Journal of Back and Musculoskeletal Rehabilitation 35 (2022) 195–205
DOI 10.3233/BMR-200354
IOS Press

Occupational injuries and patient lift usage among physical rehabilitation therapists

Bernadette McCrory[a,*], Jiahui Ma[a], Sonya L. Irons[b] and Judith M. Burnfield[c]
[a]*Mechanical and Industrial Engineering Department, Montana State University, Bozeman, MT, USA*
[b]*Madonna Rehabilitation Hospitals, Lincoln, NE, USA*
[c]*Institute for Rehabilitation Science and Engineering, Madonna Rehabilitation Hospitals, Lincoln, NE, USA*

Received 9 December 2020
Accepted 15 July 2021

Abstract.
BACKGROUND: Physical therapists (PTs) and physical therapist assistants (PTAs) are at high risk for work-related musculoskeletal pain and discomfort.
OBJECTIVE: Determine the prevalence and exposure risk factors for work-related injuries (WRIs) among rehabilitation PTs and PTAs.
METHODS: A cross-sectional research survey was conducted among 170 PTs and 67 PTAs at 51 free-standing rehabilitation hospitals and rehabilitation units embedded in general hospitals in the Midwestern states of Iowa, Kansas, Missouri and Nebraska. The prevalence of WRIs and significant risk factors for developing WRIs were determined for PTs and PTAs.
RESULTS: The 1-year prevalence of WRIs among PTs and PTAs working in physical rehabilitation was 29.5%. Multifaceted causes were identified including frequently bending/twisting, over-exerting force during patient handling activities, inadequate lifting devices, and lack of ongoing training for mechanical lifting device usage.
CONCLUSIONS: Equipment usage barriers point to a critical need for technology creation, research, and education to advance worker safety while simultaneously enhancing patient outcomes.

Keywords: Safe patient handling, physical therapy, work-related injuries

1. Introduction

While physical therapists (PTs) and physical therapist assistants (PTAs) face high one-year and lifetime prevalence rates of work-related musculoskeletal disorders across all care settings [1–7], those working in physical rehabilitation may be at particularly high risk for injury. During the early phases of recovery from a serious injury/illness, the physical demands placed on PTs and PTAs while helping patients relearn to move in bed, sit-up, stand, balance and walk can lead to overexertion injuries [2]. This is not surprising given that rehabilitation training often involves therapists helping patients lift or stabilize different body parts that may be profoundly weak, uncoordinated, or resistant to movement given the impact of a neurologic injury or illness. The potentially deleterious physiologic challenges placed on a therapist's body may be further compounded when implementing current neuroscientific principles that emphasize mass repetition (100s to 1000s of repetitions daily) to promote lasting behavioral and neuroplastic changes following neurologic injury or illness, combined with the realities of clinicians often assuming awkward postures and sometimes needing to exert relatively high muscle effort to grasp and move a heavy body part (sometimes approaching 100% of a clinician's peak force generating capacity for a muscle during gait) [8–10].

Beyond the physiologic demands of working in a physical rehabilitation environment, factors such age, gender, and work scheduling may also increase risk for

*Corresponding author: Bernadette McCrory, Mechanical and Industrial Engineering Department, Montana State University, PO Box 173800, Bozeman, MT 59717-3800, USA. Tel.: +1 406 994 2801; E-mail: bernadette.mccrory@montana.edu.

ISSN 1053-8127/$35.00

work-related injury (WRI) [7,11–14]. These challenges could be further exacerbated in rural and underserved areas, where PTs may have limited access to technology and/or help when caring for patients with complex rehabilitation needs [15,16]. Predictably, once injured, PTs reportedly depart more frequently from neurological and acute inpatient rehabilitation compared to other PT specialty areas [3] and very few experienced PTs/PTAs shift to rehabilitation mid-career following a WRI [3]. Collectively, this is concerning given the growing elderly population and the increased demand for physical rehabilitation services [17].

Safe patient handling practices and equipment can effectively decrease the risk of occupational pain and injuries as well as positively impact patients' safety and recovery [18–22]. Ergonomic and biomechanical analyses have evaluated the effectiveness of using lifting devices to reduce the risk of nurse work-related musculoskeletal disorders employing a combination of engineering and administrative controls [23–25]. Yet, the individual and institutional perspectives for using these devices vary widely across nurses and therapists. Unfortunately, both the ergonomic and biomechanical causes of WRIs in PTs and PTAs, who provide inpatient and outpatient physical rehabilitation services, have not been well researched nor has the influence of technology been explored for barriers to use in this context.

With a generally high risk of WRIs, it is critical to overcome both cultural and technology-based barriers to implement effective ergonomic and biomechanical strategies throughout physical rehabilitation. The creation of a comprehensive and integrative strategy that synergistically protects both patient and worker safety is essential to ensuring long-term functional independence and wellbeing of both populations. Accordingly, this study's aims were two-fold: 1) to evaluate the prevalence of WRIs in PTs and PTAs in the physical rehabilitation environment; and 2) to identify perceived causes of work-related pain and injuries among PTs and PTAs. The long-term goals of this work are to develop technologies and treatment approaches that promote rehabilitation workers' health and safety while simultaneously addressing patients' therapeutic needs.

2. Methods

A cross-sectional research survey was conducted among PTs and PTAs (age 19 years and older) working from 2013 to 2014 at rehabilitation facilities in Iowa, Kansas, Missouri and Nebraska, which was the primary region served by the funding agency (University of Iowa's Heartland Center for Occupational Health and Safety). In comparison to previous reports of WRIs [15,16], this study included a high proportion of critical access hospital and underserved rural areas. This study surveyed PTs and PTAs employed in acute care and post-acute care settings including inpatient rehabilitation facilities, skilled nursing facilities, and outpatient.

Initially, an online search identified all facilities providing both inpatient and outpatient physical therapy services across the four heartland states. National databases were used to identify facilities. Web-based searches verified individual facilities provided therapy services. Each director was contacted through a phone call and/or email and invited to participate in the study. Interested facilities were enrolled and sent study materials digitally and through hard copy. Once eligibility and interest were confirmed, each rehabilitation or physical therapy director was invited to send a survey link invitation to their staff via their facility's email system. The study was approved by the Institutional Review Board (IRB) at Madonna Rehabilitation Hospital prior to survey dissemination.

The survey platform (SelectSurvey.NET, ClassApps.com, Overland Park, KS) contained a multitude of question and response types, invitation features, customizable security levels and data export formats. A survey was created using this flexible platform to gather user responses anonymously and confidentially. An IRB approved consent was included at the beginning of the survey, which outlined the survey's purpose, procedures, confidentiality and anonymity assurances, investigators' contact information, participation risks and benefits, participation refusal and voluntary withdrawal.

The electronic survey content was reviewed, and pilot tested by 18 subject matter experts (i.e., physical therapists, occupational therapists, nurses and statisticians) prior to dissemination to potential research participants. The survey consisted of four sections: Section 1 Background and Demographics, Section 2 Primary Work Setting, Section 3 Workload, and Section 4 Patient Handling. Section 1 was used to gather routine background and demographic information (e.g., age, height, weight, work experience). Section 2 was used to clarify the amount and type of work performed (e.g., full-time/part-time and inpatient/outpatient). In Section 3, respondents indicated the body regions, duration, frequency, and severity of musculoskeletal pain or discomfort experienced during the past 12 months related to their work. Additionally, respondents described the

Table 1
Survey respondent characteristics and work setting information

	PT $n = 170$	PTA $n = 67$	Overall $n = 237$
Age (years)[1]	38 (11)	40 (12)	39 (11)
Height (cm)[1]	170 (9.8)	168 (8.0)	170 (9.4)
Weight (kg)[1]	73 (16)	77 (18)	74 (17)
Physical therapy experience (years)[1]	13 (10)	12 (9.6)	13 (10)
Rehabilitation experience (years)[1]	10 (9.4)	10 (8.3)	10 (9.2)
Female[2]	120 (70.6%)	48 (71.6%)	168 (70.9%)
White[2,3]	150 (88.2%)	58 (86.6%)	208 (87.8%)
Married[2]	110 (64.7%)	43 (64.2%)	153 (64.6%)
Full-time[2]	125 (73.5%)	55 (82.1%)	180 (75.9%)
Day Shift[2]	164 (96.5%)	62 (92.5%)	226 (95.4%)
Second Job[2]	29 (17.1%)	18 (26.9%)	47 (19.8%)
Doctoral Degree[2,4]	90 (38.0%)	1 (0.4%)	91 (38.4%)
Master's Degree[2,4]	41 (17.3%)	4 (1.7%)	45 (19.0%)
Bachelor's Degree[2,4]	24 (10.1%)	17 (7.2%)	41 (17.3%)
High School Diploma/Associate's Degree[2,4]	1 (0.4%)	37 (15.6%)	38 (16.0%)

[1]Mean (Standard Deviation); [2]Frequency (Relative Frequency); [3]Other races that participated included: American Indian or Alaska Native ($n = 3$), Asian ($n = 2$), and Black or African American ($n = 1$); [4]Highest Earned Degree.

effects of the pain (e.g., utilized sick leave) and any activities they believe caused or contributed to their pain (e.g., patient transfers). For Section 4, respondents indicated the type, availability and utilization of mechanical lifting devices for patient handling [26].

The data were coded to enable assessment of the primary and secondary outcomes. The primary outcome was the 1-year prevalence of WRI among PTs and PTAs working in rehabilitation facilities. The OSHA's (Occupational Safety and Health Administration) regulations defined a recordable WRI as a report of a pain or discomfort within the last 12 months that resulted in days away from work, restricted work activity or job transfer, or medical treatment beyond first aid [27]. The WRI response for each PT or PTA was coded by using the information that OSHA required for a recordable WRI. Prevalence was then calculated by dividing the count of pain/discomfort cases by the total number of survey respondents [27]. The secondary outcome was to identify perceived causes of work-related pain and injuries among PTs and PTAs. Areas of interest for the secondary outcome included work settings, therapeutic activities, and availability of patient handling resources.

Aggregated coded survey data were exported from SelectSurvey to Minitab (Version 19, Minitab Inc., State College, PA, USA) for descriptive and inferential statistical analyses. Data quality and accuracy were reviewed for erroneous and missing data. One-way analysis of variance was used to examine associations among demographic variables and the dichotomous response variable, WRI. Binary logistic regression with a logit link was used to examine the associations among categorical variables, including work settings and mechanical lifts usage, as predictors of a WRI case. The significance level was set at 0.05.

3. Results

3.1. Response rate

Of the 51 rehabilitation facilities included, 18 were located in an urban area (population $\geqslant$ 50,000), 29 were located in an urban cluster (population $>$ 2,500 and $<$ 50,000), and 4 were located in rural areas with a population less than 2,500. Of the 502 surveys distributed to PTs and PTAs at the 51 facilities, a total of 260 responses were returned for a response proportion of 51.8% (260/502).

Of the 260 returned surveys, 23 responses were excluded because individuals did not complete the consent. Therefore, a total of 237 completed responses were included in this study and the respondents' characteristics and relevant work setting information are provided (Table 1). There were 47 (19.8%) responses from Iowa, 42 (17.7%) from Kansas, 35 (14.8%) from Missouri, and 113 (47.7%) from Nebraska. The higher proportion of responses in Nebraska likely arose, in part, because the research institution was in Nebraska and had close ties with many healthcare facilities across the state.

3.2. Rehabilitation activities risk exposure

Nearly half (41.4%) of the respondents reported spending 5 to 7 hours per day delivering "hands on" care to patients, and 36.3% delivered $>$ 7 to $<$ 12 hours

Table 2
Activities and postures performed that might contribute to work-related pain/discomfort ($n = 237$)

Activities performed over 10 times per workday	Frequency (relative frequency)[1]
Patient transfer	60 (25.3%)
Balance activities	44 (18.6%)
Patient repositioning	37 (15.6%)
Manual facilitation	32 (13.5%)
Range of motion	24 (10.1%)
ADL training	14 (5.9%)
Gait training	10 (4.2%)
Joint mobilization	10 (4.2%)
Soft tissue work	7 (3.0%)
Manual muscle testing	7 (3.0%)
Lifting/moving equipment and supplies	4 (1.7%)
Applying modalities	4 (1.7%)
Device fitting	3 (1.3%)
Movements and postures performed to complete all activities	**(Average percentage of time performed per day)[2]**
Bending/twisting	39.4%[2]
Kneeling/squatting	35.0%[2]
Performing repetitive tasks	33.9%[2]
Static posture	27.6%[2]
Heavy lifting	21.8%[2]
Awkward/cramped posture	20.5%[2]
Physically fatigued	20.5%[2]

[1]Frequency (Relative Frequency) of participants reported; [2]Average percentage of time that PTs/PTAs performed the posture during a typical workday.

of daily "hands on" care. A notable portion of PT and PTA respondents reported performing high risk activities (e.g., patient transfers, working on balance activities, repositioning patients, performing manual facilitation, and range of motion activities) more than 10 times per workday (Table 2). Respondents spent more than one-third of a typical workday bending/twisting, kneeling/squatting, and performing repetitive tasks, while maintaining static postures and engaging in heavy lifting were performed greater than one-fifth of a typical workday.

3.3. Primary outcome: Prevalence of WRIs among PTs and PTAs in physical rehabilitation

A majority (61.6%) of the 237 respondents reported experiencing work-related musculoskeletal pain/discomfort during the 12 months prior to the survey and over one-quarter (29.5%) were classified as a WRI (OSHA; Table 3). Moreover, both PTs (62.4%; $n = 106$) and PTAs (59.7%; $n = 40$) reported experiencing work-related musculoskeletal pain/discomfort. Of those experiencing a WRI, the greatest portion reported that their most severe pain was in their torso (41.8%), while smaller proportions reported pain in the upper extremity (12.2%) or lower extremity (5.9%). Over 80% of PTs and PTAs that experienced pain in the torso experienced pain bilaterally with the lower back identified as the most common site. For the upper and lower extremities, most PTs and PTAs reported pain on their dominant (i.e. right) side.

The duration of pain generally lasted more than a week (16.9%) or at least once per month (28.3%). A third (33.3%) classified the pain as moderate intensity, while just a few respondents reported severe pain (5.9%). Respondents tended to continue to work with their pain/discomfort (57.0%) and self-managed their symptoms using first aid treatment (38%). Nearly one-quarter (22.4%) changed patient treatments/practices, while 13.9% sought help from a healthcare provider. Ten percent were unable to conduct their normal duties or permanently/temporarily changed jobs as a result of their WRI.

3.4. Secondary outcome: Perceived causes of work-related pain and injuries

Occupational risk factors including the force exerted, posture, repetition, and duration were extremely common during therapeutic activities (Fig. 1). Force exerted was identified by PT and PTA respondents as a primary cause of pain/discomfort when performing patient handling activities and lifting/moving equipment and

Table 3
Work-related pain/discomfort attributes ($n = 237$)

Experienced pain/discomfort during past 12 months related to their work	146 (61.6%)[1]
Experienced WRI during past 12 months	70 (29.5%)
Location	
Torso (neck, upper back, mid back or lower back)	99 (41.8%)
Upper Extremity (shoulder, elbow or wrist/hand)	29 (12.2%)
Lower Extremity (hip/thigh, knee or ankle/foot)	14 (5.9%)
Duration	
24 hours or less	48 (20.3%)
24 hours to 1 week	54 (22.8%)
$>$ 1 week to 1 month	24 (10.1%)
$>$ 1 month	16 (6.8%)
Frequency	
More than once every week	26 (11.0%)
Once a week	15 (6.3%)
Once a month	26 (11.0%)
Once every 2–3 months	39 (16.5%)
Once every 6 months or more	36 (15.2%)
Severity	
Mild (rated 1–3)	52 (21.9%)
Moderate (rated 4–6)	79 (33.3%)
Severe (rated 7–10)	14 (5.9%)
Effects[2]	
Continued to work with pain/discomfort	135 (57.0%)
Performed first aid[3]	90 (38.0%)
Changed treatments/practices[4]	53 (22.4%)
Sought treatment or consulted a healthcare provider[4]	33 (13.9%)
Prevented from completing normal duties[4]	20 (8.4%)
Changes jobs permanently/temporarily and filed claim[4,5]	4 (1.7%)
Utilized sick leave[4]	3 (1.3%)

[1]Frequency (Relative Frequency); [2]Respondents reported multiple effects of their most severe pain/discomfort; [3]First aid included stretching, massage, pain relieving medication, braces, application of heat/cold, and strengthening exercises; [4]Pain/discomfort effects that were classified as OSHA recordable work-related injuries and illnesses; [5]Includes filing a worker's compensation claim.

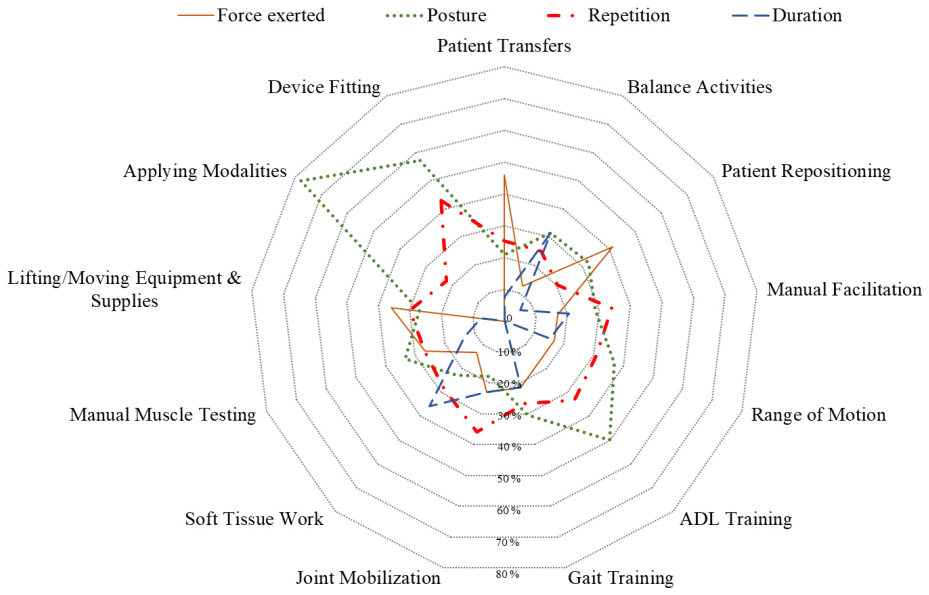

Fig. 1. Reasons for pain/discomfort while performing activities.

Table 4
Logistic regression results summary (response variable: WRI) ($n = 237$)

Factor[1]	Odds ratios for categorical predictors[2]			Coefficients[3]	
Level A	Level B	OR	95% CI	β	P-value
Age	–	–	–	0.022	0.105
PT experience	–	–	–	0.027	0.060
Safe patient handling program					
Available	Not available	0.6160	(0.3202, 1.1849)	−0.485	0.147
Full body/dependent					
Available	Not available	0.5820	(0.2652, 1.2770)	−0.541	0.177
Standing assistance/walking frame					
Available	Not available	0.4255	(0.2171, 0.8336)	−0.855	0.013*
Fixed/ceiling or wall mounted					
Available	Not available	0.5892	(0.3115, 1.1144)	−0.529	0.104
Portable/mobile/freestanding					
Available	Not available	0.5552	(0.2902, 1.0622)	−0.588	0.075
Bariatric (overhead lifts)					
Available	Not available	0.6410	(0.3310, 1.2413)	−0.445	0.187
Sit-to-stand non-mechanical lifts					
Available	Not available	0.4656	(0.2209, 0.9815)	−0.764	0.045*
Transfer boards					
Available	Not available	0.1608	(0.0164, 1.5816)	−1.830	0.117
Heavy lifting					
Performed $>$ 25% (per workday)	Performed $<$ 25%	2.1000	(1.0687, 4.1264)	0.742	0.031*
Performing repetitive tasks					
Performed $>$ 25% (per workday)	Performed $<$ 25%	1.7778	(1.0003, 3.1595)	0.575	0.050
Pain length					
Pain last $>$ 1 week	Pain last $<$ 1 week	3.0165	(1.3973, 6.5120)	1.104	0.005**
Pain severity rating (1–9)					
Severe (7–9)	Mild (1–3)	8.8571	(1.7951, 43.7011)	2.181	0.007**
	Moderate (4–6)	6.8108	(1.4300, 32.4378)		
Hip/thigh pain/discomfort					
Yes	No	4.4658	(1.6341, 12.2047)	1.496	0.004**
Used mechanical lifts before pain/discomfort					
Rarely	Always	2.4000	(0.9329, 6.1744)	0.875	0.069
Sometimes	Always	1.8750	(0.7328, 4.7975)	0.629	0.190
	Rarely	0.7813	(0.3996, 1.5272)		
Use mechanical lifts after/during pain/discomfort					
Rarely	Always	2.2759	(1.0097, 5.1297)	0.822	0.047*
Sometimes	Always	1.8333	(0.8265, 4.0666)	0.606	0.136
	Rarely	0.8056	(0.3934, 1.6494)		

[1]Only statistically significant factors/levels and marginally significant factors and their levels were listed in the table; [2]Odd ratios for level A to level B; [3]Coefficients of level A: *P-value is less than 0.05; **P-value is less than 0.01.

supplies. A large proportion of respondents identified that maintaining static postures during range of motion activities, activities of daily living training, gait training, manual muscle testing, application of modalities, and device lifting contributed to pain/discomfort.

Performing heavy lifting ($\beta = 0.742$, $p = 0.031$) greater than 25% of a workday increased the odds of WRI more than two-fold (Table 4). Additionally, performing repetitive tasks greater than 25% of the workday displayed a trend towards a higher odds of developing a WRI ($\beta = 0.575$, $p = 0.050$). In contrast, the odds of experiencing a WRI were halved by the presence of mechanical standing assistance/mechanical lift equipment ($\beta = -0.855$, $p = 0.013$) as well as the availability of non-mechanical sit-to-stand lifts ($\beta = -0.764$, $p = 0.045$). Although not achieving statistical significance, there was a trend for those who rarely used mechanical lifts before an injury to have a higher odds of a WRI then those who always used a mechanical lift. Pain that was severe ($\beta = 2.181$, $p = 0.007$), present in the hip/thigh, ($\beta = 1.496$, $p = 0.004$), or of extended duration ($\beta = 1.104$, $p = 0.005$) contributed to the highest odds of a WRI.

A wide range of lifting aids were available for use by clinicians (Table 5), yet less than 37% of clinicians reported using such mechanical devices and over half of them reported preferring manual lifting (66.2%) or non-mechanical devices (58.6%) over mechanical devices. Limited respondent training and low confidence regarding the proper use of lifting devices were re-

Table 5
Patient handling resources availability and confidence rating ($n = 237$)

Patient handling devices/resources available/provided in work area	% availability
Mechanical lifting devices	172 (72.6%)[1]
Mobile floor lifts	
Full body/dependent	138 (58.2%)
Sit-to-stand/semi-dependent	136 (57.4%)
Standing assistance/walking frame	109 (46.0%)
Bariatric	79 (33.3%)
Overhead lifts	
Fixed/ceiling or wall mounted	95 (40.1%)
Portable/mobile/freestanding	82 (34.6%)
Bariatric	79 (33.3%)
Therapeutic lifts	
Body-weight support system	103 (43.5%)
Robotic system (e.g. Lokomat)	36 (15.2%)
Exercise platform (e.g. Moveo XP)	50 (21.1%)
Adjustable/powered mat/platform	104 (43.9%)
Madonna ICARE by SportsArt (motorized elliptical)	38 (16.0%)
Non-mechanical lifting aids	
Sit-to-stand (e.g. Stedy/VanMove)	53 (22.4%)
Friction reducing (e.g. MaxiSlide/PolyGlide)	91 (38.4%)
Transfer boards	169 (71.3%)
Multi-handled gait belts	58 (24.5%)
A culture of safety for patients and clinicians	199 (84.0%)
Tools, resources and education for patient and clinician safety	195 (82.3%)
Lift team available	72 (30.4%)
Injury prevention or ergonomics program	132 (55.7%)
Safe patient handling program	156 (65.8%)
Guidelines for using patient handling equipment	119 (50.2%)
Training on how to operate and maintain mechanical lifting devices	% availability
Initial training	143 (60.3%)
Annual training	68 (28.7%)
Refresher training	81 (34.2%)
How confident do you feel operating the following during therapy sessions	% confident
Mobile lifts	168 (68.8%)
Ceiling lifts	111 (46.9%)
Therapeutic lifts	139 (58.6%)
Non-mechanical aids	151 (63.7%)

[1]Frequency (Relative Frequency).

ported. More than 70 participants reported that availability of equipment, therapeutic value for patients, size/maneuverability of lifting devices, and ability to assess patient independence as barriers to use and areas to improve (Fig. 2).

4. Discussion

Over the last decade, safety efforts in healthcare have focused primarily on patients; yet, many of the same health and safety hazards affecting patients also negatively impact healthcare workers [11]. For example, the Revised National Institute of Occupational Safety and Health (NIOSH) lifting equation suggests that, under the neutral body position with minimal twisting at hands, legs, torso or shoulders, the maximum weight that can be lifted with two hands manually, without increasing the risk of work-related pain, is 51 pounds [28]. Yet clinicians in the rehabilitation setting are often tasked with helping patients relearn to lift and move their body during bed mobility, transfers and walking. The current study sought to elucidate the impact of WRIs in the physical rehabilitation environment and to identify potential factors relevant to their occurrence so strategies could be identified to enhance worker well-being.

4.1. Prevalence and risk factors of WRI in Rehabilitation

Along with previous studies [1,2,5–7,12,13,29], PTs experienced a high risk of work-related musculoskeletal pain/discomfort in this study. Similarly, a high preva-

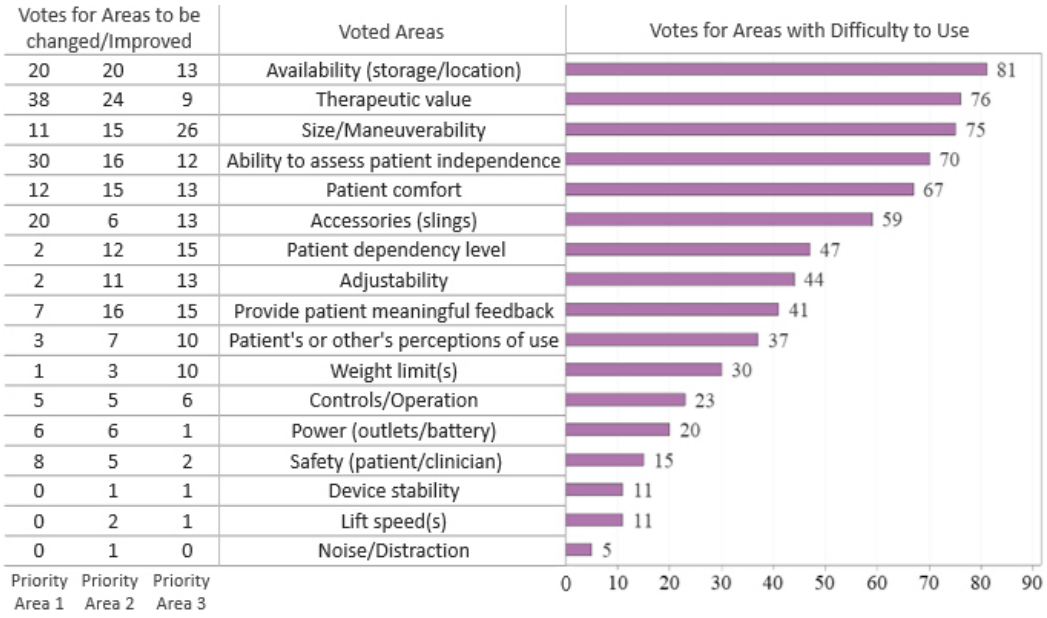

Fig. 2. Top priority areas considered for improvement (left) and difficulty areas (right) using mechanical lifting devices by rehabilitation PTs/PTAs.

lence of work-related musculoskeletal pain/discomfort was observed in PTAs, which has not been studied widely in other published studies. In the current research, participants tended to perform "risky" activities including bending/twisting, kneeling/squatting, performing repetitive tasks and maintaining static postures to assist patients during a variety of therapeutic activities.

This study's findings align with previous research reporting that work-related pain/discomfort was experienced most frequently in the low back [4–6,31,32] due to bending/twisting during therapeutic activities [1], which was confirmed in this current study. Patient handling activities (patient transfers and patient repositioning) require enormous bending/twisting and heavy lifting repeatedly. This study reinforces previous findings that patient handling activities are a significant contributor to lower back pain in PTs [2] and extends this finding to PTAs. PTs also experienced a higher work-avoidance prevalence as a result of this lower back pain than other healthcare workers in a rehabilitation hospital [32].

This study not only examined the risky activities and postures performed by rehabilitation PTs and PTAs, but also investigated the causes contributing to their work-related pain and injuries while performing those activities and postures. For patient handling activities, the force exerted was the major cause for pain/discomfort. Likewise, repetition was the major cause of pain/discomfort for PTs and PTAs during manual facilitation and joint mobilization, which significantly increased the odds of PTs and PTAs experiencing WRI. Duration of occupational activities also resulted in pain during patient balance activities and soft tissue work.

Although most work areas of the surveyed respondents were equipped with lifting devices, often these devices seem to be ineffective at preventing injuries whether due to lack of device use (training, storage location), functionality (maintenance, power, etc.), or ability to promote functional recovery for patients. Only half of the respondents reported feeling confident in being able to utilize these devices in a standard way, and few were confident in their capacity to employ them in more advanced ways (e.g. active hands-on facilitation while the patient was in device). More PTs and PTAs preferred the non-mechanical and manual lifting devices over mechanical lifting devices, while more mechanical lifting devices were available in the working areas. Lifting teams and safe patient handling programs were rarely available. Yet, lift team availability could have a significant influence on decreasing the risk of WRI [26]. For the current study, the availability of at least one lifting device and safe patient handling program reduced the risk of a WRI . Many work areas were not equipped adequately with safe patient handling resources, and this study provides strong evidence of the benefits of using these devices to reduce WRI rates.

Particularly among PTs, there is an entrenched belief that patient care supersedes personal safety [29]. Since PTs are professionally trained to understand mus-

culoskeletal injuries and their causes, a cultural phenomenon exists, whereby therapists underestimate the severity of their injuries and attempt to self-manage their injuries [11,29]. This was also observed in this study in the high prevalence of pain/discomfort and self-treatment of pain without consulting other healthcare professionals. A high proportion of PTs and PTAs reported a culture of safety for patients and clinicians at their institution (84%), as well as safety tools, resources and education in their working area (82.3%). Yet, protecting their own occupational health and safety appear to be neglected among the surveyed PTs and PTAs.

4.2. Suggestions for physical rehabilitation injury prevention

In a qualitative analysis of work-related musculoskeletal disorders among PTs, work postures, movement, lifting/moving and repetitive tasks required in therapeutic activities were activities identified that limited therapists' capability to continue working in the rehabilitation work setting [33]. Since $\sim$ 10% of participants changed duties or even their jobs due to injuries in this current study, more attention is needed to reinforce patient handling biomechanics and more active use of safe patient handling tools during therapeutic sessions. To encourage more use of lifting and safe patient handling devices, adjustments must be made to make devices fit the needs of both user groups (caregivers and patients) to promote patient outcomes [26]. Availability of equipment, therapeutic value for patients, size/maneuverability of lifting devices, and ability to assess patient independence could be integrated into existing devices or specifically designed to better accommodate therapists as a user group (i.e., user-centered design). Based on the inadequacy of safe patient handling resources and ergonomic programs, improvement from an engineering-based (equipment redesign), administrative (availability of necessary equipment, lift teams and policy) and behavioral (training for safe use of devices and equipment) aspects of safe patient handling processes need to be implemented in these work areas [34,35]. Reports of reduced injuries among the nursing community following implementation of lifting restrictions [36,37] highlights the potential value of integrating lifting restrictions for therapists. Increased collaboration between health care professionals, engineers and manufacturers is warranted to improve equipment design to accommodate more health care professionals, patients (e.g., mass, leg length, level of arousal), environment (e.g., narrower base, collapsible design) and affordability.

4.3. Limitations and future research

Since this study was a self-reported assessment over the past 12 months of occupational risks, participants' perception of pain may have been influenced by the time since injury. Recall bias may have existed with some participants unable to remember exact details from the previous 12 months. Surveys were sent out to all facilities across the four heartland states; however, no effort was made to balance response rates from larger vs. smaller and urban vs. rural facilities. A larger sample size and stratified sampling would better limit selection and misclassification bias.

While not studied, it is possible that environmental factors (e.g., room set-up) and patient-specific factors (location of injury) biased the demand placed on clinicians' bodies either unilaterally or bilaterally. Future studies, linking broader environmental factors (e.g., mat accessibility) and patient-specific injuries to clinicians' pain/discomfort/WRI could help elucidate the possible impact of these factors on clinicians.

5. Conclusion

Rehabilitation PTs and PTAs face a high risk of musculoskeletal pain/discomfort in their work environment. PTs and PTAs experienced severe pain in the torso, especially the low back. Heavy lifting combined with repetitive tasks performed during different therapeutic activities increased WRI prevalence. The significantly higher forces exerted in rehabilitation settings were reported as a primary cause of pain for patient handling activities. Safe patient handling resources were effective at decreasing the risk of WRI, especially lifting devices. Yet, inadequacy of many safe patient handling resources was reported in most work areas. Multifaceted engineering, administrative and behavioral changes are needed to holistically alter the risk of WRI among rehabilitation therapists and assistants.

As the population of older adults and those with physical disabilities expands, it will be increasingly important to ensure a healthy and fully functional workforce able to address their rehabilitation needs. Despite this critical and growing need, the current study revealed a high prevalence of work-related pain/discomfort and WRI amongst PTs and PTAs providing rehabilitation care. Understanding factors that contributed to the pain, discomfort and injuries in therapists is essential to guide workplace efforts to protect the rehabilitation workforce and advance rehabilitation care efficiently and

cost-effectively. Future research will lead to more effective strategies to design new and redesign existing safe patient handling equipment to better protect therapists from WRIs.

Acknowledgments

This research was supported in part by a pilot project research training grant from the Heartland Center for Occupational Health and Safety at the University of Iowa. The Heartland Center is supported by Training Grant No. T42OH008491 from the Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH). Special thanks to Madonna Rehabilitation Hospitals' staff and patients as well as Jane Meza, Marissa Nitz and Lindsey Trejo for their assistance in this study.

Conflict of interest

None to report.

References

[1] Anyfantis ID, Biska A. Musculoskeletal disorders among greek physiotherapists: traditional and emerging risk factors. Safety and Health at Work. 2018; 9(3): 314-8.
[2] Campo M, Weiser S, Koenig KL, Nordin M. Work-related musculoskeletal disorders in physical therapists: a prospective cohort study with 1-year follow-up. Physical Therapy. 2008; 88(5): 608-19.
[3] Cromie JE, Robertson VJ, Best MO. Work-related musculoskeletal disorders in physical therapists: prevalence, severity, risks, and responses. Physical Therapy. 2000; 80(4): 336-51.
[4] Mierzejewski M, Kumar S. Prevalence of low back pain among physical therapists in Edmonton, Canada. Disability and Rehabilitation. 1997; 19(8): 309-17.
[5] Muaidi QI, Shanb AA. Prevalence causes and impact of work related musculoskeletal disorders among physical therapists. Journal of Back and Musculoskeletal Rehabilitation. 2016; 29: 763-9.
[6] Vieira ER, Svoboda S, Belniak A, Brunt D, Rose-St Prix C, Roberts L, da Costa BR. Work-related musculoskeletal disorders among physical therapists: an online survey. Disability and Rehabilitation. 2016; 38(6): 552-7.
[7] Vieira ER, Schneider P, Guidera C, Gadotti IC, Brunt D. Work-related musculoskeletal disorders among physical therapists: A systematic review. Journal of Back and Musculoskeletal Rehabilitation. 2016; 29(3): 417-28.
[8] Buster TW, Goldman AJ, Corbridge LM, Shu Y, Burnfield JM. Partial body weight support treadmill training: clinician's upper extremity muscle activation during facilitation of hemiparetic limb movement. Proceedings in 14th Annual Meeting of the Gait and Clinical Movement Analysis Society; 2009; Denver, CO. pp. 258-259.
[9] McCrory B, Harlow A, Burnfield JM. Musculoskeletal risk to physical therapists during overground gait training: a case report. Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2014; 58(1): 1219-23.
[10] Corbridge LM, Goldman AJ, Shu Y, Buster TW, Burnfield JM. Clinician's muscle effort during partial body weight support treadmill training: is it hard work? Poster session presented at: American Physical Therapy Association's Annual Conference and Exposition; 2009 Baltimore, MD.
[11] Cromie JE, Robertson VJ, Best MO. Work-related musculoskeletal disorders and the culture of physical therapy. Physical Therapy. 2002; 82(5): 459-72.
[12] Bork BE, Cook TM, Rosecrance JC, Engelhardt KA, Thomason M-EJ, Wauford IJ, Worley RK. Work-related musculoskeletal disorders among physical therapists. Physical Therapy. 1996; 76(8): 827-35.
[13] Iqbal Z, Alghadir A. Prevalence of work-related musculoskeletal disorders among physical therapists. Medycyna Pracy. 2015; 66(4): 465-69.
[14] King P, Huddleston W, Darragh AR. Work-related musculoskeletal disorders and injuries: differences among older and younger occupational and physical therapists. Journal of Occupational Rehabilitation. 2009 Sep; 19(3): 274-83.
[15] Sanford JT, Johnson AD, Townsend-Rocchiccioli J. The health status of rural caregivers. Journal of Gerontological Nursing. 2005; 31(4): 25-31.
[16] Sanford JT, Townsend-Rocchiccioli J. The perceived health of rural caregivers. Geriatric Nursing. 2004; 25(3): 145-8.
[17] Waters KR, Luker KA. Staff perspectives on the role of the nurse in rehabilitation wards for elderly people. Journal of Clinical Nursing. 1996; 5(2): 105-14.
[18] Dennerlein JT, Day E, Mulloy DF, Somerville J, Stoddard AM, Kenwood C, Teeple E, Boden LI, Sorensen G, Hashimoto D. Lifting and exertion injuries decrease after implementation of an integrated hospital-wide safe patient handling and mobilisation programme. Occupational and Environmental Medicine. 2017; 74(5): 336.
[19] Mayeda-Letourneau J. Safe patient handling and movement: a literature review. Rehabilitation Nursing. 2014 May-Jun; 39(3): 123-9.
[20] Nelson A, Collins J, Siddharthan K, Matz M, Waters T. Link between safe patient handling and patient outcomes in long-term care. Rehabilitation Nursing. 2008; 33(1): 33-43.
[21] Nelson A, Harwood KJ, Tracey CA, Dunn KL. Myths and facts about safe patient handling in rehabilitation. Rehabilitation Nursing. 2008; 33(1): 10-7.
[22] Perlow E, Tunney N, Lucado A. Integrating safe patient handling into physical therapist education: reducing the incidence of physical therapist injury and improving patient outcomes. Journal of Physical Therapy Education. 2016; 30(2).
[23] Koppelaar E, Knibbe JJ, Miedema HS, Burdorf A. Individual and organisational determinants of use of ergonomic devices in healthcare. Occupational and Environmental Medicine. 2011; 68(9): 659.
[24] Zhuang Z, Stobbe TJ, Hsiao H, Collins JW, Hobbs GR. Biomechanical evaluation of assistive devices for transferring residents. Applied Ergonomics. 1999; 30(4): 285-94.
[25] Jang R, Karwowski W, Quesada PM, Rodrick D, Sherehiy B, Cronin SN, Layer JK. Biomechanical evaluation of nursing tasks in a hospital setting. Ergonomics. 2007; 50(11): 1835-55.
[26] McCrory B, Burnfield JM, Darragh AR, Meza JL, Irons SL, Chernyavskiy P, Link AM, Brusola G. Work injuries among therapists in physical rehabilitation. Proceedings of the Human

Factors and Ergonomics Society Annual Meeting. 2014; 58(1): 1072-6.

[27] Recording and reporting occupational injuries and illnesses under Public Law 91-596. Federal Register, Vol. 36; No. 128–Friday, July 2, 1971. Occupational Health Nursing. 1971 Sep; 19(9): 16-26.

[28] Waters TR. Applications manual for the revised NIOSH lifting equation [microform]/Thomas R. Waters, Vern Putz-Anderson, Arun Garg. Putz-Anderson V, Garg A, National Institute for Occupational S, Health. Division of B, Behavioral S, editors. Cincinnati, Ohio: Springfield, VA: U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National; Institute for Occupational Safety and Health, Division of Biomedical and Behavioral Science; For public sale by U.S. Dept. of Commerce, Technology Administration, National Technical Information Service, 1994.

[29] Campo M, Darragh AR. Impact of work-related pain on physical therapists and occupational therapists. Physical Therapy. 2010 Jun; 90(6): 905-20.

[30] Alghadir A, Zafar H, Iqbal ZA, Al-Eisa E. Work-related low back pain among physical therapists in riyadh, saudi arabia. Workplace Health & Safety. 2017; Aug; 65(8): 337-345.

[31] Molumphy M, Unger B, Jensen GM, Lopopolo RB. Incidence of work-related low back pain in physical therapists. Physical Therapy. 1985 Apr; 65(4): 482-6.

[32] Alperovitch-Najenson D, Treger I, Kalichman L. Physical therapists versus nurses in a rehabilitation hospital: comparing prevalence of work-related musculoskeletal complaints and working conditions. Archives of Environmental & Occupational Health. 2014; 69(1): 33-9.

[33] Passier L, McPhail S. Work related musculoskeletal disorders amongst therapists in physically demanding roles: qualitative analysis of risk factors and strategies for prevention. BMC Musculoskeletal Disorders. 2011 Jan 25; 12: 24.

[34] Nelson A, Baptiste AS. Evidence-based practices for safe patient handling and movement. Clinical Reviews in Bone and Mineral Metabolism. 2006; 4(1): 55-69.

[35] Waters TR, Rockefeller K. Safe patient handling for rehabilitation professionals. Rehabilitation Nursing. 2010; 35(5): 216-22.

[36] Evanoff B, Wolf L, Aton E, Canos J, Collins J. Reduction in injury rates in nursing personnel through introduction of mechanical lifts in the workplace. American Journal of Industrial Medicine. 2003; 44(5): 451-7.

[37] Garg A, Kapellusch JM. Long-term efficacy of an ergonomics program that includes patient- handling devices on reducing musculoskeletal injuries to nursing personnel. Human Factors. 2012; 54(4): 608-25.