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Effect of Workload on Musculoskeletal Degeneration

Youngki Kim, Jongeun Kim, Dongmug Kang, Soohong Park

Occupational and Environmental Medicine, Pusan National University, Yangsan Hospital, Gyeongsangnam-do, 626-870

Corresponding Author
Jongeun Kim
Occupational and Environmental Medicine, Pusan National University, Yangsan Hospital, Gyeongsangnam-do, 626-870
Mobile : +82-10-6858-9321
Email : kim-jongeun@hanmail.net

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Objective: The aim of this study is to investigate the effect of workload on musculoskeletal degeneration.

Background: It is important that workers maintain a health body for a long time as a measure of aging workers. In order do so, it is necessary to find out if workload can effect on musculoskeletal degeneration.

Method: Epidemiological studies on workload or occupation and disc degeneration, osteoarthritis of knee were identified through database and bibliography searches.

Results: Epidemiological studies showed that workload certainly effect on musculoskeletal degeneration. But we couldn't know which of individual factors and occupational factors further contribute to the musculoskeletal degeneration. And we could find that studies on workload and genetic factors were very few. In addition, there was also very few studies that it was possible interaction between individual factors as obesity and occupational factors as heavy manual lifting.

Conclusion: Our reviews suggest that it need to conduct study between workload and genetic factors for musculoskeletal degeneration. This further study can identify attributable risk of workload for musculoskeletal degeneration, and contribute to the measure of aging workers.

Application: This paper can help to establish research plan for the measure of aging workers.

Keywords: Work-related musculoskeletal disorder, disc degeneration, osteoarthritis, workload

1. Introduction

According to the 2012 Industrial Accident Statistics report by the Korea Occupational Safety & Health Agency, patients with musculoskeletal disorders (n = 5230) accounted for 77.6% of all patients with occupational diseases (n = 6742), with lumbago patients (n = 3792) accounting for 70% of the patients with musculoskeletal disorders (Korea Occupational Safety & Health Agency, 2012). As musculoskeletal disorders have become the most prevalent occupational diseases, the number of rejected compensation claims for musculoskeletal disorders is increasing proportionally to the number of approvals. And the biggest rejected reasons were degenerative musculoskeletal disorders (Korea Workers' Compensation & Welfare Service, 2010). However, there are dissenting views regarding the relationship between degenerative musculoskeletal disorders and occupational musculoskeletal disorders. The position that degenerative musculoskeletal disorders are not an occupational disease is based on the claim that degenerative musculoskeletal disorders are caused by the natural aging process, or that degenerative changes in the musculoskeletal system are caused by genetic factors (Hassett et al., 2003; Karasik et al., 2008; Sambrook et al., 1999; Weiler et al., 2012). If this position is correct, then the prevention of degenerative musculoskeletal disorders with artificial methods, such as ergonomic improvements, would be impossible. Unfortunately, South Korea is becoming a super-aged society at an unprecedented rate (Statistics Korea, 2006); therefore, there is a sense of urgency regarding preparations for the aging workforce. However, if the progression of musculoskeletal degeneration is only due to aging, an extreme conclusion could be drawn that measures designed to prepare for aged workers are meaningless. This raises the question of whether labor actually affects musculoskeletal degeneration. Unfortunately, as it is currently impossible to distinguish between individual factors (e.g., age) and occupational factors (e.g., workload), it is impossible to clearly discern whether (or how much) work affects the progression of musculoskeletal degeneration. Nevertheless, it is essential to ascertain whether work influences musculoskeletal degeneration, for future workers' compensation, developing preventative measures, and explaining the importance of ergonomic interventions.

In foreign countries, mainstream measures focus on maintaining a healthy workforce, and as a healthy workforce requires healthy bodies, minimizing workload to delay the progress of degeneration can be an excellent measure for aging. Therefore, the objective of the present study is to investigate whether workload has an influence on musculoskeletal degeneration, and, if so, to review the literature for relevant risk factors, and to present subjects for future studies. The review focused on disc degeneration and degenerative osteoarthritis, as disc degeneration is the main cause of disc herniation and degenerative osteoarthritis is a typical degenerative musculoskeletal disorder that is rarely approved in compensation.

2. Disc Degeneration

As previously mentioned, occupational musculoskeletal disorders are mainly comprised of lumbago-related diseases, among which herniation of disc is the most prevalent condition. Herniation of disc is a medical condition in which the Nucleus Pulposus (NP) (at the center of the disc) protrudes from the outer Annulus Fibrosus (AF). The causes can be accident-related, although even slight external pressure can induce a rupture when degenerative changes are present. Therefore, as degenerative changes in the disc are the main cause of herniation of disc, determining whether workload affects degenerative changes in the disc is critical to understanding the relationship between occupational factors and the causes of herniation of disc.

2.1 Etiology of disc degeneration

The etiology of disc degeneration is highly correlated with degenerative changes to the external AF that surrounds the NP. In younger patients, the distribution of blood vessels in the AF allows nutrients to be delivered to the NP and supports regeneration in the case of injury, although the blood vessels in the AF are destroyed in aged patients, which is believed to facilitate the degeneration (Grunhagen et al., 2006; Moore, 2006).

2.1.1 Age, sex and body weight

The correlation between age and disc degeneration has been well established. Miller et al. (1988) studied 600 disc specimens from 237 cadavers, and reported that disc degeneration was detected in 16% of patients who died in their 20s, while disc degeneration was detected in 98% of patients who died in their 70s. At the time, men of all ages exhibited greater disc degeneration compared to women, and similar results have been reported from studies using magnetic resonance imaging (MRI) and surgery (Goh S et al., 2000; Vucetic et al., 1999). In addition, other studies have reported a correlation between obesity and disc degeneration (Like et al., 2005; Rodacki et al., 2005, Hangai et al., 2008). In a recent large-scale twin study, Body mass index (BMI) was a statistically significantly contributor to disc degeneration and reduced disc height, after adjusting for age and gender

(Williams et al., 2010).

2.1.2 Nutritional factors

One of the primary factors involved in disc degeneration is the failed supply of nutrients to the disc cells (Nachemson et al., 1970). Although blood vessels in the AF are heavily distributed to the endplates, their permeability begins to decrease between the ages of 20 and 30 years old, and their decreasing number helps to drive the onset of tissue degeneration (Crock et al., 1991; Boos et al., 2002). In addition, as vascular depletion creates a decreased water supply to the NP, the NP becomes dehydrated, further contributing to the reduction of disc pressure and height (Buckwalter, 1995).

2.1.3 Mechanical load and injury

Many studies have also shown that continuous physical load contributes to disc degeneration, and that occupational factors can be included as a physical load factor. In previous studies, it has been suggested that injury or occupational factors cause structural damage to the disc, resulting in disc degeneration (Allan and Waddell, 1989), and these results have also been confirmed in animal models (Iatridis et al., 1999; Lipson and Muir, 1981). In particular, the fact that degeneration proceeds rapidly in the area adjacent to the fused spine strongly supports the hypothesis that physical factors affect disc degeneration (Eck et al., 1999; Park et al., 2004). In addition, the results of many epidemiological studies also support these conclusions, which will be discussed below.

2.1.4 Genetic factors

Recent studies suggest that genetic factors exert the greatest influence on disc degeneration (Mayer et al., 2013; Livshits et al., 2011). In particular, there have been various familial aggregation studies, including a study of 115 monozygotic male twins, which reported that disc degeneration in the upper lumbar spine was caused by physical load (7%) and genetic factors (77%), compared to only 2% and 43% in the lower lumbar spine, respectively (Bättie et al., 1995). In addition, Sambrook et al. (1999) studied 172 monozygotic and 154 dizygotic twins, and reported that 74% and 73% of disc degeneration in the lumbar and cervical spine, respectively, can be explained by genetic factors. Meanwhile, other studies have attempted to identify the genes that are responsible for disc degeneration, and a recent review has reported that the genes for Vitamin D receptor, aggrecan, type I, XI collagen, asporin, matrix metalloproteinase 1, 2, 3, IL-1, and IL-6 all play significant roles in disc degeneration (Mayer et al., 2013). However, given the comparison of disc degeneration according to occupation (the twins studies), there are limitations to comparing disc generation based on physical load. Therefore, as there are only a few genetic studies that have compared gene expression based on physical load, addition studies are needed to examine gene expression according to the occupational load.

2.2 Effect of workload on disc degeneration

Currently, the common physical load factors that are thought to cause lumbago include whole body vibration, heavy material handling and heavy lifting, and flexion and extension of the lumbar spine (Bernard et al., 1997). The studies regarding whole body vibrations have typically been conducted among professional drivers, who have an elevated risk of disc herniation, as well as swelling and degenerative disc disease (Jensen et al., 1996; Luoma et al., 1998). Moreover, an analysis of the gene expression induced by disc degeneration was conducted among 61 workers who were exposed to whole body vibration, and this analysis revealed greater gene expression among the workers compared to the control group (Virtanen et al., 2007). This can be viewed as a prime example of the gene-environmental interaction, wherein genetic factors are not only inherited factors, but are also capable of interacting with environmental factors.

While whole body vibration is a factor that is job-specific (e.g., driving), heavy material handling is a factor that is commonly encountered in various occupations. Therefore, determining the relationship between heavy material handling and disc degeneration is critical. In Sørensen's cohort study (3,833 participants), the results indicated that frequent exposure to physical workloads increased the risk of herniated lumbar disc disease by 3.9-fold (Sørensen et al., 2011). In the case-control study by Seidler et al. (2009) among lumbar disc herniation and lumbar disc narrowing patients, cumulative occupational lumbar loads exhibited a dose-response relationship with degenerative disc diseases in both men and women. In addition, posture-related factors, such as flexion and extension of lumbar spine, are also related to disc degeneration, with Seidler et al. (2003) reporting that forward bending was significantly correlated with lumbar disc herniation, osteochondrosis, and spondylosis in their cases (n = 267) and controls (n = 197). Another study has reported that repetitive flexion and extension of the lumbar spine increased the risk of lumbar disc herniation (Callaghan et al., 2001). Sambrook et al. (1999) and Bättie et al. (1995) have also reported that progression of disc degeneration tended to increase in the lower regions of the lumbar spine, which may indicate that physical factors affect disc degeneration independent of age or genetic factors. For example, if the degenerations were caused by age or genetic factors, the degenerations should occur equally throughout the spine. However, as degenerations occur earlier in the lower lumbar spine, compared to in the upper lumbar spine, physical factors may be involved. In addition, individual factors (e.g., age and obesity) may also be related to the physical factors, although increasing age may also indicate a greater exposure to the occupational factors. Moreover, obesity can facilitate degeneration through various chemical and physiological changes, and body weight itself can also act as a physical factor by exerting a load on the spine.

3. Knee Osteoarthritis

Osteoarthritis is a degenerative disease that infiltrates the cartilage and the surrounding structures. Osteoarthritis typically occurs in the knee, the hip, hand, and foot joints, and its incidence is rapidly increasing in Asian countries (Fransen et al., 2011). The knee joint is most frequently affected by degenerative osteoarthritis, although it is not typically recognized as industrial accident. Therefore, it is necessary to investigate whether osteoarthritis of the knee can be caused by work-related factors.

3.1 Etiology of knee osteoarthritis

There are various risk factors for osteoarthritis of the knee, which can be broadly classified as individual or physical factors.

3.1.1 Individual factors

Among the individual factors, age and gender are the major risk factors, and it is commonly understood that the incidence of degenerative osteoarthritis increases with age. However, osteoarthritis of the knee, hip, and hand joints tends to occur more frequently in women (compared to men), and a particularly rapid increase is observed near the onset of menopause (de Kierk et al., 2009). In addition, there is a strong evidence for genetic factors, as a traditional twins study has reported that genetic factors contribute to 39–65% of all osteoarthritis in the hand and the knee joints, 60% in the hip joint, and 70% in the spine (Spector et al., 2004). Kerkhof et al. (2010) have also reported that the C allele of rs3815148 on chromosome 7q22 increased the incidence of osteoarthritis in the knee by 1.14-fold and accelerated the progression of osteoarthritis by 30%. Nutritional factors are also important, as demonstrated by the association between insufficient Vitamin D intake and the increased risk of osteoporosis and osteoarthritis (Bergink et al., 2009; Konstari et al., 2012; Blagojevic et al., 2010). Obesity is another potent and well-established risk factor, as it ultimately leads to metabolic syndrome, and the related metabolic abnormality and systemic inflammation are considered to be one of the most probable mechanisms for osteoarthritis (Puenpatom et al., 2009).

3.1.2 Mechanical factors

The mechanical and physical factors for degenerative osteoarthritis of the knee are typically observed in occupational activities, and these include heavy material handling, kneeling, or squatting (Cooper et al., 2013). Similar to the effect of obesity, heavy material handling is thought to increase the physical loads on the lower limbs, thereby contributing to the incidence of osteoarthritis. In addition, the repetitive processes of kneeling or squatting are thought to fatigue the knee joint, by placing continuous pressure on the meniscus, thereby leading to degenerative rupturing and osteoarthritis.

3.1.3 Effect of workload on knee osteoarthritis

Historically, a number of epidemiological studies have indicated that load on the knees contributes to degenerative osteoarthritis (Waugh, 1950; Seedholm et al., 1979; Wickström et al., 1983; Waldron and Cox, 1989), and these positive results are still currently reported. In particular, kneeling, heavy lifting, and workload attributed to both kneeling and heavy listing are known to increase the risk of degenerative osteoarthritis of the knee (Sandmark et al., 2000; Manninen et al., 2002; Baker et al., 2003; Rytter et al., 2009; Dahaghin et al., 2009; Klussmann et al., 2010; Lau et al., 2000; Coggen et al, 2000; Holmberg et al, 2004; Rossignol, 2004; Jensen, 2008; Amin et al., 2008; Andersen et al., 2012; Ezzat et al., 2013). In addition, Rossignol (2003) has reported that blue-collar workers have higher risk of osteoarthritis of the knee compared to white-collar workers (Rossignol, 2003). Rossignol et al. (2004) have also reported that persons who engage in labor-intensive work complain of symptoms before they are 50 years old, indicated that osteoarthritis develops at a slightly earlier age in this population, compared to the general population. McMillan and Nichols (2005) have also concluded that there is sufficient evidence to indicate that the high rate of osteoarthritis and meniscal tears among miners is caused by their work-related kneeling, squatting, and crawling. More recently, McWilliams et al. (2011) conducted a meta-analysis regarding the occupational factors for osteoarthritis of the knee, in which they concluded that occupational activities increase the risk of osteoarthritis of the knee. Compared to the number of epidemiological studies regarding the effects of occupational factors on disc degeneration, more epidemiological studies have evaluated osteoarthritis of the knee and the occupational factors, and the latter studies have reported consistent results. However, the number of studies regarding genetic factors, compared to the number of studies regarding disc degeneration, is insufficient and studies regarding the associations between occupational and genetic factors are nearly non-existent.

4. Conclusions

Figure 1 is an illustration of the risk factors that contribute to musculoskeletal degeneration, which is thought to be a multifactorial condition.

These factors can be generally divided into individual and occupational factors. Most previous epidemiological studies have focused on the effect of occupational factors on musculoskeletal degeneration (e.g., on disc degeneration and degenerative osteoarthritis), and have concluded that occupational factors affect musculoskeletal degeneration. However, the degree that occupational factors contribute to musculoskeletal degeneration remains unknown (i.e., the magnitude of the effect of a1 and a2 [Figure 1] on degeneration). Given the large number of studies that have evaluated the effect of genetic factors, a1 may be the dominant path for degeneration, although the lack of data prevents a similar conclusion for degenerative osteoarthritis. However, as the exposure to workload was not systemic in the studies that claim genetic factors dominate disc degeneration, the reliability of their claims is subject to dispute. In addition, there is a tendency to consider genetic factors as individual factors, although this is not an appropriate assumption. While the genes that induce musculoskeletal degeneration are inherited, and their expression may increase with aging, the expression of genes involved in musculoskeletal degeneration may also be affected by the occupational and physical factors that accelerate degeneration (b2 in Figure 1). Therefore, if this pathway is confirmed, the magnitude of the individual and occupational factors effect on musculoskeletal degeneration would need to be reexamined. Meanwhile, obesity or nutrition (individual factors) can also influence the mechanical factors (path b1 in Figure 1), with obesity having the same effect as handling heavy materials, as stated previously. Therefore, future studies are needed to evaluated the magnitude of paths a1 and a2 effects, as well as studies that can evaluate paths b1 and b2. In particular, studies related to

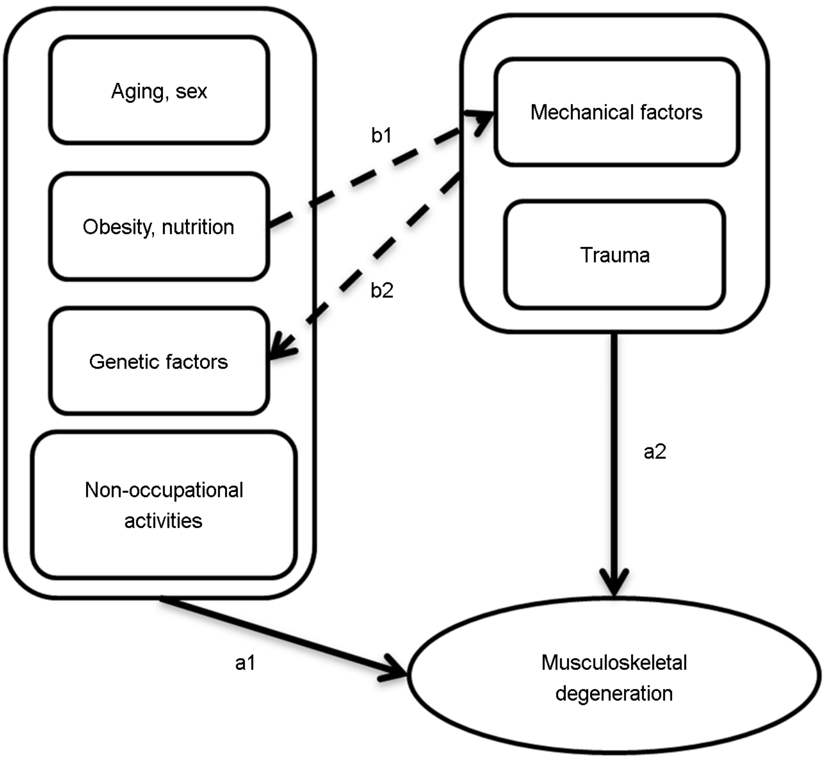

Figure 1. Risk factors for musculoskeletal degeneration

path b2 are expected to yield results that will be vital in determining the magnitude of the occupational factors effect on musculoskeletal degeneration. In addition, the results from these studies are expected to reveal that the effects of aging are not uncontrollable, and can be controlled (to some degree) by reducing the workload. Therefore, the horizons of ergonomics can be further expanded.

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Author listings

Youngki Kim: mungis@pusan.ac.kr
Highest degree: PhD, Medical Graduate School, Inje University
Position title: Assitant Professor, Department of Occupational and Environmental Medicine, Pusan National University, Yangsan Hospital
Areas of interest: Musculoskeletal disorders, Workers' Compensation, Return-to-Work

Jongeun Kim: kim-jongeun@hanmail.net
Highest degree: PhD, Medical Graduate School, Inje University
Position title: Assitant Professor, Department of Occupational and Environmental Medicine, Pusan National University, Yangsan Hospital
Areas of interest: Musculoskeletal disorders, Medical Treatment

Dongmug Kang: kangdm@pusan.ac.kr
Highest degree: PhD, Medical Graduate School, Kosin University
Position title: Professor, Department of Occupational and Environmental Medicine, Pusan National University, Yangsan Hospital
Areas of interest: Asbestosis, Risk Factor Research

Soohong Park: shounsy@naver.com
Highest degree: Master, Medical Graduate School, Pusan National University
Position title: 3rd Resident, Department of Occupational and Environmental Medicine, Pusan National University, Yangsan Hospital
Areas of interest: Musculoskeletal disorders, Job Stress