Review

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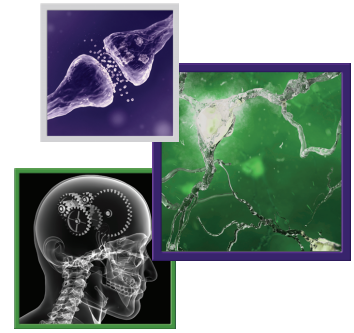

Musculoskeletal pain in Parkinson's disease: a narrative review

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Practice points

- Pain is highly prevalent in Parkinson's disease (PD) and this prevalence is higher than in older adults.
- It is important to screen for pain in PD and determine type, frequency and severity.
- The most common sites for pain in PD are the shoulder and low back, though the neck, knee and hip should not be forgotten.
- PD appears to increase the risk of complication and/or poor outcome after orthopedic surgery.
- Physical therapy should be considered in the initial treatment for pain in people with PD.
- A multidisciplinary team of healthcare professionals will likely optimize pain management for people with PD.

The prevalence of musculoskeletal (MSK) pain in people with Parkinson's disease (PD) is higher than that of age-matched controls. In this review, we outline what is known about MSK pain in PD, focusing on the neck, shoulder, knee, hip and low back. We also compare what is known about MSK pain in PD to what is known in older adults without PD. Finally, we outline areas of for future research related to MSK pain in people with PD.

Lay abstract: Joint pain in people with Parkinson's disease (PD) is more common than other healthy older adults. In this paper, we describe what is known about joint pain in PD, focusing on the neck, shoulder, knee, hip and low back. We also compare how much is known about pain in PD versus how much is known about pain in older adults without PD. Finally, we suggest ways future researchers can help the world better understand pain in PD.

Tweetable abstract: Musculoskeletal pain in Parkinson's disease: a narrative review. Musculoskeletal pain is prevalent in individuals with Parkinson's disease. What do we know about it and how might we study it going forward?

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Keywords: geriatric • musculoskeletal • older adult • orthopedic • pain • Parkinson's disease • rehabilitation

People with Parkinson's disease (PD) report experiencing pain more frequently than age-matched older adults without PD [1]. Pain is estimated to occur in approximately 40–85% (mean 67.6%) of people with PD [2]. Though frequently associated with advanced disease [3], pain may be present early in PD [4] or even before PD diagnosis [5]. Of the motor and non-motor symptoms in early PD, pain is regularly cited as one of the most bothersome [6]. Further, pain negatively impacts quality of life (QOL) in PD [4,7]. Despite its prevalence and negative impact on QOL, pain is under-recognized and under-treated in this population.

The presentation of pain in people with PD varies. To date, much of the research published on pain in PD treats pain irrespective of classification (e.g., body area, type of pain). However, there are classification schemes and measures available to better understand pain syndromes and characteristics of pain in PD. Ford suggests five categories of pain in PD: musculoskeletal (MSK), radicular/neuropathic, dystonia, central or primary pain and akathisia [8]. Chaudhuri and associates validated use of the King's PD Pain Scale to rate pain severity and frequency in seven domains [9]. Mylius and colleagues developed the Parkinson's Disease Pain Classification Scheme, which

Table 1. Neck pain key points.

- Cervical spine deformity and forward head posture are associated with neck pain in PD.
- Severity of neck pain is associated with pain in other body regions.
- There is currently no standard of care for managing neck pain in PD, and more research is needed in this area.

PD: Parkinson's disease.

categorizes PD-related pain as either nociceptive, neuropathic or nociplastic [10]. These classifications are useful for better understanding factors contributing to and identifying treatments for specific pain syndromes in people with PD.

MSK pain appears to be the most prevalent pain type among people with PD [11–13]. MSK pain in PD is defined as nociceptive pain that is localized to different body regions and is not significantly modulated by dopaminergic treatment [8,14,15]. People with PD are at a higher risk for developing MSK pain compared with age-matched older adults without PD [16]. Common body areas affected by MSK pain are the neck, shoulder, hip, knee and low back [17]. The origins of MSK pain in PD are not well understood. Currently, it is unclear how factors associated with MSK pain in these body areas in PD are similar or different from those in older adults without PD. Understanding what is known about MSK pain in older adults may stimulate investigations in PD to determine overlapping and independent mechanisms of MSK pain in PD. Identifying risk factors for development and persistence of MSK pain in PD will allow investigators to better identify potential therapeutic interventions to address it.

The purpose of this narrative review of MSK pain in PD is threefold: to summarize the current evidence surrounding with a specific focus on neck, shoulder, hip, knee and low back pain (LBP); to describe what is known in PD compared with older adults without PD; and to identify areas for future research.

Neck pain

To our knowledge, only one study has reported on the prevalence of neck pain in people with PD [17]. In a sample of 400 people with PD, 5.5% (n = 22) reported neck pain compared with 2.9% of age-matched controls [17]. The prevalence of neck pain in older adults without PD is estimated at 12–40% [18,19] and increases with age [20]. Neck pain in the general population may be due to facet joint irritation (i.e., osteoarthritis), degeneration of the intervertebral disc, and/or irritation of the spinal nerve roots [21]. It should be noted, however, that radiographic findings are not strong predictors of neck pain [22]. In fact, it is more widely accepted that the origins of pain involve multiple factors (e.g., sensory, biomechanical, psychological) [23].

People with PD often have cervical spine deformities [24]. Alwardat and colleagues reported that postural deformity (e.g., Pisa syndrome, camptocormia, antecollis) related to neck-related disability and pain in people with PD [25]. Indeed, forward head posture is associated with neck pain in older adults [26]. Further, cervical spine range of motion may distinguish between individuals with and without nonspecific neck pain [27]. In addition to potential biomechanical contributions to neck pain, psychologic factors may also play a role. Vogt *et al.* noted depression was associated with neck pain in older adults [18]. Depression is common among people with PD [28] and thus may contribute to the onset and persistence of neck pain. However, this warrants further exploration. It is also important to note that severity of neck pain is associated with pain at other body sites [18,29]. As such, it is possible that neck pain in PD may co-occur with other pain at other sites (e.g., low back, shoulder).

There is no clear standard for medical management of neck pain in people with PD. Specific to reducing neck pain in PD, it is unclear whether nonsteroidal anti-inflammatory drugs (NSAIDs), opioid or dopaminergic medications are effective. There are no studies investigating the efficacy of physical therapy for neck pain in PD. The efficacy of surgical procedures (e.g., cervical decompression and fusion) in reducing neck pain in people with PD is also unknown. The effects of surgery (anterior cervical decompression and fusion) on pain and disability in middle-aged to older adults are mixed [30,31]. However, people with PD who underwent cervical decompression and fusion were more likely to have perioperative complications, longer length of stay in the hospital, greater hospital costs and nonhome discharge [32]. Table 1 contains summary points for neck pain in PD.

Shoulder pain

The prevalence of shoulder pain in people with PD varies widely from 15 to 80% [17,33]. In the general elderly population, 31% reported shoulder pain for 3 or more months in the previous year [34]. When directly comparing people with PD and age-matched controls, shoulder pain or disturbance is more common in people with PD [17,35]. When assessing their shoulder pain intensity at its worst, people with PD rated it at moderate to severe (i.e., 4–10

Table 2. Shoulder pain key points.

- Shoulder pain is very common in PD and may be a presenting symptom of the disease.
- Frozen shoulder and rotator cuff pathology are highly prevalent in PD and are likely sources of pain and disability in PD.
- Surgical intervention for shoulder pain in PD, specifically TSA, is associated with poor functional outcomes and increased risk for complications.

PD: Parkinson's disease; TSA: Total shoulder arthroplasty.

out of 10 on the Visual Analog Scale) [33]. People with PD may complain of shoulder pain prior to, at, or after the time of diagnosis. Indeed, in a study by Stamey and associates, 11% of patients with PD reported experiencing shoulder pain before the diagnosis of PD [36]. A similar survey found that 12% of respondents reported shoulder pain as their first symptom of PD, and that the side of shoulder pain was also the location of the first typical PD symptom [37]. The side of the body on which shoulder pain presented correlated to the side of maximal PD symptom severity [36]. These findings suggest that PD motor manifestations may play a role in shoulder pain.

Frozen shoulder and rotator cuff pathology are often associated with shoulder pain in PD. Frozen shoulder is more prevalent among people with PD compared with age-matched older adults without PD [35,36]. Riley and colleagues noted, in their sample of people mean age of 56.9 years at the time of their PD diagnosis, that the occurrence of frozen shoulder peaked within the 2 years prior to PD diagnosis [35]. This finding related to age of onset of frozen shoulder in PD is in agreement with the suggestion that frozen shoulder most frequently occurs between the ages of 40 to 65 years old [35,38]. Rotator cuff pathology is common among patients with PD. In people with PD without shoulder pain complaints, 12 of 56 shoulders had full thickness supraspinatus muscle tears [39]. Nearly half of the 56 shoulders presented with supraspinatus tendinosis [39]. Koh *et al.* studied 33 people with PD, 30 of whom reported shoulder pain [40]. Of the 33, 22 had rotator cuff tendon tearing on ultrasound [40]. Further, people with PD with rotator cuff tendon tears had worse shoulder-related disability compared with those without tendon tears [40].

There is no clear standard for pharmacologic, surgical or rehabilitative treatment of shoulder pain and/or pathology in people with PD. Madden and Hall reported that 40% of people with PD with shoulder pain had improvement with PD-specific treatment (e.g., dopaminergic medication, deep brain stimulation) [33]. However, 40% of people with PD with shoulder pain reported PD-specific treatment was not effective for shoulder complaints [33]. Specific to shoulder pain, it is unclear how people with PD respond to NSAIDs or other classes (e.g., opioid) of pain medication.

Surgery is often an option to treat shoulder pain that may be related to osteoarthritis (OA) and/or rotator cuff pathology. To our knowledge, there are no studies investigating rotator cuff repair in people with PD. In older adults (i.e., age 65 years and older) without PD, success rates for healing of the rotator cuff repair range from 68 [41] to 81.5% [42]. Patient satisfaction following rotator cuff repair in adults aged 62 or older also appears high (i.e., $\geq$81%) [43–45]. It is important to note that the likelihood of re-tear of the rotator cuff repair and patient satisfaction may be related to the size of the initial tear [41,46,47]. Total shoulder arthroplasty (TSA) and reverse TSA (RTSA) are more commonly reported surgeries for shoulder impairment in PD. With respect to TSA, a retrospective analysis of 15 people with PD at an average of 5.3 years of follow-up demonstrated improvements in pain [48]. However, functional results (e.g., range of motion) were often poor and 20% required revision surgery [48]. Similar to traditional TSA, Cusick and colleagues reported people with PD undergoing RTSA experienced reductions in pain, although this reduction was not statistically significant [49]. Further, people with PD post-RTSA had poorer clinical outcomes, greater complications and more revision surgery compared with those without PD [49]. In older adults, TSA and RTSA are associated with reduced pain and improved range of motion [50,51]. However, while not specific to older adults, a recent Cochrane review concluded there was insufficient evidence to suggest any type of shoulder replacement is more effective than other treatments for shoulder OA or rotator cuff arthropathy [52].

The efficacy of rehabilitation for shoulder pain in older adults, either prior to or after surgery, is unclear. Though methodological quality of studies varied and there was not a focus on older adults, a Cochrane review suggests exercise may be effective in improving shoulder function in people with shoulder pain [53]. Similarly, in a sample of adults in their middle 50 s with shoulder impingement, exercise, when compared with no treatment, resulted in improved pain and function [54]. To our knowledge, there are no studies reporting on the effects of rehabilitation on shoulder pain in people with PD. Table 2 contains summary points for shoulder pain in PD.

Table 3. Hip pain key points.

- Hip pain, compared with pain at other joints, appears less common in people with PD.
- Hip pain in people with PD is most likely to be related to osteoarthritis or hip fracture.
- Specific to hip pain, there are no studies of the efficacy of pharmacologic or rehabilitative treatments in reducing pain.
- Total hip arthroplasty may improve function in PD; however, people with PD are at higher risk for surgical complications and revision surgeries compared with those without PD.

PD: Parkinson's disease.

Hip pain

Hip pain, compared with other joints, appears to be less common among people with PD. Of 400 people with PD, nine (2.3%) reported hip pain [17]. In the same study, there was no significant difference in prevalence of hip pain in PD when compared healthy controls (one out of 138; 0.7%) [17]. In a study in which more than 6500 adults over the age of 60 years were interviewed, 14.3% reported significant, frequent hip pain [55]. Studies with larger samples are needed to accurately compare the prevalence of hip pain between people with PD and older adults without PD. Hip OA, which is associated with aging [56], appears to be the major contributor to hip pain in older adults. Hip fracture, which occurs more frequently in the elderly [57] and for which people with PD are at higher risk [58], can also be a contributor to hip pain among older adults. To our knowledge, there are no reports describing the characteristics (e.g., intensity, duration, impact on disability) of hip pain in people with PD.

Interestingly, people with moderate hip OA demonstrated gait deviations that may contribute to an increased risk of falls [59]. Among older adults with LBP, concomitant hip symptoms may contribute to worsened physical performance compared with those without hip symptoms [60]. Furthermore, in older adults reporting LBP, those with signs and symptoms consistent with hip OA were at a greater risk for falls compared with those without hip complaints [61]. Further research is needed to investigate whether and how MSK pain, particularly in the low back and hip, might increase fall risk among people with PD.

With respect to management of hip pain/hip OA in PD, to our knowledge, there is no evidence regarding the efficacy of pharmacologic or rehabilitative treatment specific to hip pain in PD. In people with hip osteoarthritis without PD, oral NSAIDs are recommended for pain reduction [62–64]. Physical exercise is also recommended in this population [65] and is associated with slight improvement in pain and function [66,67]. More is known regarding elective hip surgery for people with PD. A recent systematic review suggests that people with PD undergoing total hip arthroplasty (THA) have higher rates of wound infection and require revision surgery more frequently than those without PD [68]. Perioperatively, people with PD undergoing THA are more likely to experience delirium, altered mental status, urinary tract infection and require a blood transfusion [69]. People with PD are also more likely to have dislocations [68,70] and periprosthetic fractures than those without PD [68]. Short-term mortality rate in THA does not appear to differ when comparing people with PD to those without PD [71,72]. With respect to function, people with PD undergoing THA self-report improved function as measured by the SF-12 [73]. Those with PD undergoing elective THA may have greater independence with walking up to three years after surgery compared with those who undergo THA subsequent to a hip fracture [74]. Table 3 contains summary points for hip pain in PD.

Knee pain

People with PD appear to experience knee pain at approximately the same rate as healthy older adults without PD. Gundogdu and colleagues reported 21.4% of participants with PD experienced knee pain compared with 20.0% of aged-matched controls [75]. Though the results were not significantly different, Kim and associates reported 18% of people with PD experienced knee pain compared with 12.3% of age-matched controls [17]. Despite the prevalence of knee pain in PD, as of yet, there does not appear to be data related to its description (e.g., intensity, duration, impact on disability). In older adults, knee pain can be associated with the patellofemoral joint, the tibiofemoral joint, or both. Isolated tibiofemoral pain appears to be most common; however, combined pain (i.e., patellofemoral + tibiofemoral) is associated with greater pain, functional limitations, and reduced QOL compared with pain isolated to a single knee area [76].

In older men who do not have PD, knee pain is associated with mobility problems, falls and co-morbidity burden [77]. Over a period of 30 months, older adults with knee pain demonstrated worsened performance in time taken to climb stairs and transfer in and out of a car [78]. In people with knee osteoarthritis, evidence suggests that radiographic evidence of OA severity is of limited utility in predicting functional limitation [79]. However, recent

Table 4. Knee pain key points.

- Knee pain appears to be prevalent in PD, but not more so than in the general population.
- TKA for OA in PD is effective at reducing knee pain, but the results are mixed for functional improvement post-op.

PD: Parkinson's disease; OA: Osteoarthritis; TKA: Total knee arthroplasty.

work suggests that structural knee abnormalities as well as psychologic and environmental factors play a role in the development and exacerbation of knee pain in older adults [80]. Much work remains to better characterize knee pain in people with PD, whether and how PD manifestations contribute to knee pain, and how knee pain affects mobility in people with PD.

With respect to management of knee pain/knee osteoarthritis in PD, to our knowledge, there is no evidence regarding the efficacy of pharmacologic or rehabilitative treatment specific to knee pain in PD. Much work is focused total knee arthroplasty (TKA) and recovery from TKA [73,81–83]. Reduced pain is common following TKA in people with PD [83–85]. Functional improvement is possible for people with PD following TKA [83,84]. However, results are mixed as to whether people with PD improve in function following TKA to the same extent as older adults without PD [73,81,86]. Rondon and colleagues reported higher rates of periprosthetic infection in patients with PD who had TKA compared with controls (12.7 vs 0%) [73]. Confusion [87] and flexion contracture [86,88] may occur in people with PD post-TKA. Survival at 1-year post-TKA is similar between people with PD and those who do not have PD [82]; however, mortality rates, when measured between 2 and 10 years post-TKA, appear to be higher for people with PD compared with age-matched controls [73,82,86]. Severity of PD manifestations may play a role in outcomes after TKA [83,84]. Perioperative management of PD manifestations by a neurologist is critical and may enhance immediate outcomes after TKA [89]. Table 4 contains summary points for knee pain in PD.

Low back pain

LBP appears to be one of the most common sites of MSK pain in people with PD. Prevalence estimates of LBP in people with PD range from 42.9 [90] to 87.6% [91]. The prevalence of LBP in people with PD exceeds that of LBP in older adults without PD [1,90–95]. There is mixed evidence regarding sex differences when considering LBP prevalence in people with PD [93,96]. The intensity of LBP in people with PD tends to be higher than age-matched older adults [92]. Furthermore, people with PD may be more likely to have chronic LBP compared with age-matched older adults [93].

In people with PD, both motor and nonmotor manifestations are related to the presence of, or disability related to, LBP. Gross measures of PD motor manifestations, typically either the Hoehn & Yahr stage or Movement Disorders Society-Unified Parkinson's Disease Rating Scale – section III, demonstrate weak or moderate relationships with LBP intensity [97] and LBP-related disability [98,99] in people with PD. Standing posture [95,98] and muscle rigidity [95,98] are also related to LBP intensity and LBP-related disability. With respect to nonmotor manifestations, depression is related to the presence of LBP [95] and LBP-related disability [99]. Though not statistically significant, anxiety was also related to the presence of LBP in people with PD [95]. Intensity of LBP and LBP-related disability are negatively related to QOL in people with PD [98,99].

People with PD with LBP report greater difficulty performing activities of daily living when compared with people with PD who do not have LBP [95]. In those with LBP, activities of daily living performance is negatively related to LBP-related disability [98,99]. Preliminary work suggests that LBP primarily affects one's ability to stand for a prolonged period of time, lift objects from low surfaces, walk long distances and sleep [98]. Further, self-reported physical activity is negatively related to LBP-related disability in people with PD [98].

Many factors (e.g., biomechanical, psychologic, sensory) are associated with LBP in older adults without PD [100]. With respect to biomechanical factors, older adults with LBP have greater levels of intra-muscular fat, often indicative of tissue damage, within the multifidi muscles compared with age-matched older adults without LBP [101]. Additionally, in older adults with LBP, intra-muscular fat within the trunk muscles was associated with LBP intensity and functional performance [102]. Older adults with LBP also have smaller erector spinae (i.e., cross-sectional area) compared with those without LBP [101]. Lumbar flexion and extension range of motion are reduced in older adults with LBP compared with those without LBP [103]. Self-reported back stiffness is related to LBP-related disability in older adults [104]. Finally, older adults with LBP demonstrate gait deficits (i.e., slower self-selected gait speed and shorter stride length) [105] and impaired postural responses to perturbation [106] compared with those without LBP.

Table 5. Low back pain key points.

- LBP is the most common site of pain in PD and is more prevalent than in healthy older adults.
- LBP is related to motor and nonmotor symptoms of PD.
- In people with PD, LBP can negatively impact the ability to perform daily activities.
- Surgical treatment for LBP in people with PD is associated with higher risk of complication and revision surgery. More research is needed to assess the efficacy of pharmacologic and rehabilitative treatments of LBP in people with PD.

LBP: Low back pain; PD: Parkinson's disease.

In addition to biomechanical factors related to LBP in older adults, psychologic factors also likely contribute to LBP in this population. Rudy and colleagues reported older adults with chronic LBP have greater depression, as measured by the Geriatric Depression Scale, compared with those without LBP [107]. Weiner and colleagues noted reduced cognitive function in older adults with chronic LBP compared with those without LBP [108]. Further, cognitive function was associated with pain severity in those with LBP [108]. In older adults with LBP, greater fear-avoidance beliefs associated with physical activity were related to greater LBP-related disability [109].

Little is known about the efficacy of treatment for LBP in people with PD. This is perhaps because investigators studying pharmacologic treatments for pain rarely stratify participants by location or type of pain. As such, to our knowledge, there are no studies investigating pharmacologic pain treatments focused solely on people with PD with LBP. In older adults without PD, NSAIDs are frontline pharmacologic treatments for LBP [110]. Dopaminergic agents [111,112] and deep brain stimulation [113] may lead to reduced pain (not specific to LBP) in people with PD. Trenkwalder and colleagues noted that oxycodone-naloxone was effective in reducing severe MSK pain compared with placebo; however, it should be noted that this subgroup of participants was not the primary focus of this investigation [114].

Lumbar surgery is an option for treating intractable LBP in people with PD. While studies suggest surgical treatment may reduce pain [115] and LBP-related disability [115], people with PD are at higher risk for surgical complication [115–117] and revision surgery [115,116,118]. Very little is known about whether rehabilitation is effective in reducing LBP for people with PD. Myers and colleagues reported yoga led to reduced LBP-related disability (i.e., improvement) in people with PD [119]. In older adults with LBP without PD, trunk muscle training combined with neuromuscular electrical stimulation led to reduced LBP as well as improved physical function [120]. Table 5 contains summary points for LBP in PD.

Discussion

In this narrative review, we focused on MSK pain in people with PD and understanding how its presentation compares to that of older adults without PD. From this review, three themes emerge: pain is prevalent in multiple joints and at higher rates in individuals with PD and yet is understudied in this population, surgical treatment for MSK problems in PD is associated with poor outcomes and little is known about the efficacy of medication and rehabilitation in reducing MSK pain in PD.

Disease-specific factors may explain the increased prevalence of MSK pain among people with compared with age-matched older adults without PD. Altered pain processing is common in PD and is likely related to dopaminergic mechanisms [121,122]. Nonmotor manifestations (e.g., depression, anxiety) in PD may also factor into the pain experience [95]. Motor manifestations like rigidity and impaired posture are frequently implicated as potential pain generators in people with PD [8]. Both of these factors may impair movement kinematics leading to abnormal joint stress, which may be associated with MSK pain [123,124]. For example, people with PD often walk with flexed knees, which increases stress across the knee joint and could result in pain [125]. Additionally, rounded shoulders and increased thoracic kyphosis are associated with abnormal scapular kinematics, which may predispose one to painful shoulder conditions [126]. Finally, rigidity and hypokinesia may contribute to lack of joint movement in PD. Just as excessive, repetitive joint movement may damage a joint, reduced joint movement and loading may do the same [127]. For example, people with PD may not frequently move their shoulder through their available range of motion, which could lead to reduced ability to tolerate future stresses [127].

Pain relief is common after MSK surgery in PD; however, it is unclear why surgical complications and revisions tend to occur at higher rates after orthopedic surgery in people with PD compared with those for older adults without PD. Although joint arthroplasty changes the joint surface, PD motor manifestations remain and likely continue contributing to abnormal joint loading postsurgery. This may have a negative influence on the healing of the prosthesis and surrounding tissue. Lack of movement and physical activity, which is common in PD [128], may

also contribute to poorer healing after surgery and may be a risk factor for surgical complications. It is important to note that postsurgical complications in people with PD are not confined to orthopedic surgery [129]. It is possible that psychological stress associated with surgery could negatively impact PD manifestations and physical function [130]. Indeed, preliminary work suggests that people with PD may be susceptible to postoperative cognitive decline [131]. Additionally, in people who did not have PD, those undergoing orthopedic surgery were at a higher risk for chronic, postsurgical pain [132]. Further, the severity of chronic postsurgical pain was related to functional impairment [132]. These relationships warrant investigation in people with PD, particularly those undergoing orthopedic surgery. It is clear that people with PD should consult their neurologist prior to undergoing orthopedic surgery in an effort to determine the best possible course for pain relief while avoiding suboptimal and potentially dangerous outcomes.

The data surrounding surgery for MSK issues in PD suggest that more conservative treatments (e.g., medication, physical therapy) should be frontline treatments for MSK pain in people with PD. Optimization of PD-specific treatments is an important initial consideration for pain management in people with PD, particularly for those experiencing pain during off periods [133]. To this end, rotigotine improved fluctuation related pain; however, its effect on MSK pain was not different from that of placebo [112]. Deep brain stimulation of the subthalamic nucleus, though not done specifically for pain, was associated with a reduction in the presence of MSK pain [134]. Patients with PD reported that NSAIDs were most frequently used and most effective drugs in managing their pain As previously mentioned, opioid medication may relieve pain in people with PD [114]. Future investigations of the efficacy of opioids in PD should, if possible, isolate samples to people with PD with MSK pain and consider dosing in accordance with previously published findings. To our knowledge, investigators have not prospectively studied the efficacy of physical therapy for pain in people with PD. Buhmann and colleagues surveyed people with PD who reported frequently using physical therapy to manage pain [4]. Furthermore, these individuals noted physical therapy for was efficacious, but also reported its effects were relatively short lasting [4]. While certain forms of exercise (e.g., yoga [119]) are associated with reduced pain, the mechanism(s) by which this occurs is unclear. Investigators in rehabilitation should develop a theoretical framework to identify factor(s) that cause, mediate, and/or moderate MSK pain development and maintenance in PD, which will better inform intervention development.

Much work remains to better understand and identify effective treatments for MSK pain in people with PD. Given the multi-factorial nature (e.g., genetic, sensory, biomechanical, psychologic) of pain, large-scale studies are needed to identify unique factors contributing to specific MSK pain conditions in people with PD. There is a need to better understand pain behavior in people with PD. For example, how does MSK pain change over time (e.g., days, years) in people with PD? How does physical activity, or lack thereof, affect pain behavior in people with PD? Better understanding pain behavior may lead to more effective treatments. Finally, investigators studying pain and treatments for pain in PD should better categorize patients in an effort to minimize the chance that heterogeneity of pain types biasing study findings. To this end, the newly developed Parkinson's Disease Pain Classification Scheme [10] and its utility in aiding treatment of MSK pain in people with PD warrants continued exploration.

Conclusion

MSK pain is more common in people with PD compared with age-matched older adults. Neck, shoulder, knee, and LBP are common pain sites in PD. Despite the high prevalence of MSK pain in PD, relatively little is known about joint-specific pain conditions. Much work remains to better understand and effectively treat MSK pain in people with PD.

Future perspective

In the next decade, we will better understand the incredibly complex nature of MSK pain in people with PD. We will have identified prominent factors contributing to MSK pain in people with PD. Additionally, we will better understand how these contributing factors interact with one another to cause and maintain MSK pain in PD. It is our hope that in 10 years, we will have studies, which include samples with homogenous pain types, investigating the efficacy of conservative treatments for MSK pain in PD.

Author contributions

RP Duncan and LE Tueth made substantial contributions to the conception of this review, drafted and revised the manuscript, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Papers of special note have been highlighted as: • of interest; •• of considerable interest

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