidities, body mass index (BMI), and level of sensory impairment. Photos of pressure ulcers present for each patient were validated by three tissue viability nurses and graded according to international guidelines through consensus [26].

Patients were monitored for a minimum of 5 h and a maximum of 4 days (median 21.3 h). The duration of the monitoring period was affected by patient preference, their care needs and ability of clinician to return to collect the equipment. Where patients were able to see the monitor and had the ability to reposition, they could use the interface pressure image to support their movements. Individuals remained on the support surface which had been prescribed to them, receiving their normal level of care over the monitoring period. Patients, carers, and visiting clinicians were able to report any issues with the monitoring equipment and had the opportunity to stop the study at any time.

Following data collection, the raw data of each patient were extracted from the continuous pressure monitor. These were anonymised, saved, and securely stored. To facilitate the storing process, some recordings were down sampled from 1Hz (1 sample every second) to a minimum sampling frequency of 0.2Hz (1 sample every 5 s).

2.3. Posture and mobility prediction

The pressure profile of each patient was analysed with a customised intelligent algorithm [21–23] to estimate the frequency and magnitude of movements. The algorithm to analyse pressure data as a surrogate for detecting changes in lying postures had been developed in the host lab and comprehensively described [21–23]. To review briefly, the algorithm used the derivative signal of combined parameters, including the centre of pressure (COP) in both planes of the sensing array and the contact area above a specific threshold (20 mmHg), to identify the large-scale movements. These were defined as a movement where clear evidence of changes in the spatial distribution of pressures was achieved via postural changes [21]. Prior to movement detection, pressure parameters were subjected to a series of processing steps, which included filtering to remove noise. The sum of the derivative signal was subjected to discriminant thresholds to identify the events associated with movements. Subject-specific thresholds were established for each individual, with a two-step verification process.

1. A large-scale movement was defined as a relative change in contact area (≥20 mmHg) between the current and previous posture exceeding a threshold value of 3.2 %, representing the minimum change in the contact area from established data [21].
2. A static posture was defined as a posture sustained for a period exceeding 90 s, which has been reported to represent the minimum time required for soft tissues to recover from loading in individuals at risk of PU [27].

The analysis was applied to all 22 patients. A convenient sample of five patients was selected amongst this cohort and the movement events were detected with the algorithm from their pressure data. These were used for corroboration with an experienced specialist tissue viability nurse, with extensive experience in clinical use of pressure monitoring (NAW).

Following this initial comparison, the algorithm provided a higher sensitivity to movement prediction than that of clinical observations. To improve the convergence between observed and predicted events, fixed width windows of the derivative data were created to reduce the sensitivity of the algorithm and avoid duplication of movement observation caused by smaller scale movements occurring during postural changes. For each window, the new prediction was then compared with the independent annotation to determine the optimal window length.

Schematic in Fig. 1 shows representative images of pressure distributions (Fig. 1A) and the temporal profile of the derivative, with the postural changes highlighted by red markers (Fig. 1B).

Following the detection of postural changes with the optimised algorithm, the subsequent movement features were estimated for each patient, involving.

- Frequency of movements per hour.
- Interval between postural changes, namely duration of each static posture.
- Percentage of time spent in static postures for more than 2 h.

2.4. Pressure signature

For each patient, temporal pressure signatures of peak pressure gradient, were estimated across the monitoring period (Fig. 1C) using a custom software developed in Matlab (Mathworks, USA). Peak pressure gradient is defined as the change in pressure between adjacent sensing cells, with measurement unit of mmHg/cm. In the present study it was calculated in a diagonal direction with respect to the long axis of the mat. For each of the static postures detected, magnitude and duration of peak pressure gradient was estimated (Fig. 1D) and parametric descriptors of this signal were defined (mean ± standard deviation). This is represented for one posture in Fig. 1E, which shows mean and standard deviation, indicated with a marker and error bars, of the peak pressure gradient (y-axis) and the time during which the specific posture was sustained (x-axis).

This pressure-time relationship was estimated relative to a sigmoid injury threshold [10]. Previous studies demonstrated that relatively low pressures compromise tissue viability [28]. In particular, a recent study [29] demonstrated changes in the microvascular and lymphatic response following an applied pressure of 30 mmHg, with greater compromise appearing at higher loads, e.g. 60 mmHg and 90 mmHg. Accordingly, in this study three arbitrary exposure thresholds based on the sigmoid relationship between pressure and time were identified (Fig. 1E), which we refer to a low, moderate, high, and very high pressure/time exposure. For each patient, the periods of static posture were annotated using the sigmoid curves and the proportion of time in each exposure threshold as a product of the total monitoring period was calculated.

3. Results

3.1. Patients

From the 105 community residents monitored during PROMISE study, a convenient sample of 22 patients were included for the current analysis, with their demographics detailed in Table 1.

This revealed a wide range of ages (30–95 years of age) and BMI (17.5–47 kg/m^2). Patients also had a series of co-morbidities e.g.,

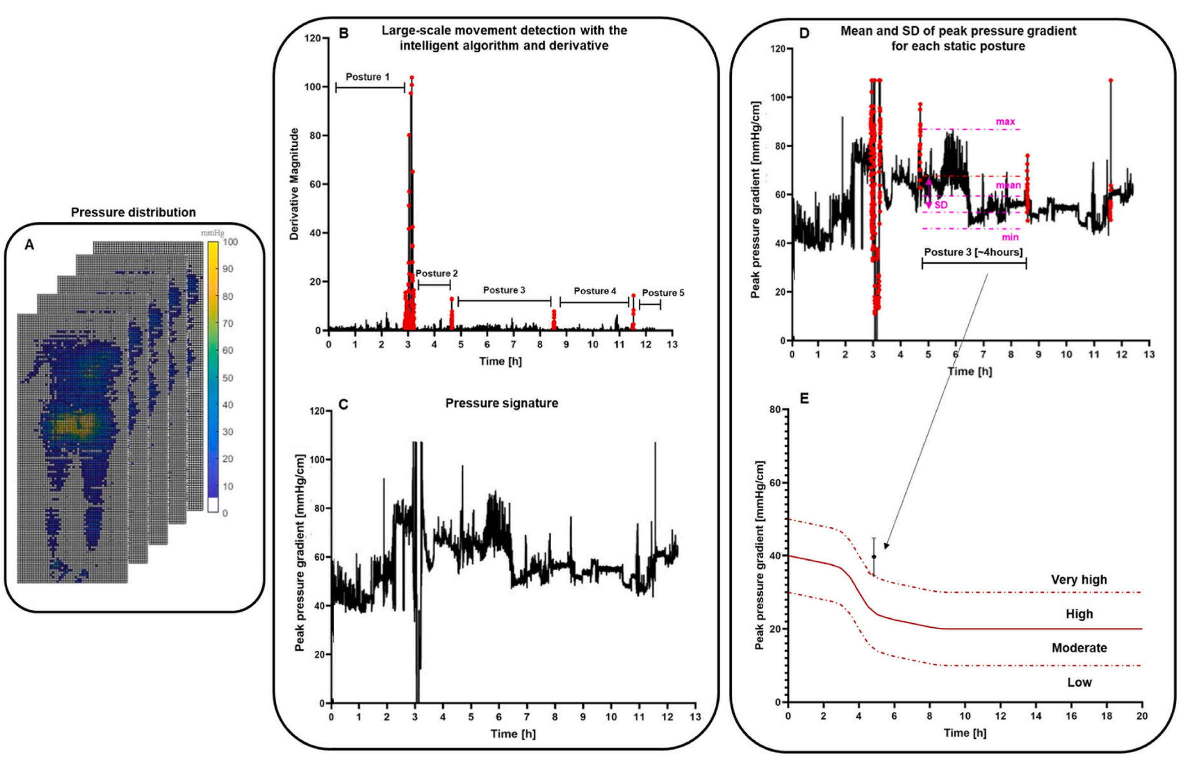

Fig. 1. Schematic representing the methodology developed to detect posture, mobility (A, B), pressure signatures (C, D) and categories of exposure (E).

Table 1
Patients demographics, pressure ulcer category, and support surface type.

Patient No.	Age	Weight [kg]	Height [cm]	BMI [kg/m^2]	Frailty score	PU stage	Mattress type
1	74	108	152	46.7	6	Cat 2	Dynamic Air Overlay
2	92	60	157	24.3	6	Cat 2	Dynamic Air Overlay
3	78	60	167	21.5	6	Cat 2	Static Foam Mattress
4	87	85	180	26.2	8	Cat 2	Dynamic Air Overlay
5	87	95	170	32.9	8	Cat 2	Static Foam Mattress
6	66	82	160	32.0	7	Cat 2	Own Mattress
7	66	66	161	25.5	6	Unstageable	Static air overlay
8	52	40	162	15.1	6	Unstageable	Dynamic Air Mattress
9	86	50	160	19.5	7	Cat 2	Dynamic Air Overlay
10	68	45	141	22.5	7	Cat 4	Dynamic Air Mattress
11	30	/	/	31.0	7	Cat 2	Static air Overlay
12	65	/	/	21.0	7	Unstageable	Powered Hybrid (Air and Foam)
13	71	/	/	24.0	7	Unstageable	Powered Hybrid (Air and Foam)
14	82	58	180	17.9	6	Cat 3	Dynamic Air Mattress
15	60	127	183	37.9	4	Unstageable	Static Foam Mattress
16	56	40	152	17.5	5	Healing Cat 4	Powered hybrid (Air and Foam)
17	82	44	150	19.6	7	Cat 3	Own Mattress
18	43	67	170	23.3	7	Cat 2	Static Foam Mattress
19	95	70	162	26.5	7	Healed	Dynamic Air Mattress
20	81	95	175	31.0	8	Cat 3	Dynamic Air Mattress
21	65	/	/	18.0	7	Unstageable	Dynamic Air Mattress
22	74	75	180	23.1	7	Cat 2	Powered hybrid (Air and Foam)

diabetes, spinal cord injury, some of which may have influenced the susceptibility to skin damage. The majority of these patients were living with moderate (4–6 frailty score), severe (7 frailty score) and very severe frailty (8 frailty score) [30] and all had a pressure ulcer on their buttock region, e.g., sacrum, lower spine, hip or ischial tuberosity.

NB. Support surfaces are described by type and mode. This includes 'Overlay' – device placed on top of mattress, 'Dynamic' – has capability to provide alternating pressures within the device, 'Static' device which has no active internal pressure changes, 'Powered hybrid' – combination of static foam and air cells which may have the capability to alternate.

3.2. Movement analysis

Table 2 shows the movement features for each patient. Analysis of the data revealed differing recording periods, from approximately 5 h (P#20) to a maximum of 47 h (P#22).

A high degree of subject variability was evident, with the frequency of postural changes ranging between 0.1 and 1.9 movements per hour, and the largest interval between postural changes ranging between 1.7 and 18.8 h. In addition, 17/22 patients spent at least 60 % of their monitoring period in static postures for more than 2 h.

Closer examination of the data revealed that the patients with a low frequency of postural changes were exposed to static postures for longer periods, with a greater proportion of time in positions which exceeded 2 h (Fig. 2A). In addition, two distinct clusters of patients were identified when the number of postural changes were related to the percentage of time spent in static postures >2 h (Fig. 2B). Indeed, five patients performed up to >15 postural changes during the monitoring period, with less than 40 % of their time over the monitoring period in static postures >2 h.

Table 2
Movement features estimated from the continuous pressure data following prediction with the intelligent algorithm.

Patient No.	Monitoring period [h]	No. Postural changes	No. Static postures	Freq. of postural changes per hour	Largest interval [h] between postural changes	% time spent in postures >2h
1 (D)	15.1	23	22	1.4	2.5	28.8
2 (D)	15.6	19	20	1.2	2.3	14.9
3 (S)	21.7	4	5	0.2	7.7	76.6
4 (D)	22.9	3	4	0.1	13.6	96.8
5 (S)	11.4	3	4	0.3	7.1	62.5
6 (O)	6.8	5	6	0.7	5.5	81.3
7 (S)	16.4	8	9	0.5	6.9	62.8
8 (D)	20.9	6	7	0.3	12.1	78.2
9 (D)	23.7	9	10	0.4	7.3	65.6
10 (D)	9.8	19	20	1.9	1.7	0.0
11 (S)	50.1	7	7	0.1	17.9	96.0
12 (H)	46.4	9	7	0.2	18.8	94.0
13 (H)	34.2	8	7	0.2	14.1	92.1
14 (D)	44.0	59	60	1.3	6.9	38.7
15 (S)	12.6	4	5	0.3	3.9	78.5
16 (H)	43.1	30	31	0.7	2.9	32.8
17 (O)	17.9	5	6	0.3	6.5	84.2
18 (S)	23.4	4	5	0.2	9.7	89.9
19 (D)	20.2	4	5	0.2	14.9	73.6
20 (D)	5.4	1	2	0.2	5.1	93.4
21 (D)	42.4	7	8	0.2	13.3	92.2
22 (H)	47.0	13	12	0.3	16.0	77.4
Range	5.4–50.1	1–59	4–60	0.1–1.9	1.7–18.8	0–96.8

NB. 'D' Dynamic mattress, 'S' Static Mattress, 'H' Hybrid Mattress, 'O' Own mattress.

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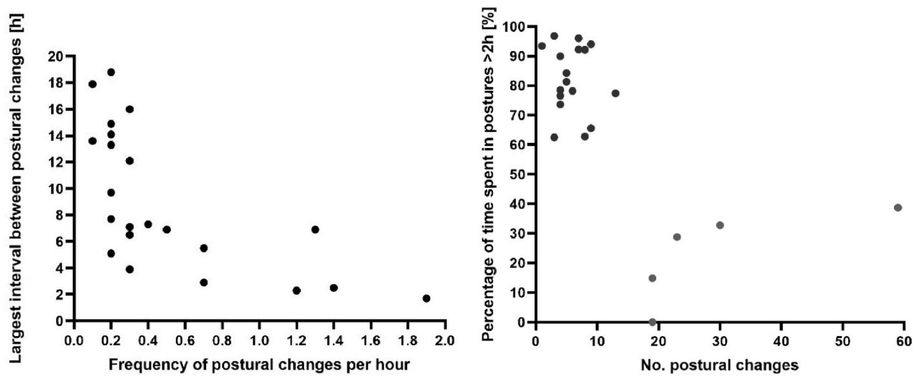

Fig. 2. A) Relationship between the frequency of postural changes per hour (x-axis) and the largest interval time between postural changes [hours] (y-axis). **B)** Relationship between the number of postural changes detected with the algorithm and the percentage of time spent in static postures for more than 2 h (y-axis).

3.3. Pressure profile

Fig. 3 shows the duration (x-axis) and magnitude (y-axis) of the mean peak pressure gradient (SD represented with the error bars) during each of the static postures, for 8 patients, who were purposely selected to reflect a range of demographics. Data revealed that the pressure-time profiles varied across patients. As an example, Pt #1 showed 22 static postures sustained for a relatively short period of time (<2.5 h), with some postures sustaining a mean peak pressure gradient greater than 40 mmHg/cm and a high standard deviation, as depicted by the error bars. By contrast, Pt #11 showed lower peak pressure index values (below 30 mmHg/cm) and standard deviations, with postures sustained for longer periods e.g., ~18 h. It was interesting to note that some patients, e.g., Pt #1 and Pt #16 had clusters of static postures that lasted less than 3 h, with variations in peak pressure gradient magnitude.

The proportion in each exposure threshold with respect to the monitoring period was estimated for all patients (Table 3). Data revealed that some patients e.g., Pt #2, Pt #7, Pt #10, Pt #16, spent most of their time (>50 %) in the low threshold. On closer inspection of Pt #2 and Pt #16, their respective data revealed a high number of postural changes with static postures sustained for short periods (<3 h), with their combined mobility and pressure signatures falling in the low exposure threshold. By contrast, there were patients e.g., Pt #6, Pt #13, Pt #17, Pt #19, Pt #20, whose combined mobility, and pressure signatures fell in the very high exposure threshold for >80 % of their time (Pt #6 and #19), equally in the high and very high thresholds for ~40 % of the time (Pt #17) and in the high threshold for >60 % of their time (Pt #19 and #20). Other patients from the cohort of 22 revealed extended periods in the moderate category of exposure threshold (Pt #11, Pt #12, Pt #18), whereby prolonged static postures (>10 h) were associated with mean peak pressure gradient values of approximately 20 mmHg/cm.

4. Discussion

This study represented a secondary analysis of the Quality Improvement project 'PROMISE' and aimed at evaluating posture, mobility, and pressure profiles of a cohort of 22 patients, resident in the community who had acquired a pressure ulcer. Their pressure monitoring data acquired during prolonged lying postures were analysed using a multi-step approach. This included an intelligent algorithm for movement detection [23], pressure data analysis for prolonged postures, and translation to a novel threshold detection system which employed a sigmoid curve for pressure exposure [10]. The data revealed large heterogeneity in the movement profiles and pressure signatures (Fig. 3), with some patients exposed to potentially harmful pressures over prolonged periods (Table 3). This corresponded to the patients selected having current pressure ulcers. The proposed method of analysing continuous pressure monitoring data requires further assessment using prospective data collection in different care settings to understands its potential in supporting patient care and pressure ulcer prevention strategies.

Previous studies characterised movement patterns in a range of patient cohorts. A recent study on a small cohort of in-patients with spinal cord injury used continuous pressure monitor as surrogate posture and mobility detection and demonstrated that patients who experienced skin damage had either a very high or very low frequency of movement in lying [24]. A similar result was shown in an observational study in which hospital patients' movements were monitored with a piezoelectric motion sensor, and reported that pressure ulcers occurred both in low and high movers [31].

The present study represents the first of this kind in using a continuous pressure monitor to characterise both movements and pressure signature through pressure-time exposure. The comparison movement data between the present study and previous research is limited by the difference in monitoring technologies and thresholds to define movement [31,32]. However, in both the present study and similar community monitoring evaluations, a range of immobility observations have been made, with observations of community residents immobile for >3 h [32]. However, there is a need for better consensus and reporting consistency regarding what constitutes a macro-movement (change in posture) and micro-movement, which may not relieve previously loaded tissue sites [33].

Patients had a range of different frailty scores, severity of pressure ulcers and were supported on different surfaces, including those that were dynamic and/or static in nature (Table 1). Table 2 identifies several patients with a high number of postural changes (Pt #1, Pt #2, Pt #10, Pt #14, Pt #16, Pt #22). There exists a potential for the algorithm to detect the movement of the dynamic mattress being used by some patients, rather than subtle or pronounced postural changes, which was observed in a previous application of the algorithm [24]. However, data revealed that some patients on dynamic mattress systems had low movement profiles (Table 2), indicative of low levels of mobility which were not fully counteracted by the mattress settings. To mitigate this risk of false movement detection, the algorithm provided patient specific thresholds for movement using the derivative signals from centre of pressure and contact area [23]. It is also of note that for some patients e.g., Pt #1, there was a large degree of variance in the pressure data within postures, denoted with error bars on the sigmoid curves (Fig. 3), could be indicative of small-scale movements e.g. legs or arms movements, performed within static postures [23]. It is not fully known how some of these smaller scale movements may support tissue health and perfusion [30,32]. However, the results from this study have clearly demonstrated that some community patients with pressure ulcers, sustained prolonged static postures for >10 h. This prolonged exposure of pressure over vulnerable tissue sites may have contributed to the development of the pressure ulcer.

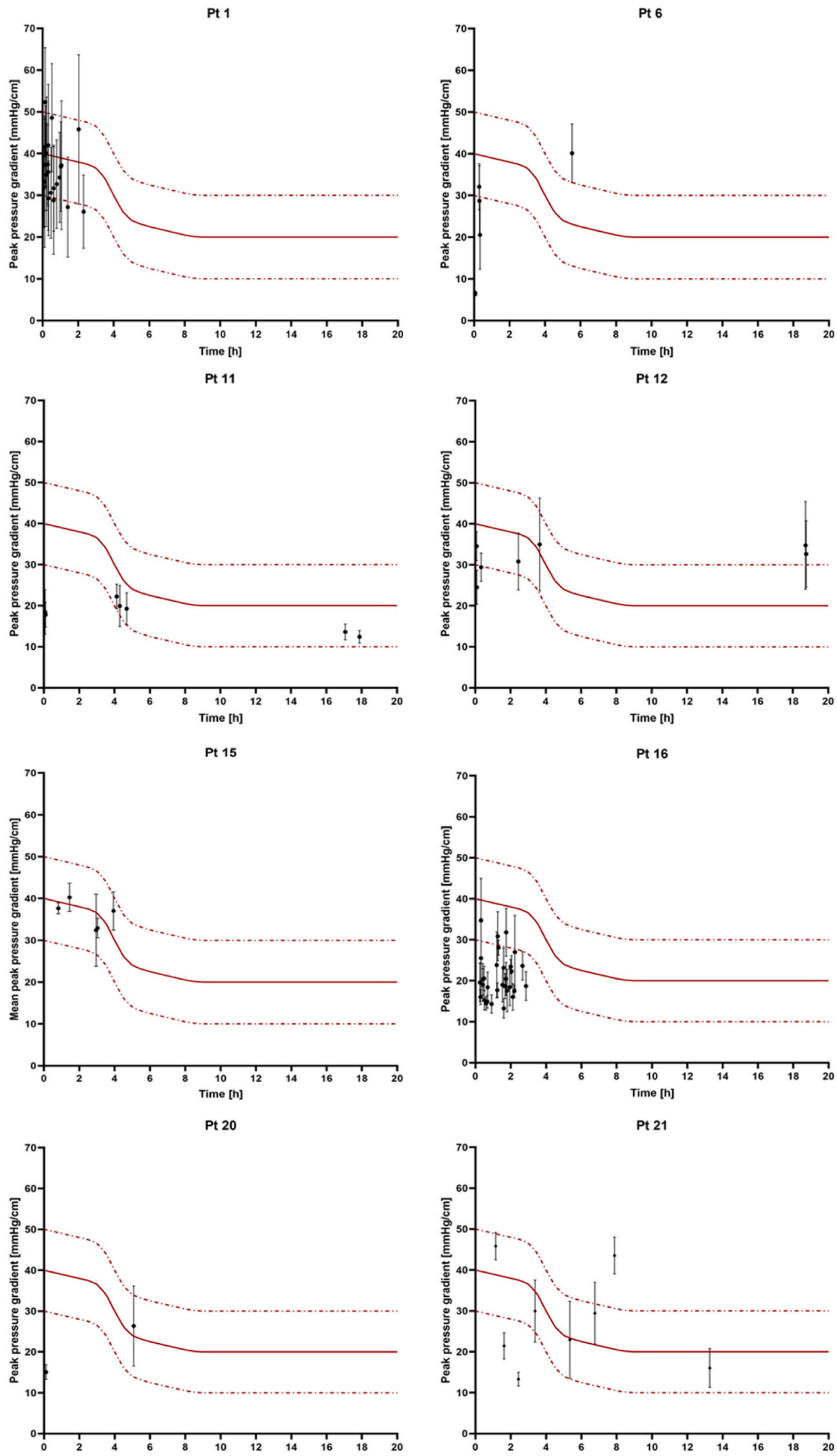

Fig. 3. Duration (x-axis) and magnitude (y-axis) of the mean peak pressure gradient (SD represented with the error bars) during each of the static postures, for patients P#1, P#6, P#11, P#12, P#15, P#16, P#20, P#21. In red are represented the three arbitrary injury thresholds based on the sigmoid relationship between pressure and time exposure [10]. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 3
Proportion of time [%] with respect the monitoring period in each exposure threshold for all 22 patients.

Patient No.	Low	Medium	High	Very High
1	30.9	41.4	20.1	0.9
2	84.3	0	0	0
3	31.1	23	35.5	0
4	37.5	0	59.3	0
5	35.6	62.5	0	0
6	11.1	4.2	0	81.3
7	93.7	0	0	0
8	35.5	0	59.1	0
9	40.5	54.6	0	0
10	82.1	3.7	0.5	2.7
11	9.7	86.7	0	0
12	14.2	80.8	0	0
13	0	11.7	1.6	82.1
14	23.5	17.4	6.3	33.8
15	0	53.8	42.6	0
16	86.7	7.7	0	0
17	11.3	0	41.6	43.5
18	15.4	80.8	1.6	0
19	21.7	0	73.6	0
20	2.1	0	93.4	0
21	9.6	51.9	18.7	18.6
22	15.5	24.4	46.7	0

The pressure data presented in the current study relates to the peak pressure gradients during a given posture. The thresholds from which these gradients may cause tissue damage will be dependent on several patient factors [34]. Consequently, three arbitrary thresholds were selected in the present study to encompass these factors, with these depicted over time using an established sigmoid curve [10]. The corresponding analysis revealed that for some patients, pressure gradients exceeded 45 mmHg/cm for prolonged periods e.g., Pt#21, which have been shown to occlude both local vascular and lymphatic microvasculature [29]. These values are likely to be a consequence of the immersion properties of the support surface, posture of the individual and their morphology, for example the shape and prominence of bony landmarks [35]. Pressure gradients represent one of many pressure parameters that could be explored, which are dependent on the resolution and accuracy of the pressure monitoring system. Future versions of this algorithm may require further pressure parameters e.g., peak pressure index [36], more specific areas of interrogation, for example a region of interest over the site of the pressure ulcer, and subject specific thresholds that take into account patient's history, e.g. comorbidity. However, the development of an algorithm that accounts for pressure over time and movement profiles represents a step change in the prior clinical use of interface pressure mapping, whereby snap shots are commonly used to support clinical decision making [37]. Indeed, our study has demonstrated that long term monitoring provides critical information regarding mobility and pressure over time, which may create new insight into exposure to harmful loads.

The study has limitations that preclude the generalisability of the results. The data analysis presented represents a cohort of 22 community dwelling individuals from the quality improvement study 'PROMISE'. These correspond to individuals aged between 30 and 92 years old, with the majority being of white British ethnicity. The monitoring period varied based on pragmatic care factors and ranged from 5 to 47 h, limiting the time of observation for some patients included. In addition, the patients were cared for on a variety of mattress systems, which may have influenced the sensitivity of the movement algorithm and subsequent estimation of static postures. Some patients spent prolonged periods sat out of bed, which is not taken into account in the present study. Subsequent developments should aim to distinguish between the movements of an active support surface system and patient-induced movements, including being able to differentiate between movements of the upper and lower limbs compared to trunk/buttocks. Indeed, it is of note that some movement detected by the algorithm may not result in offloading of vulnerable tissue areas, for example the sacrum and buttocks where the wounds were situated (Table 2). In addition, the thresholds selected for the pressure exposure were based on human and animal studies [38], and further refinement of patients specific thresholds is required to better reflect the variability in tissue vulnerability observed in different patient cohorts.

Our observation highlights that many individuals in the community settings often experience prolonged periods of static lying postures. This may reflect the personal circumstance of health or social care support, leading to an inability to regularly change positions [39]. Patients on dynamic systems still require regular repositioning, when possible, as not all dynamic mattresses offer the same benefits, and several patients in the cohort developed pressure injuries despite using dynamic systems. Using continuous pressure monitoring and the pressure exposure thresholds presented in the study, patient self-management could be supported through recognition of prolonged harmful postures. It also offers the opportunity for personalised care to optimise support surface selection and provide targeted repositioning strategies for those individuals with prolonged immobility.

5. Conclusion

This study has presented a secondary analysis of continuous pressure monitoring data from the community, in a cohort of patients with pressure ulcers. Through the application of an intelligent algorithm to detect large-scale movements and a novel sigmoid exposure threshold analysis, the study has shown how some patients are exposed to prolonged postures, with potentially harmful pressure values under vulnerable bony landmarks. Future trials are required to assess how this approach could be used as an adjunct to clinical practice and to support patient self-management of pressure ulcer risk.

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Declaration of interest

None.

Declaration of competing interest

All authors declare no conflict of interest.

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