Repositioning for preventing pressure ulcers: a systematic review and meta-analysis

Objective: The aim of this systematic review was to assess the effects of different repositioning regimens on pressure ulcer (PU) incidence in at-risk adult individuals without existing PUs.
Method: Using systematic review methodology, randomised controlled trials (RCTs), including cluster-RCTs, prospective non-RCTs, pre–post-studies and interrupted-time-series studies were considered. Specifically explored was the impact of the frequency of repositioning, use of repositioning systems and use of turning teams. The search was conducted in January 2019, using PubMed, CINAHL, SCOPUS, Cochrane and EMBASE databases. Data were extracted using a pre-designed extraction tool and analysis was undertaken using RevMan.
Results: A total of 530 records were returned, of which 16 met the inclusion criteria. Half of studies were conducted in intensive care units (50%). The mean sample size was 629±604 participants. Frequency of repositioning was explored in nine studies. PU incidence was 8% (n=221/2834) for repositioning every 2–3 hours, versus 13% (n=398/3050) for repositioning every 4–6 hours. The odds ratio (OR) was 0.75 (95% confidence interval (CI): 0.61–0.90, p=0.03), suggesting that there is a 25% reduction in the odds of PU development in favour of more frequent repositioning. Use of a repositioning system was explored in three studies. PU incidence was 2% (17/865) for the repositioning system, versus 5.5% (51/926) for care without using the repositioning system. The OR was 0.26 (95% CI: 0.05–1.29, p=0.10); this finding was not statistically significant. Use of a turning team was explored in two studies. PU incidence was 11% (n=22/200) with use of a turning team versus 20% (n=40/200) for usual care. The OR was 0.49 (95% CI: 0.27–0.86, p=0.01) suggesting that there is a 51% reduction in the odds of PU development in favour of use of a turning team. Using GRADE appraisal, the certainty of the evidence was assessed as low.
Conclusion: The results of this systematic review indicate that more frequent repositioning and use of a turning team reduce PU incidence. However, given the low certainty of evidence, results should be interpreted with caution.
Declaration of interest: The authors have no conflicts of interest.

pressure ulcer • prevention • repositioning • systematic review • turning

Pressure ulcers (PUs) continue to be a major global health problem, despite significant investments in education and development of evidence-based practice guidelines.[1–4] A PU is defined as 'localised injury to the skin and/or underlying tissue, usually over a bony prominence, as a result of pressure, or pressure in combination with shear'.[4] Mortality in patients with PUs is almost two times higer than in patients without PUs.[5] Around the world, PU prevalence in healthcare settings ranges from 0–72.5%, with large variations observed between different countries and clinical settings (for example, acute care, age care and community care).[4] From a financial perspective, PUs are expensive to treat. Findings of a recent systematic review estimated that the cost of treating PUs per patient per day ranged from €1.7–470.5, while the cost of preventing PUs was €2.6–87.6.[6] Therefore, prevention of PUs is a way to reduce healthcare expenditure and to improve patient care.[7]

PUs can be prevented by determining who is most at risk and implementing effective prevention strategies, such as patient repositioning, managing moisture and incontinence, monitoring nutrition, using modern support surfaces, and continual education about evidence-based practices.[4] An important component for PU prevention is repositioning of patients with limited mobility.[8–11] Repositioning of an individual is undertaken to reduce the duration and magnitude of pressure over vulnerable areas of the body and to contribute to comfort, hygiene, dignity and functional ability.[4] Repositioning is a powerful yet practical preventive measure that is within the domain, power and control of all health professionals.[12]

Pressure, from lying or sitting on a part of the body, results in oxygen deprivation to the affected area.[13]

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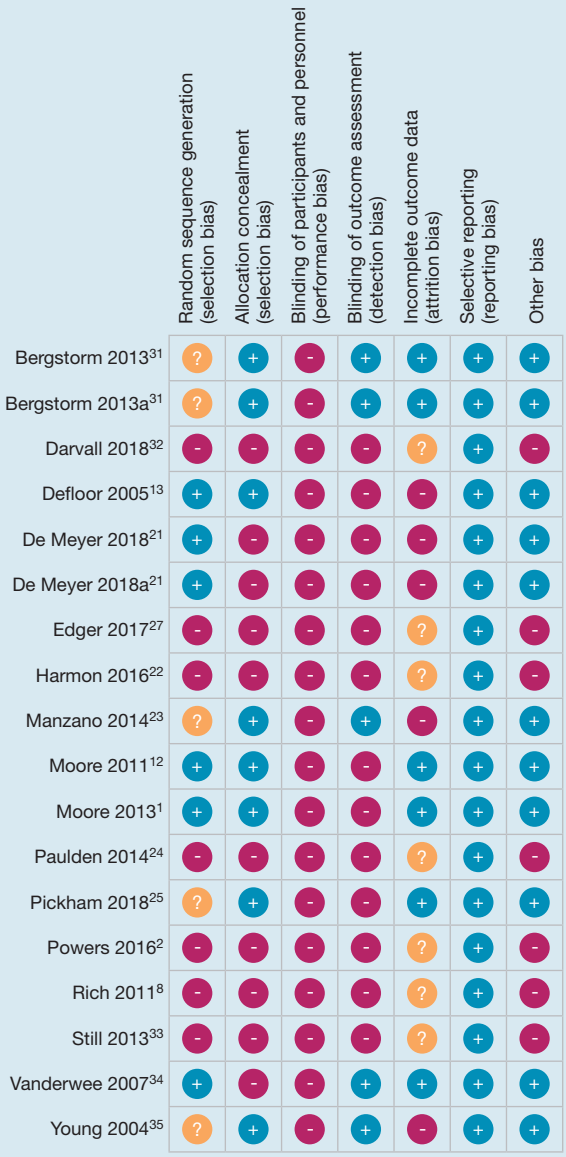
Fig 1. Risk of bias summary: review authors' judgements about each risk of bias item for each included study



Typically, this situation leads to pain and discomfort, which stimulates the individual to move. On the other hand, if patients have activity/mobility impairment due to lack of sensation, they will not experience discomfort and will require assistance to move.[12–14] The 90-degree lateral position has been shown to decrease blood flow and transcutaneous oxygen tension to near anoxic levels and to increase interface pressures.[15,16] Conversely, this is not the case when the individual is placed in the 30-degree lateral inclined position.[15–18] Repositioning reduces the interface pressure and duration of pressure experienced by tissues and so decreases tissue hypoxia.[12–14,19]

Historically, the first study relating to repositioning was conducted by Norton et al.[20] In this study, the incidence of PUs was explored using varied repositioning schedules (every 2–3 hours, every 4 hours, or two, three, four times a day) compared with standard preventive care—chiefly consisting of massage with local applications such as soap and zinc creams. The incidence of PUs in the group which received repositioning was 9%, while in the other group 26% of the residents developed PUs.

International PU prevention and treatment guidelines recommend that modulation of the frequency of repositioning be based on individual patient needs.[4] Although repositioning frequency is an important component of PU preventive strategies, recent developments in the field of repositioning have led to a renewed interest in repositioning techniques, nursing time, cost of nursing time, repositioning system, nurses' compliance, nurses' and patients' preferences, comfort and acceptability, use of turning teams, repositioning complications and wearable patient sensors.[1,2,12,21–27] However, few writers have been able to draw on any systematic research into repositioning[9,14,28] and so much uncertainty still exists about this subject matter.

Aim

The aim of this systematic review was to assess the effects of different repositioning regimens on PU incidence in at-risk adult individuals without existing PUs in any healthcare setting. The research question was: 'What is the effect of different repositioning regimens on PU incidence in at-risk adults without existing PU?'

Methods

Criteria for considering studies for this review: types of studies

The systematic review included published and unpublished randomised controlled trials (RCTs), including cluster-RCTs, non-RCTs (NRCTs), prospective studies, pre–post-studies and interrupted-time-series (ITS) studies where the full text of the article was available. All other types of studies were excluded. No language or date of publication restrictions were applied.

Types of participants

Any adult, without an existing PU, nursed in any healthcare setting was included.

Types of interventions

Studies describing the following comparisons were eligible for the review:

- Repositioning compared with no repositioning
- Comparisons between different frequencies of repositioning
- Comparisons between use of a repositioning system compared with no repositioning system.

Types of outcome measures: primary

The proportion of people developing a new PU (as

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previously defined[4]) of any grade at any point during the study.

Types of outcome measures: secondary

- Patient preferences
- Ease of use of repositioning method
- Nursing workload (repositioning time)
- Costs associated with implementing different repositioning regimens.

Electronic searches

The following electronic databases were searched to identify relevant literature:

- Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library) (latest issue)
- Ovid MEDLINE (1946 to search date)
- Ovid MEDLINE (in-process and other non-indexed citations) (latest issue)
- Ovid EMBASE (1974 to search date)
- EBSCO CINAHL Plus (1937 to search date)
- Scopus.

The following clinical trials registries were also searched to identify unpublished and ongoing studies:

- WHO International Clinical Trials Registry Platform
- The International Standard Randomised Controlled Trial Number (ISRCTN) registry
- ClinicalTrials.gov
- EU Clinical Trials Register
- DART-Europe.

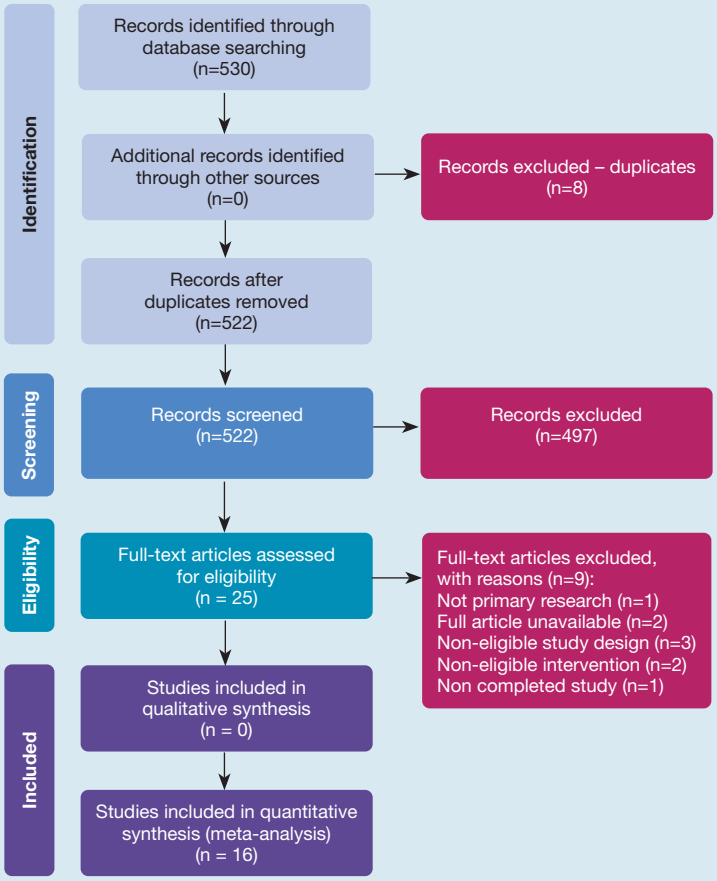
To identify further published, unpublished and ongoing studies, the review team:

- Scanned the reference lists of all identified studies and reviews
- Searched grey literature using Open Grey
- Searched international organisation reports (European Wound Management Association (EWMA), European Pressure Ulcer Advisory Panel (EPUAP) and Wounds Australia).

The keywords used in the search included:

- #1: pressure ulcer OR ulcer, pressure OR ulcers, pressure
- #2: bedsore OR bedsores OR bed sores OR bed sore OR sore, bed OR sores, bed
- #3: pressure sore OR pressure sores
- #4: decubitus ulcer OR decubitus ulcers OR ulcer, decubitus OR ulcers, decubitus
- #5: pressure injury OR pressure injuries
- #6: #1 OR #2 OR #3 OR #4 OR #5
- #7: patient moving OR moving, patient OR movings, patient OR patient movings
- #8: patient repositioning OR patient repositionings OR repositioning, patient OR repositionings, patient
- #9: patient moving and lifting OR patient lifting OR lifting, patient OR liftings, patient
- #10: patient handling OR handling, patient OR handlings, patient OR patient handlings
- #11: #7 OR #8 OR #9 OR #10
- #12: Prevention
- #13: #6 AND #11 AND #12.

Fig 2. PRISMA flow diagram for study selection



Study selection

The article titles were assessed by two authors independently, and the abstracts (when available) of the studies identified by the search strategy were screened for their eligibility, according to the inclusion and exclusion criteria. The full text version of potentially relevant studies was obtained and two authors independently screened this against the inclusion criteria. Consensus between the two authors in relation to the studies and the data to be included was obtained through discussion, when discrepancies were identified.

Data extraction

Data from the retrieved articles were extracted and inserted into a table using the following headings: study name, author, date of study, setting, unit, sample size, design, intervention, comparison and outcomes.

Data analysis

The quality of studies was assessed independently by two authors, without blinding to journal or authorship, using the Cochrane Collaboration tool for assessing risk of bias.[29] This tool addresses six specific domains, namely: sequence generation; allocation concealment; blinding; incomplete outcome data; selective outcome

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Table 1. Study characteristics

Geographical locations
Australia[32]
Belgium[13,21,34]
Canada[24,36]
Ireland[1,12]
Spain[23]
UK[35]
US[2,8,22,25,27,31,33,36]
Year of publication
2004[33]
2005[11]
2007[32]
2011[7,10]
2013[1,29,31]
2014[21,22]
2016[2,20]
2017[25]
2018[19,23,30]
Study design
Prospective, cluster-randomised controlled trial[10]
Prospective cohort study[7]
Multisite randomised clinical trial[1,22,29]
A nonrandomised comparison design[2]
Before-and-after study[25,31]
A descriptive correlational study[20]
Cluster, three-arm, randomised controlled pragmatic trial[11,19,21,23,32,33]
Pre–post intervention evaluation study[30]

reporting; and other issues (for example, extreme baseline imbalance) (Fig 1). We assessed blinding and completeness of outcome data for each outcome separately. A 'risk of bias' table for each eligible study was completed. This was incorporated into an overall grading of the evidence related to each of the main outcomes using GRADE (grades of recommendation, assessment, development and evaluation).[29] The certainty of the body of evidence was assessed against five principal domains:

- Limitations in design and implementation
- Indirectness of evidence or generalisability of findings
- Inconsistency of results, for example unexplained heterogeneity and inconsistent findings
- Imprecision of results where confidence intervals are wide
- Publication bias.[29]

PU incidence as an outcome was assessed using the following comparison domains in the 'summary of findings' tables:

- More frequent repositioning versus usual care
- Repositioning system versus standard of care (SoC)
- Turning team versus SoC.

In this review, following the extraction of the main findings from the papers, meta-analysis statistical synthesis was undertaken using RevMan.[30] Relative risks (RR) and 95% confidence intervals (CI) were calculated for dichotomous outcomes, and mean differences (MD) and 95% CI were calculated for continuous outcomes. Results of comparable trials were pooled using the fixed-effect model and 95% CI. Heterogeneity was investigated by calculating the I^2 statistic.[29]

Results

Overview of all included studies

Fig 2 outlines the flow of articles through this review. Following the initial search, a total of 530 hits from database searching and the reference section of the relevant papers were achieved. After exclusion of duplicates, 522 remained. Following assessment of the titles and abstracts, 497 were excluded as not meeting the inclusion criteria. The full text of two articles was not available and from the remaining articles, seven were excluded for being, for example, not primary research, of non-eligible study design, non-eligible intervention or non-completed study. Therefore, 16 articles were deemed eligible for inclusion.[1,2,8,12,13,21–25,27,31–35] These papers form the basis of this review.

Study design

The studies were conducted between 2004 and 2018. Of the included studies, 10 employed a randomised controlled design,[1,12,13,21,23–25,31,34,35] one was a prospective cohort study,[2,8] two were before-and-after studies,[27,33] one was a descriptive correlational study,[22] and the final study was a pre–post intervention evaluation.[32]

Geographical location

The geographical location of the studies varied between Australia,[32] Belgium,[13,21,34] Canada,[24,36] Ireland,[1,12] UK,[35] US[2,8,22,25,27,31,33,36] and Spain[23] (Table 1).

Study settings

The study settings varied and included long-term care,[1,12,31] acute care,[8,35] intensive care,[2,21–23,25–27,32,33,36] nursing homes,[13,24,34] and a rehabilitation centre[21] (Table 2).

Sample size

The mean sample size was 629 participants (standard deviation (SD)=604), varying between 46[35] and 2259[32] participants (Table 2).

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Table 2. Description of included studies

	Patient/population	Setting	Mean±SD	Minimum	Maximum
Patient	Patients at risk of pressure ulcers	Long-term care[1,12,31]	629±604	46[35]	2259[32]
	Patients with no pressure ulcers	Acute care[8,35]			
		Intensive care unit[2,21–23,25–27,32,33,36]			
		Nursing homes[13,24,34]			
		Rehabilitation[21]			
Intervention	Repositioning the 30° tilt every three hours during the night versus the 90° lateral rotation every six hours at night regimens[10]				
	Repositioning the 30° tilt (left side, back, right side, back) 2–3-hourly overnight, 2–3-hourly during the day versus sacrum and heels free from contact with support surface versus repositioned 90° lateral and supine positions 2–3-hourly overnight, 2–3-hourly during the day[33]				
	Repositioning frequency: less than every two hours, at least every two hours[7]				
	Three repositioning schedules: two hours turn group, three hours turn group and four hours turn group on pressure ulcer prevention[34]				
	Repositioning two hours turning, four hours turning for preventing pressure ulcer development in patients in intensive care unit under mechanical ventilation[21]				
	Repositioning patients lying on a pressure-reducing mattress alternately for two hours in a lateral position and four hours in a supine position in comparison with repositioning every four hours[32]				
	Repositioning two hours on a standard institutional mattress, three hours on a standard institutional mattress, four hours on a viscoelastic polyurethane foam mattress, six hours on a viscoelastic polyurethane foam mattress and standard-care group[11]				
	Repositioning all haemodynamically stable patients every two hours around the clock with the implementation of the turn team[31]				
	Repositioning for critically ill patients from five hours to three hours[30]				
	Turning care relying on traditional turn reminders and standard practices, or optimal turning practices, influenced by real-time data derived from a wearable patient sensor[23]				
	Two methods for patient positioning on the development of pressure ulcers; specifically, standard of care using pillows versus a patient-positioning system[2]				
	The economic consequences from a repositioning schedule of two-hour intervals to a schedule of three-hour or four-hour intervals[22]				
	Costs associated with repositioning every three hours, using the 30° tilt every six hours, using the 90° lateral rotation[1]				
	A turn team system was implemented patients deemed at risk for pressure ulcer development every two hours[20]				
	Using turning system with or without being combined with an algorithm for tailored repositioning to improve nurses' compliance to repositioning frequencies in patients at risk for pressure ulcer development[19]				
	Using the repositioning system for hospital-acquired pressure ulcer[25]				
	Using a repositioning device, measure staff-perceived level of exertion with device use, and assess return on investment[25]				
Comparison	More frequent turning versus usual care[7,10,11,21,29–33]				
	Repositioning system versus standard of care[2,19,25]				
	Turn team versus standard of care[20,24]				
Comparison	Pressure ulcer incidence				
	Nursing time for repositioning				
	Cost				
	Nurses' perception				
	Patients' perception				
	Turning team				
	Complication				

SD—standard deviation

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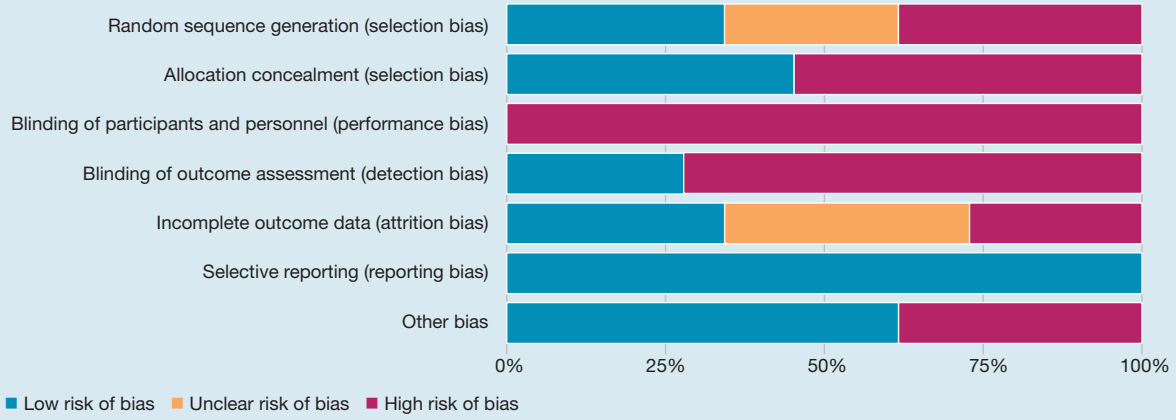
Fig 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study



Risk of bias

The risk of bias in the included studies is summarised in Fig 1 and Fig 3. The risk of bias for each study was independently assessed by two authors and any disagreements resolved through consensus. For all included studies, the Cochrane tool for assessing risk of bias was used.[29]

Selection bias: generation of the randomisation sequence

Selection bias was a low risk for five studies, because they described use of robust randomisation methods (for example, using a computer-based random number generator) for random sequence generation.[1,12,13,21,34,36] Generation of randomisation sequence was not included in four studies and so risk of bias was unclear.[23,25,31,35] The remaining seven studies did not provide information about generation of randomisation sequence as the methodology of studies did not include this domain and, therefore, were at high risk of bias.[2,8,22,24,26,27,32,33]

Allocation concealment

Low risk of bias in this domain was found in seven studies, as they described methods used to conceal the allocation to study group.[1,12,13,23,25,31,35,36] All other studies were at high risk of bias for this domain.[2,8,21,22,24,26,27,32–34] De Meyer et al.[21] and Vanderwee et al.[34] did not provide a description of how randomisation was achieved, while the methodology of six studies did not include this domain.[2,8,22,24,27,33]

Performance bias: blinding participants and personnel

All studies were at high risk of bias in this domain because it was impossible for participants and nurses to be blinded.[1,2,8,12,13,21–25,26,27,31–36]

Detection bias: blinding of outcome assessment

Low risk of detection bias was found for four studies as they used independent reviewers to assess the study outcomes.[23,31,34,35,36] Of the 12 studies at high risk of bias in this domain, five did not provide information on the blinding of the outcome assessors,[1,12,13,21,25] while the methodology of the remaining seven studies did not include this domain.[2,8,22,24,26,27,32,33]

Attrition bias: incomplete outcome data

Low risk of bias was found in four studies as they conducted an intention-to-treat analysis.[1,12,31,34,36] In four studies, the dropouts were not comprehensibly described with regard to the numbers of participants in the intervention and control groups and, therefore, were at high risk of bias.[13,21,23,35] The remaining seven studies did not provide information about generation of randomisation sequence as the methodology of studies did not include this domain and, therefore, were also at high risk of bias.[2,8,22,24,27,32,33]

Reporting bias: selective reporting

All studies were at low risk of bias in this domain because they reported all outcomes alluded to in the paper.[1,2,8,12,13,21–25,27,31–35]

Other bias

Low risk of bias was found in nine studies in this domain, as other potential sources of bias were not identified.[1,12,13,21,23,25,31,34,35] The remaining seven studies were judged as high risk of bias due to the research methods used in these studies.[2,8,22,24,27,32,33]

Comparisons and outcomes

Comparison 1: more frequent repositioning versus less frequent repositioning

Outcome—pressure ulcer incidence: Fig 4 outlines the results of the meta-analysis of the studies exploring more frequent repositioning versus less frequent repositioning.[8,12,13,23,31–35] The I^2 is 63%, indicating there is not a high risk of heterogeneity among the studies. As can be seen from Fig 4, there is a statistically significant difference in PU incidence, in favour of more frequent repositioning (PU incidence 8% (221/2834) for

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Table 3. Daily nursing time for repositioning

Study	Characteristic of repositioning	Daily nursing time spent repositioning per patient	p-value
Manzano et al.[23]	Two-hourly turning (30° tilt)	21 minutes (range: 14–27)	p<0.001
	Two-hourly turning (30° tilt)	11 minutes (range: 8–15)	
Moore et al.[1]	Three-hourly turning during the night (30° tilt)	18.5 minutes	Not specified
	Six-hourly turning during the night (90° tilt)	24.5 minutes	
Paulden et al.[24]	Two-hourly turning	102.8 minutes	Not specified
	Three-hourly turning	68.5 minutes	
	Four-hourly turning	51.4 minutes	

more frequent repositioning versus 13% (398/3050) for usual care). The OR was 0.75 (95% CI: 0.61–0.90, p=0.03), suggesting that there is a 25% reduction in the odds of PU development for the more frequent repositioning group, with the true population reduction parameter being somewhere between 10% and 39%. However, using GRADE, the certainty of the evidence has been assessed as low (downgraded twice for very serious risk of bias across multiples domains within the included studies).

Outcome—nursing time: three studies focused on daily nursing time spent repositioning.[1,23,24] Manzano et al.[23] reported that the median (interquartile range, IQR) daily nursing workload for two-hourly repositioning (head and foot of bed elevated 30 degrees left side with 30 degree tilt, back, right side with 30 degree tilt, back) was 21 minutes (14–27) versus 11 minutes (8–15) per patient (p<0.001) for four-hourly repositioning (head and foot of bed elevated 30 degrees left side with 30-degree tilt, back, right side with 30-degree tilt, back). Moore et al.[1] found that the mean daily nurse time for repositioning was 18.5 minutes for use of the 30-degree tilt (left side, back, right side, back) every three hours during the night, and 24.5 minutes using 90-degree lateral rotation every six hours during the night. Paulden et al.[24] showed that the total amount of staff time spent repositioning each resident at risk of developing a PU was 102.8 minutes per day with two-hour repositioning, 68.5 minutes per day with three-hour repositioning, or 51.4 minutes per day with four-hour repositioning (Table 3).

Outcome—cost of nurse time for repositioning: this was assessed in three studies.[1,21,24] Moore et al.[1] showed that nursing repositioning cost per day was €7.41 for three-hourly repositioning compared with €9.80 cost per day for six-hourly repositioning. Paulden et al.[24] reported that the economic consequences for a daily repositioning schedule of two-hour intervals was $32.10, three-hour intervals was $21.40 and four-hour intervals was $16.05. De Meyer et al.[21] found that the

Fig 4. Comparison more frequent repositioning (2–3 hours) versus less frequent repositioning (4–6 hours), Outcome—pressure ulcer incidence. M-H—Mantel-Haenszel test; CI—confidence interval

	2–3 hours		4–6 hours			Odds ratio	Odds ratio
Study or subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95%CI	M-H, Fixed, 95%CI
Bergstorm 2013[31]	8	321	2	328	0.8%	4.17 [0.88, 19.77]	
Bergstorm 2013a[31]	8	321	9	295	3.8%	0.81 [0.31, 2.13]	
Darvall 2018[32]	23	1165	38	1094	15.8%	0.56 [0.33, 0.95]	
Defloor 2005[13]	113	230	220	511	32.6%	1.09 [0.80, 1.48]	
Manzano 2014[23]	17	165	32	164	11.9%	0.47 [0.25, 0.89]	
Moore 2011[12]	3	99	13	114	4.8%	0.24 [0.07, 0.88]	
Rich 2011[8]	14	139	16	130	6.1%	0.80 [0.37, 1.71]	
Still 2013[33]	12	229	42	278	14.8%	0.31 [0.16, 0.61]	
Vanderwee 2007[34]	20	122	24	113	8.6%	0.73 [0.38, 1.40]	
Young 2004[35]	3	23	2	23	0.7%	1.57 [0.24, 10.44]	
Total (95%CI)		2834		3050	100.0%	0.75 [0.61, 0.90]	
Total events	221		398				
Heterogeneity: Chi^2=24.01, df=9 (p=0.004); I^2=63%							
Test for overall effect: Z=2.99 (p=0.003)							

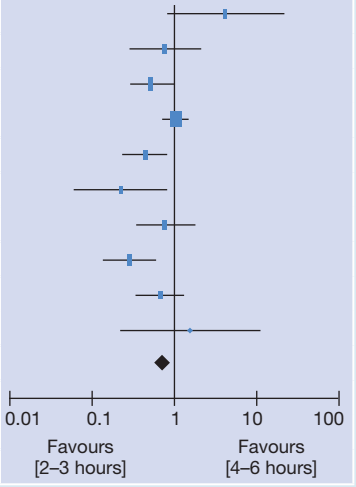

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Table 4. Daily cost of nurse time for respositioning

Study	Characteristic of repositioning	Daily cost of nursing time for repositioning
Moore et al.[12]	Three-hourly turning	€7.41
	Six-hourly turning	€9.80
Paulden et al.[24]	Two-hourly turning	€32.10
	Three-hourly turning	€21.40
	Four-hourly turning	€16.05
De Meyer et al.[21]	Two-hourly turning (with a turning system combined with an algorithm)	€14.28
	Three-hourly turning (with a turning system combined with an algorithm)	€9.52
	Four-hourly turning (with a turning system combined with an algorithm)	€7.14
	Two-hourly turning (with a turning system without an algorithm)	€13.08
	Three-hourly turning (with a turning system without an algorithm)	€8.72
	Four-hourly turning (with a turning system without an algorithm)	€6.54
	Two-hourly turning (with standard of care)	€37.80
	Three-hourly turning (with standard of care)	€25.20
	Four-hourly turning (with standard of care)	€18.90

calculated cost for patient repositioning in bed per day was €14.28 (two-hourly repositioning), €9.52 (three-hourly repositioning) and €7.14 (four-hourly repositioning) with use of a turning system combined with an algorithm versus €13.08 (two-hourly repositioning), €8.72 (three-hourly repositioning) and €6.54 (four-hourly repositioning) with use of a turning system without an algorithm, and €37.80 (two-hourly repositioning), €25.20 (three-hourly repositioning) and €18.90 (four-hourly repositioning) for SoC (Table 4).

Comparison 2: repositioning system versus care without using repositioning system

Outcome—pressure ulcer incidence: Fig 5 outlines the results of the meta-analysis of the three studies exploring the impact of a repositioning system versus care without using the repositioning system.[2,21,27] An I^2 score between 75% and 100% indicates considerable heterogeneity (I^2=77). Therefore, a random effects model for the meta-analysis was undertaken. As can be seen from Fig 5, there is no statistically significant difference in PU incidence between the study groups (PU incidence 2% (17/865) repositioning system versus 5.5% (51/926) SoC). The OR was 0.26 (95% CI: 0.05–1.29, p=0.10), suggesting that there was a 74% reduction in the odds of PU development when a repositioning system is used. However, the 95% CI includes an OR of 1, indicating a non-statistically significant finding. Furthermore, using GRADE, the certainty of the evidence was assessed as very low (downgraded twice for very serious risk of bias across multiples domains within the included studies and once for imprecision due to a wide 95% CI).

Outcome—cost: the cost impact of a repositioning system was addressed by Edger,[27] who reported costs calculated for each stage of PU. The return on investment (RoI) was calculated by comparing the cost of hospital-acquired pressure ulcers (HAPUs) and the treatment used after the intervention, with the costs of HAPUs before the intervention. The intervention was found to be cost-effective, with an estimated RoI of $16,911 (US dollars, per month for six months).

Outcome—turn angle: the relationship between turn angle and the repositioning system was assessed in two studies.[2,21] Powers[2] reported that the average turn angle achieved using a repositioning system was 31.03°, while the average turn angle achieved using SoC was 22.39°. De Meyer et al.[21] found that use of the turning and repositioning system was associated with significantly more correctly positioned patients (30–45° tilted side-lying position) (69.6% versus 34.6% of patients).

Outcome—nurses' compliance: this was evaluated by De Meyer et al.[21] The study found that nurses' compliance with repositioning frequencies increased significantly in the experimental groups when patients were cared for in bed (94.6%, using a turning system combined with an algorithm) versus 69% (using a turning system without an algorithm for SoC) and 84.9% (using a turning system with or without an algorithm for tailored repositioning) versus 71.4% (SoC).

Outcome—nurses' and patients' preferences, comfort and acceptability: the relationship between nurses' and patients' preferences, comfort and acceptability, and

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Fig 5. Comparison of repositioning system versus standard of care (without using repositioning system). Outcome—pressure ulcer incidence. M-H—Mantel-Haenszel test; CI—confidence interval

	Experimental		Control			Odds ratio	Odds ratio
Study or subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Random, 95%CI**	**M-H, Random, 95%CI**
De Meyer 2018[21]	3	81	18	91	29.1%	0.16 [0.04, 0.55]	
De Meyer 2018a[21]	13	53	18	91	32.5%	1.32 [0.59, 2.97]	
Edger 2017[27]	0	702	9	714	16.9%	0.05 [0.00, 0.91]	
Powers 2016[2]	1	29	6	30	21.5%	0.14 [0.02, 1.27]	
Total (95%CI)		865		926	100.0%	0.26 [0.05, 1.29]	
Total events	17		51				
Heterogeneity: Tau^2=1.92; Chi^2=13.08; df=3 (p=0.004); I^2=77%							
Test for overall effect: Z=1.66 (p=0.10)							

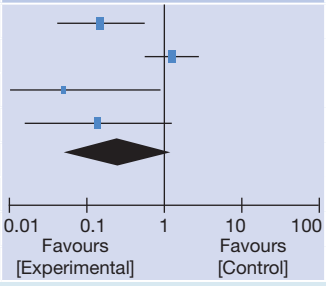
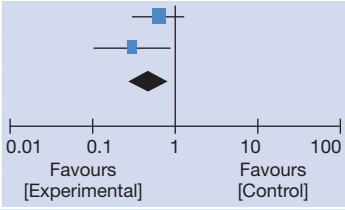


Fig 6. Comparison of turn team versus standard of care. Outcome—pressure ulcer incidence. M-H—Mantel-Haenszel test; CI—confidence interval

	Experimental		Control			Odds ratio	Odds ratio
Study or subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95%CI**	**M-H, Fixed, 95%CI**
Harmon 2016[22]	17	100	25	100	59.3%	0.61 [0.31, 1.23]	
Still 2013[33]	5	100	15	100	40.7%	0.30 [0.10, 0.86]	
Total (95%CI)		200		200	100.0%	0.49 [0.27, 0.86]	
Total events	22		40				
Heterogeneity: Chi^2=1.27; df=1 (p=0.26); I2=21%							
Test for overall effect: Z=2.48 (p=0.01)							



repositioning system was assessed in three studies.[2,21,27] Powers[2] found that no nurse injuries were reported for repositioning with SoC versus a repositioning system. De Meyer et al.[21] showed that most of the patients (81.3%) admitted to wards using the repositioning system indicated that they were lying comfortably. Edger[27] used the Borg Scale for evaluation of the repositioning system compared with SoC. The need for less physical effort was reported using the repositioning device (8.83±0.61=very light) compared with SoC (15.92±0.37=hard). The Borg Scale measured perceived exertion that was ranked on a scale of 6–20, where higher scores indicated greater exertion.[37] The mean exertion score, when manually repositioning patients, was 88% greater compared with the mean exertion score using the repositioning device (p<0.001; t-test).

Comparison 3: turning team versus standard of care (without turning team)

Outcome—pressure ulcer incidence: Fig 6 outlines the results of the meta-analysis of the two studies exploring the impact of a turning team.[22,26] The I^2 is 21%, indicating low heterogeneity among the studies. As can be seen from Fig 6, there is a statistically significant difference in PU incidence, in favour of a turning team (PU incidence 11% (22/200) turning team versus 20% (40/200) SoC). The OR was 0.49 (95%CI: 0.27–0.86, p=0.01), which suggests that there was a 51% reduction in the odds of PU development with use of a turning team, with the true population reduction parameter being between 15% and 73%. However, using GRADE, the certainty of the evidence was assessed as low (downgraded twice for very serious risk of bias across multiples domains within the included studies).

Outcome—repositioning and complications: the relationship between repositioning and possible complication in terms of nurses' and patients' experience was assessed in two studies.[2,23] Manzano et al.[23] showed that device-related adverse events (for example, when mechanical ventilation is used) were significantly more frequent in the two-hour group (47.9%, 79/165) than in the four-hour group (36.6%, 60/164), (hazard ratio: 1.50, 95% CI: 1.06–2.11, p=0.02). There were no differences in unplanned extubation and endotracheal tube obstruction. Powers[2] found that no nurse injuries were reported for repositioning with SoC versus the repositioning system.

Discussion

The results of this systematic review indicated that there is a 25% reduction in the odds of PU development in favour of more frequent repositioning, a 59% reduction in the odds of PU development when a repositioning system is used, and a 51% reduction in the odds of PU development in favour of use of a turning team.

Meta-analysis of six RCTs,[12,13,23,31,34,35] one pre–post intervention study,[32] one prospective cohort study[8] and

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one before–after study[33] showed that development of PU was significantly reduced by more frequent repositioning compared with SoC. It is necessary to clarify exactly what is meant by more frequent repositioning. In the studies, it was demonstrated that more frequent repositioning ranged from two hours[8,13,23,31,33–35] to three hours,[12,32] and this was compared with SoC (less frequent repositioning every 4–6 hours).[34] Patients turned two-hourly or three-hourly developed fewer PUs (PU incidence 8%, 221/2834, three hours or more frequent repositioning, versus 13%, 398/3050 four hours, or less often). Similar results were found with the use of a turning team, or use of a positioning system, both of which enhanced concordance with repositioning. Although the certainty of the evidence was low, because of risk of bias in multiple areas of the included studies, a large number of patients were included in the studies and achieving a lower incidence of PUs was a clinically relevant finding.

For patient repositioning, guideline recommendations require nurses to assess multiple criteria to determine the frequency of repositioning, rather than routinely adopt a specific repositioning interval.[4] In accordance with the present results, repositioning makes a difference to PU prevention by reducing pressure and as such concords with the pathological processes involved with PU development.[8,12,13,23,31–35] The findings are therefore applicable to patients considered to be at risk of PU development, in both hospital and community care settings.

The findings of three individual studies, one RCT,[21] one before–after study[27] and one comparison cohort study,[2] included in a meta-analysis, indicated that there is no statistically significant difference in PU incidence with using a repositioning system versus SoC (without using repositioning system). In addition, the effectiveness of repositioning systems were evaluated in terms of cost,[27] turn angle,[2,21] nurses' compliance[21] and nurses' and patients' preferences, comfort and acceptability.[2,21,27] The repositioning system used in the studies[2,21,27] was designed to assist staff with turning and repositioning patients, and to help reduce the incidence of PUs by offloading the sacrum. The aim of the repositioning system was to help staff safely achieve compliance with turning protocols, while reducing strain on the hands, wrists, shoulders and back.[38] The system includes a low-friction glide sheet with grip surface and integrated handles to reduce the effort needed to turn patients, a built-in antishear strap to prevent patients from sliding in bed, disposable microclimate body pads to control heat and assist with moisture control, and two 30° body wedges to facilitate the turning and positioning of patients at the recommended 30° angle.[2,21,27] It can be challenging for staff to accomplish repositioning safely and efficiently. Lifting is not the only aspect of moving patients that presents physical demands for nursing staff. More than half of the injuries attributed to personnel working in healthcare are due to overexertion from moving and lifting patients, further emphasising the need for adherence to best practices for safe patient handling.[38,39] The results of this systematic review indicated that no nurse injuries were reported with use of a repositioning system. Furthermore, one study showed that patients reported that they were lying comfortably with the repositioning system,[21] and one study found that nurses expended less effort when using the repositioning systems.[27] The evidence from the studies reviewed suggests that repositioning systems may provide comfort for both patients and nurses.

Meta-analysis of two studies, one descriptive correlational study[22] and one before–after implementation study,[33] reported that development of a PU was significantly reduced when using a turning team. In both studies, the turning team was responsible for repositioning haemodynamically stable patients every two hours around the clock. Kalisch et al.[40] showed that patient repositioning was identified as missed care 82% of the time; they also noted that the most common reason cited for missed repositioning episodes was inadequate staff resources. However, Harmon et al.[22] reported that the verbal warning intervention served as a helpful reminder and an equal proportion of the staff indicated that they received adequate support from the turning team. Although the turning team is effective in decreasing development of PUs, it can be a challenging system to adopt because providing a turning team requires either hiring new staff or repurposing existing staff.[41,42]

PU prevention is expensive; one argument in the literature is that repositioning is time-consuming and requires significant human resources.[1,13] In this systematic review, three studies focused on daily nurse time spent repositioning.[1,23,24] The cost of nurse time for repositioning was also assessed in three studies.[1,21,24] The lowest daily nursing time for repositioning was reported in Manzano et al.[23] as 11 minutes for four-hourly turning, while the highest nursing time was 102.8 minutes for two-hourly turning.[24] The highest daily cost of nurse time for repositioning was €37.80 for two-hourly turning[21] and the lowest was €6.54 for four-hourly turning.[21]

Pressure from lying or sitting on a particular part of the body results in oxygen deprivation to the affected area.[13] There are normally a number of stimulators, during sleep and while awake, that motivate the individual to move.[43] Failure to reposition will result in ongoing oxygen deprivation and inevitable tissue damage, because of ongoing occlusion of blood supply to the affected area.[13] In terms of the pathology of PU development, individuals will sustain a PU unless the magnitude of the pressure and the shear, or the duration of exposure to pressure and shear, or both, are reduced and/or removed.[13,44] Reducing pressure and shear is helped by an appropriate seating device or mattress.[44] However, even with these systems, individuals still require repositioning and the challenge remains as to how to get regular, effective repositioning adopted into

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practice. Thus, in order to achieve this, we may need to consider alternatives, and turning teams or repositioning systems may be a solution. However, the studies using a repositioning system included here had methodological flaws and thus the evidence certainty was very low. Given the potential value for repositioning systems within the community setting, more robust studies of these devices are needed.

The results of this systematic review indicate that device-related adverse events were more frequent in the two-hourly repositioned group than in the four-hourly repositioned group. There were no differences in unplanned extubation and endotracheal tube obstruction.[23] Changes in the body position of patients receiving mechanical ventilation in the intensive care unit are frequent. However, use of mechanical ventilation may inadvertently cause omissions in turning, repositioning and other interventions to advance patient mobility and thus, may contribute to PU formation.[45] In general, therefore, it seems that it is important to develop protocols specifically on repositioning for patients with mechanical ventilation. This is of importance given that implementation of simple and effective safe patient handling can yield better outcomes for both patients and caregivers.[44]

Quality of the evidence

All included studies were at risk of bias in one or more domains. Interpretation and therefore conclusions on the effects of the interventions should be drawn against the background of these findings. True allocation concealment prevents the researcher from being aware which group, experimental or control, a participant is allocated to, ensuring that the participant is assigned to a specific study group by chance.[29] Concealment of group allocation was inadequately described in nine studies.[2,8,21,22,24,27,32–34] It has been suggested that lack of a clear description of allocation concealment leads to bias in assessing outcome of studies; the size of the effect could be overestimated and so give a false impression of the value of the intervention.[46] Studies without adequate allocation concealment tend to report larger estimates of effect when compared with those which describe adequate allocation concealment.[47]

Blinding was poorly reported, with incomplete blinding of investigators, participants, outcome assessors and the data analyst, in most studies. Lack of blinding can introduce bias, particularly when outcomes are subjective, and may lead to potential overestimation of the effect of the intervention, resulting in bias in favour of the intervention.[48] However, blinding of participants and caregivers is difficult to achieve in wound care; blinding of outcome assessors is possible, and was achieved in the studies by Bergstrom et al.[31] Manzano,[23] Vanderwee[34] and Young.[35]

The rationale for using intention-to-treat analysis is twofold; it maintains treatment groups that are similar (apart from random variation) and therefore validates the use of randomisation, and allows for handling of protocol deviations, further protecting the randomisation process.[49] Low risk of bias in this domain was found in four studies, as they conducted intention-to-treat analysis for attrition bias.[1,12,31,34] In essence, omitting those who do not complete the study from the final analysis may bias the outcomes of the study because those who do not complete may do so because of adverse effects of the intervention.[50] All GRADE assessments showed that the evidence for more frequent repositioning versus SoC, a repositioning system versus SoC, and a turning team versus SoC for PU incidence was of low certainty. The evidence was downgraded because of the high risk of bias in all domains. Thus, this low-certainty evidence should be interpreted with caution.

Limitations

This systematic review is limited by the certainty of the evidence being assessed as low. Therefore, the results should be interpreted with caution. Another limitation is that there is a wide range of repositioning techniques and frequencies of repositioning, limiting the interpretation of the data in terms of the identification of the ideal repositioning method and/or frequency.

Conclusion

Repositioning plays a central role in the prevention of PUs. The results of this systematic review indicate that fewer PUs develop when patients are repositioned every 2–3 hours when compared with less frequent repositioning, every 4–6 hours. The use of a turning team also reduces PU incidence, probably because it helps to achieve concordance with the repositioning schedule. Given the clinical relevance of these findings, this information can be used to develop targeted interventions aimed at preventing PUs. This study also examined the relationship between repositioning and cost, nursing time, turn angle, complications, nurses' compliance, and nurses' and patients' preferences, comfort and acceptability. Given the uncertainty of the evidence, and the persisting high incidence of PUs, further trials are needed to examine more closely the links between repositioning and these domains. JWC

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Reflective questions

- What is the importance of repositioning as a pressure ulcer prevention strategy?
- What should be frequency of repositioning for prevention of pressure ulcers?
- What is the effect of using the turn team on pressure ulcer incidence?

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