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Negative Impacts of Prolonged Standing at Work on Musculoskeletal Symptoms and Physical Fatigue: The Fifth Korean Working Conditions Survey

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Purpose: We aimed to investigate variations in the risk of low back pain (LBP), lower extremity muscle pain, and whole body fatigue according to differences in prolonged standing work hours in relation to risk factor exposure and rest frequency.
Materials and Methods: From the fifth Korean Working Conditions Survey data collected in 2017, data for 32970 full-time workers who worked for more than 1 year at their present job were analyzed. We classified the workers according to exposure to fatigue or painful postures, carrying heavy objects, performance of repetitive movements that burden the musculoskeletal system, and how often they took a break. Relationships between time spent in a standing posture at work and risks of LBP, lower extremity muscle pain, and whole body fatigue were analyzed by multivariate logistic regression.
Results: Of the full-time workers in the survey, 48.7% worked in a standing position for more than half of their total working hours. A higher odds ratio (OR) value for lower extremity muscle pain was observed in female not exposed to carrying heavy objects [OR: 3.551, 95% confidence interval (CI): 3.038–4.150] and not exposed to performing repetitive movements (OR: 3.555, 95% CI: 2.761–4.557).
Conclusion: Changes in work methodologies are needed to lower the number of hours spent in a prolonged standing posture at work, including being able to rest when workers want to do so, to reduce pain and fatigue.

Key Words: Fatigue, low back pain, lower extremity, standing position, workers

INTRODUCTION

As working environments improve, prevent work-related diseases has garnered increasing interest. Numerous occupations, however, demand spending a prolonged amount of time working in a standing posture, and prolonged standing at work can have detrimental effects, leading to various musculoskeletal disorders (MSDs):[1-3] prolonged standing at work leads to low back pain (LBP),[4] pain in the thoracic region,[5] lower limb discomfort,[6] vascular disorders,[2,3] and MSDs.[5] When the standing time is prolonged, ankle blood pressure and soleus blood flow increase; hence, prolonged standing correlates with lower limb discomfort.[7]

Prolonged standing is commonly required in jobs related to sales, food service, healthcare, education, and manufacturing. Per analysis of the European Survey of Working Conditions, 47% of workers performed work tasks in a standing position for more than 75% of their work time.[8] A high prevalence of LBP was reported for teaching jobs:[9] LBP was more frequent among university teachers with a higher body mass index and those with an uneven weight-bearing posture.[10] Prolonged standing

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was also associated with ankle/foot related disorders.[11] In the manufacturing sector, plantar fasciitis was reported to be relatively common in workers required to stand for long periods.[12] Additionally, increased tightness of the posterior muscles of the lower extremity was reported in such cases, leading to musculoskeletal pain (MSP) and MSDs.[13] Standing for long periods was also observed in workers at checkout counters, and this group showed the highest prevalence of lower limb and ankle/foot discomfort.[12] Awkward or unsafe standing postures reportedly contribute to work-related MSP.[14] Carrying heavy loads and performing repetitive motions reportedly increased the risk for MSP among farm workers.[15] Moreover, as a cumulative consequence of prolonged standing for performing various tasks, a variety of negative health outcomes, including MSDs, whole body fatigue, cardiovascular insufficiency, and pregnancy problems, has been reported in many workers.[16]

Proper breaks at work are necessary to prevent the risk of causing prolonged standing pain or discomfort. A seated break with mild lumbar flexion may alleviate LBP induced by prolonged standing.[17] Alternatively, standing intervention, such as the use of a standing aid, could potentially reduce LBP.[18] Standing on a floor mat and/or wearing shoe in-soles also reportedly provided comfort and alleviated or reduced fatigue from standing.[19] Based on these points of view, it is important to understand how long various workers are required to stand and work, and the length of time spent standing at which pain and fatigue arise. Additionally, whether carrying heavy objects or performing repetitive tasks on prolonged standing will aggravate MSDs, such as LBP and lower extremity muscle pain, should be confirmed. Based on this, it is necessary to establish countermeasures and provide interventions at an appropriate level by characterizing the conditions in the working environment, including whether or not workers are exposed to specific risk factors.

The purpose of this study was to investigate the risk of MSP and physical fatigue according to the proportion of time spent standing during work using representative data for Korean workers. The relationships between standing time and pain and fatigue were also examined in the context of risk factors that could influence pain and fatigue, including active rest.

MATERIALS AND METHODS

Study population

Data from the fifth Korean Working Conditions Survey (KWCS) conducted by the Korea Occupational Safety and Health Agency from July to November in 2017 formed the basis of this study. KWCS is conducted every 5 years using a complex sampling framework, and the survey participants are selected to represent the Korean working population. Economically active Korean employees and self-employed workers aged >15 years participated in the KWCS. Comprehensive data on job status, socioeconomic position, working time, health behaviors, and exposure to physical and psychological hazards were collected using face-to-face interviews.[20]

A total of 50205 workers participated in the fifth KWCS, and we excluded 9216 who were temporary workers, daily workers, or others. We only included self-employed or regular workers. We further excluded 4855 participants who worked less than 40 hours per week. To meet the temporal conditions for prolonged standing to cause pain and fatigue, an additional 1792 workers currently employed for less than 1 year in the workplace were excluded. We excluded them considering that the MSP and physical fatigue of workers who were temporary or worked for less than 1 year in their current workplace might not have been due to the task at the responding workplace. Finally, data from 32970 participants, excluding the data of 1372 incomplete respondents, were used for final analysis (Fig. 1).

General and occupational characteristics

Data on general characteristics, such as sex, age, educational level, and monthly income, for the study population were obtained from the KWCS. We divided the continuous values of age into five categories as follows: lesser than 30, 30–39, 40–49, 50–59, and more than 60 years old. Educational level was recategorized into three groups as follows: middle school graduate or below, high school graduate, and college graduate or above. Monthly income was divided into four categories as follows: less than 2000000, 2000000–2999000, 3000000–3999000, and more than 4000000 Korean won.

Occupational characteristics included type of occupation, business size, and weekly working hours. There were 11 occupational groups in the fifth KWCS, and we recategorized these into five groups as follows: managers or professionals, office workers, service workers, sales workers, and technicians or skilled workers. Business size was categorized into three levels

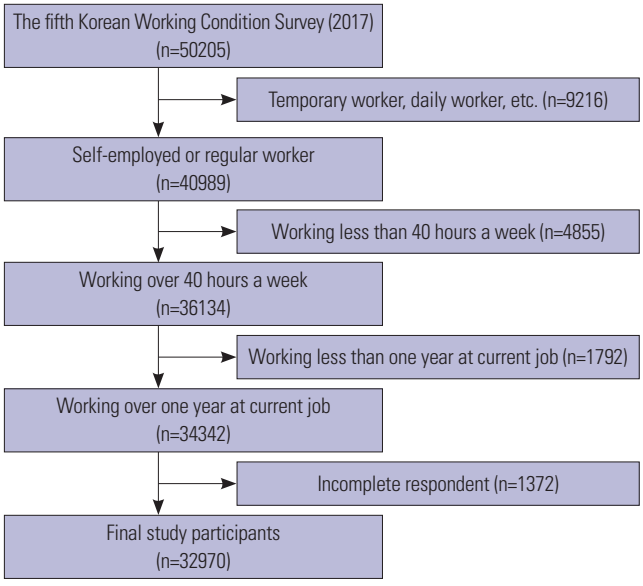

Fig. 1. Schematic diagram depicting study population.

based on the number of employees: small (1–9), medium (10–249), and large (more than 250). Weekly working hours were evaluated using the question, "How many hours do you usually work per week at your primary paying workplace?" To calculate the working hours, commuting time and lunch breaks were excluded. Because the current Labor Standards Act in Korea sets the working hours to 8 hours per day and 40 hours in a week, with a limit of a maximum of 52 hours in a week, we categorized working hours per week into three groups as follows: 40 hours; 41 hours or more, but 52 hours or less; and more than 52 hours.

Prolonged standing (proportion of time spent standing up compared to total hours worked)

Prolonged standing was evaluated as the proportion time spent standing up compared to the total hours worked. Prolonged standing was considered an independent variable and was investigated using the following question: "Does your work require a prolonged standing posture?." Participants answered this question by selecting one of the following options: "all working hours," "almost all working hours," "three quarters," "one half," "one quarter," "barely," and "never." We combined the "all working hours" and "almost all working hours" groups into the "almost all working hours" group, and we combined the "barely exposed" and "never exposed" groups into the "rarely stand and work" group.

Exposure to prolonged standing-related risk factors and frequency of active rest

Working in awkward postures, lift and carrying heavy objects, and repetitive movement may be risk factors of MSD.[21] Hence, participants were asked the following question: "Does your work include fatigue-inducing or painful postures, carrying heavy objects, or repetitive movement?." Participants answered this question by selecting one of the following options: "all working hours," "almost all working hours," "three quarters," "one half," "one quarter," "barely," and "never." We dichotomized the responses into "No" if participants checked "barely" or "never" and into "Yes" if the other answers were checked.

The application of work-rest cycles is effective for reducing workload-induced fatigue.[22] We evaluated the effect of the proportion of working hours spent performing work activities on pain and fatigue, depending on whether the workers were allowed to rest when they wanted. KWCS participants were asked the following question: "Please select the item that best describes your working environment in the following context: I can rest when I want." Participants answered the question by selecting one of the following options: "always," "most of the time," "sometimes," "rarely," or "never." We categorized "always" and "most of the time" into "always/often" and combined "rarely" and "never" into the category termed "rarely/never."

Musculoskeletal symptoms and physical fatigue

Musculoskeletal symptoms were considered dependent variables in this study, and they were investigated using the following question: "Have you had any of the following health problems in the past 12 months: LBP, lower extremity muscle pain, or whole body fatigue?." Health problems were evaluated based on two answer options, "Yes" and "No," We analyzed the data as per participants' responses.

Statistical analysis

To identify differences in the general and occupational characteristics according to the proportion of standing time during work, chi-square tests were performed. Moreover, univariate and multivariate logistic regression analyses were implemented to analyze relationships among proportions of standing time during work, MSP, and whole body fatigue according to exposure to risk factors, such as fatigue or painful posture, carrying heavy objects, and repetitive movements. Additionally, we also used univariate and multivariate analyses to identify relationships between proportion of standing time during work and LBP, lower extremity muscle pain, and whole body fatigue according to the level of active rest. Finally, the analysis was adjusted for related variables, including sociodemographic variables and work-related risk factor variables to investigate the relationship between MSP and fatigue according to the proportion of standing time during work. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated in the context of three models: Model 1 was adjusted for sex and age; Model 2 was adjusted for sex, age, education, monthly income, occupation, business size, and weekly working hours; and Model 3 was adjusted for fatigue or painful posture, carrying heavy objects, repetitive movement, and the option to rest when the worker wants, in addition to the covariates used in Model 2. All statistical analyses were performed using R statistical package version 3.6.1 (R Core Team, 2018) and Jamovi version 1.0.5.0 (Jamovi project, 2019). All statistical tests were two-sided, and statistical significance was set at $p<0.05$.

Ethics statement

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Wonju Severance Christian Hospital (CR320331), Wonju, Korea.

RESULTS

General and occupational characteristics of the participants

Table 1 presents the demographic information and occupational environmental characteristics of the participants. There were more male than female in the population, and the age range was 30–60 years. More than half of the participants were vocational college graduates, with a monthly income ranging

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between 2 million and 4 million won. Job types were evenly distributed, although technicians and skilled workers accounted for one-fourth of the population. There were 19713 (59.8%) people employed by small businesses operated by one to nine workers. Among the participants, 12395 (37.6%), 10385 (31.5%), and 10190 (30.9%) participants worked for 40, 41 to 52, and more than 52 hours per week, respectively. Regarding the proportion of time spent standing up to total hours worked, half of the study population worked in a standing posture for <25% of their total work hours. The prevalences of LBP, lower extremity muscle pain, and whole body fatigue were 3953 (12.0%), 5624 (17.1%), and 8008 (24.3%), respectively.

Table 1. General and Occupational Characteristics of the Study Participants

Characteristics	n (%)
Total	32970 (100.0)
Sex	
Male	17532 (53.2)
Female	15438 (46.8)
Age (yr)	
<30	2465 (7.5)
30–39	6619 (20.1)
40–49	8794 (26.7)
50–59	9302 (28.2)
≥60	5790 (17.6)
Education	
Middle school graduate or below	3895 (11.8)
High school graduate	12541 (38.1)
College graduate or above	16534 (50.1)
Monthly income (Korean won, KRW)	
<2000000	8629 (26.2)
2000000–2999000	10382 (31.5)
3000000–3999000	7724 (23.4)
≥4000000	6235 (18.9)
Occupation	
Manager or professional	5808 (17.6)
Office worker	5577 (16.9)
Service worker	6420 (19.5)
Sales worker	6682 (20.3)
Technician or skilled worker	8483 (25.7)
Business size (number of employees)	
Small (1–9)	19713 (59.8)
Medium (10–249)	9259 (28.1)
Large (≥250)	3998 (12.1)
Weekly working hours	
40	12395 (37.6)
41–52	10385 (31.5)
>52	10190 (30.9)
Proportion of time spent standing up compared to total hours worked (quartile)	
Rarely stand and work	10154 (30.8)
One quarter (1/4)	6897 (20.9)
One half (1/2)	5818 (17.6)
Three quarters (3/4)	4312 (13.1)
Almost all working hours	5789 (17.6)
Prevalence of musculoskeletal pain and fatigue	
Low back pain	3953 (12.0)
Lower extremity muscle pain	5624 (17.1)
Whole body fatigue	8008 (24.3)

Compared to male, female tended to work in a standing posture for more than 75% of their work hours (p<0.001). High school graduates had the highest tendency to work in a prolonged standing posture throughout the work hours (51.1%), but those with an education level higher than college graduation tended to perform prolonged standing work for less than a quarter of their working hours (63.7%, p<0.001). Managers and professionals and office workers spent most of their working time without prolonged standing (19.9%, and 38.0%, respectively), while service workers spent most of their working time in a standing posture (35.9%, p<0.001). Those who worked for 40 hours per week tended to stand rarely while working (52.2%); the group that worked for more than 52 hours per week comprised the largest proportion of workers who performed prolonged standing work for most of their working hours (39.6%, p<0.001) (Supplementary Table 1, only online).

Effect of risk exposure and prolonged standing work on MSP/whole body fatigue

Table 2 shows the results of the analysis of the relationships between the risk of MSP/whole body fatigue and prolonged standing according to exposure of risk factors that impact the musculoskeletal system. Calculating ORs by dividing the participants into males and females, we found that the overall risk of MSP/whole body fatigue for females was higher than that for males. When working in fatigue- or pain-inducing postures, the risk of low extremity muscle pain increased as the proportion of prolonged standing time increased in both male and female participants. This trend also remained statistically significant for the "almost all working hours" group with reference to prolonged standing time. The OR of low extremity muscle pain was higher in the group not exposed to fatigue or painful posture, and the ORs thereof in male and female were 2.180 (95% CI: 1.680–2.829) and 2.795 (95% CI: 2.244–3.482), respectively.

For work involving the carrying of heavy objects, the risk of lower extremity muscle pain increased as the proportion of prolonged standing work time increased, regardless of exposure to risk factors. However, in the "almost all working hours" group with reference to prolonged standing time, the risk of LBP was higher among workers required to carry heavy objects (OR: 1.434, 95% CI: 1.151–1.788) and repetitive movements (OR: 1.680, 95% CI: 1.431–1.971) than among those who were not in male. For whole body fatigue, the group not involved in carrying heavy objects showed a higher risk than

Table 2. ORs and 95% CIs for Musculoskeletal Pain and Fatigue with Reference to the Proportion of Prolonged Standing Time at Work according to Exposure of Risk Factors

	Proportion of time spent standing up to total hours worked (quartile)	Male			Female		
		Low back pain	Lower extremity muscle pain	Whole body fatigue	Low back pain	Lower extremity muscle pain	Whole body fatigue
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Fatigue or painful posture							
Unexposed	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	1.145 (0.891–1.472)	1.019 (0.808–1.286)	1.119 (0.955–1.311)	0.957 (0.723–1.267)	1.321 (1.040–1.676)*	1.200 (1.000–1.440)
	One half (1/2)	0.956 (0.692–1.323)	1.622 (1.268–2.073)*	1.218 (1.009–1.470)*	1.408 (1.072–1.850)*	2.385 (1.907–2.983)*	1.643 (1.365–1.977)*
	Three quarters (3/4)	0.987 (0.667–1.458)	1.707 (1.278–2.280)*	1.281 (1.023–1.604)*	1.291 (0.952–1.751)	2.533 (1.999–3.210)*	1.247 (1.006–1.546)*
	Almost all working hours	0.965 (0.660–0.412)	2.180 (1.680–2.829)*	1.224 (0.982–1.526)	1.405 (1.064–1.855)*	2.795 (2.244–3.482)*	1.352 (1.110–1.646)*
Exposed	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	0.857 (0.721–1.018)	1.057 (0.902–1.238)	0.965 (0.840–1.108)	1.326 (1.085–1.619)*	1.334 (1.115–1.596)*	1.246 (1.058–1.468)*
	One half (1/2)	0.918 (0.773–1.090)	1.175 (1.004–1.375)*	1.049 (0.913–1.205)	1.330 (1.095–1.616)*	1.491 (1.255–1.773)*	1.456 (1.243–1.704)*
	Three quarters (3/4)	0.906 (0.749–1.096)	1.294 (1.091–1.534)*	1.174 (1.009–1.366)*	1.423 (1.166–1.737)*	1.539 (1.288–1.838)*	1.426 (1.212–1.679)*
	Almost all working hours	1.098 (0.929–1.299)	1.363 (1.167–1.591)*	1.262 (1.100–1.448)*	1.677 (1.397–2.012)*	1.956 (1.662–2.302)*	1.521 (1.309–1.768)*
Carrying heavy objects							
Unexposed	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	0.901 (0.738–1.100)	0.879 (0.726–1.063)	0.946 (0.822–1.088)	1.119 (0.910–1.375)	1.419 (1.188–1.696)*	1.269 (1.098–1.466)*
	One half (1/2)	0.876 (0.686–1.119)	1.249 (1.016–1.535)*	1.068 (0.906–1.258)	1.556 (1.273–1.903)*	2.301 (1.941–2.727)*	1.844 (1.598–2.128)*
	Three quarters (3/4)	0.791 (0.579–1.080)	1.431 (1.126–1.818)*	1.318 (1.091–1.593)*	1.513 (1.218–1.879)*	2.505 (2.097–2.992)*	1.730 (1.482–2.019)*
	Almost all working hours	1.270 (0.999–1.614)	1.785 (1.453–2.193)*	1.339 (1.127–1.590)*	2.126 (1.770–2.554)*	3.551 (3.038–4.150)*	2.046 (1.783–2.349)*
Exposed	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	1.082 (0.864–1.353)	1.151 (0.945–1.401)	1.081 (0.912–1.281)	1.262 (0.957–1.666)	1.141 (0.891–1.461)	1.211 (0.960–1.527)
	One half (1/2)	1.211 (0.970–1.512)	1.355 (1.115–1.646)*	1.201 (1.014–1.423)*	1.212 (0.924–1.591)	1.234 (0.970–1.568)	1.325 (1.058–1.660)*
	Three quarters (3/4)	1.242 (0.980–1.575)	1.453 (1.182–1.786)*	1.261 (1.052–1.511)*	1.344 (1.021–1.770)*	1.253 (0.981–1.601)	1.220 (0.968–1.538)
	Almost all working hours	1.434 (1.151–1.788)*	1.598 (1.316–1.941)*	1.438 (1.214–1.704)*	1.440 (1.109–1.871)*	1.407 (1.115–1.774)*	1.284 (1.031–1.599)*
Repetitive movements							
Unexposed	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	1.237 (0.940–1.628)	1.436 (1.102–1.871)*	1.357 (1.125–1.637)*	1.215 (0.880–1.676)	1.452 (1.091–1.932)*	1.791 (1.429–2.246)*
	One half (1/2)	1.029 (0.727–1.456)	2.022 (1.521–2.687)*	1.350 (1.080–1.688)*	1.728 (1.271–2.349)*	2.347 (1.796–3.068)*	1.961 (1.554–2.476)*
	Three quarters (3/4)	1.070 (0.691–1.657)	2.370 (1.690–3.322)*	1.631 (1.245–2.137)*	1.349 (0.927–1.963)	2.502 (1.861–3.364)*	1.698 (1.293–2.230)*
	Almost all working hours	1.396 (0.960–2.030)	2.605 (1.907–3.559)*	1.594 (1.234–2.059)*	2.088 (1.549–2.816)*	3.555 (2.761–4.577)*	2.019 (1.594–2.557)*
Exposed	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	1.117 (0.950–1.313)	1.196 (1.035–1.381)*	1.140 (1.011–1.286)*	1.525 (1.274–1.826)*	1.662 (1.417–1.949)*	1.311 (1.143–1.504)*
	One half (1/2)	1.368 (1.162–1.610)*	1.601 (1.387–1.848)*	1.441 (1.275–1.629)*	1.789 (1.500–2.135)*	2.246 (1.925–2.621)*	1.851 (1.621–2.115)*
	Three quarters (3/4)	1.356 (1.131–1.625)*	1.732 (1.481–2.025)*	1.566 (1.368–1.792)*	1.944 (1.624–2.326)*	2.316 (1.977–2.712)*	1.707 (1.487–1.960)*
	Almost all working hours	1.680 (1.431–1.971)*	1.986 (1.724–2.288)*	1.761 (1.559–1.990)*	2.283 (1.936–2.692)*	2.882 (2.492–3.333)*	1.906 (1.679–2.164)*

OR, odds ratio; CI, confidence interval.
*$p<0.05$.

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Table 3. ORs and 95% CIs of Musculoskeletal Pain and Fatigue with Reference to the Proportion of Prolonged Standing Time at Work according to How Often Workers Could Rest When They Wanted

Rest when worker wants	Proportion of time spent standing up to total hours worked (quartile)	Male			Female		
		Low back pain	Lower extremity muscle pain	Whole body fatigue	Low back pain	Lower extremity muscle pain	Whole body fatigue
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Always/often	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	1.467 (1.201–1.793)*	1.599 (1.333–1.917)*	1.521 (1.303–1.775)*	1.948 (1.549–2.450)*	1.845 (1.514–2.250)*	1.707 (1.421–2.052)*
	One half (1/2)	1.541 (1.244–1.911)*	2.148 (1.782–2.588)*	1.619 (1.371–1.910)*	1.859 (1.467–2.356)*	2.126 (1.742–2.596)*	1.945 (1.615–2.342)*
	Three quarters (3/4)	1.769 (1.393–2.247)*	2.144 (1.734–2.651)*	1.842 (1.528–2.220)*	1.640 (1.263–2.130)*	1.954 (1.573–2.427)*	1.636 (1.332–2.009)*
	Almost all working hours	1.700 (1.356–2.131)*	2.426 (1.996–2.949)*	1.948 (1.638–2.317)*	1.972 (1.549–2.511)*	2.179 (1.775–2.673)*	2.020 (1.669–2.445)*
Sometimes	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	1.226 (0.959–1.567)	1.268 (1.016–1.581)*	1.124 (0.952–1.328)	1.599 (1.226–2.085)*	1.916 (1.510–2.430)*	1.639 (1.353–1.986)*
	One half (1/2)	1.687 (1.323–2.152)*	1.939 (1.562–2.406)*	1.688 (1.428–1.996)*	2.158 (1.672–2.784)*	2.972 (2.370–3.726)*	2.577 (2.142–3.101)*
	Three quarters (3/4)	1.504 (1.131–2.000)*	2.449 (1.939–3.093)*	1.739 (1.436–2.105)*	2.450 (1.893–3.171)*	2.987 (2.366–3.771)*	2.228 (1.834–2.707)*
	Almost all working hours	2.349 (1.839–2.999)*	2.782 (2.238–3.458)*	1.932 (1.617–2.308)*	2.809 (2.209–3.572)*	3.897 (3.140–4.836)*	2.221 (1.849–2.669)*
Rarely/never	Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
	One quarter (1/4)	0.829 (0.605–1.137)	1.117 (0.840–1.484)	1.155 (0.926–1.440)	0.852 (0.589–1.234)	1.243 (0.898–1.721)	1.307 (1.023–1.670)*
	One half (1/2)	1.055 (0.766–1.453)	1.503 (1.128–2.001)*	1.323 (1.048–1.670)*	1.795 (1.326–2.431)*	2.618 (1.983–3.457)*	1.847 (1.468–2.323)*
	Three quarters (3/4)	1.050 (0.736–1.498)	1.730 (1.274–2.348)*	1.676 (1.306–2.151)*	2.179 (1.616–2.938)*	3.709 (2.826–4.868)*	2.176 (1.727–2.741)*
	Almost all working hours	1.549 (1.179–2.037)*	2.089 (1.622–2.691)*	1.874 (1.522–2.308)*	2.631 (2.041–3.392)*	4.648 (3.666–5.894)*	2.274 (1.869–2.768)*

OR, odds ratio; CI, confidence interval.
*$p<0.05$.

did the group that carried heavy objects at work in female. In the "almost all working hours" group based on prolonged standing time, the risk of LBP was relatively high upon exposure to the risk factor of repetitive movement in both male (OR: 1.680, 95% CI: 1.431–1.971) and female (OR: 2.283, 95% CI: 1.936–2.692) participants, compared to the unexposed group.

The risk of lower extremity muscle pain and whole body fatigue tended to increase as the proportion of prolonged standing work time increased. In the "almost all working hours" group with reference to prolonged standing time, the risk of lower extremity muscle pain was relatively higher in the group not exposed to the risk factor of performing repetitive movements (aOR: 3.217, 95% CI: 2.638–3.924) than in the group exposed to this risk factor (aOR: 2.183, 95% CI: 1.968–2.421) after adjusting for sex and age (Supplementary Table 2, only online).

Availability of rest when the worker wants

Table 3 shows the results of the analysis of the relationship between prolonged standing time and MSP/whole body fatigue according to categories based on the frequency of "rest when the worker wants." For lower extremity muscle pain, the OR increased significantly in female as the level of the frequency at which workers could take a break when they wanted decreased. The risk of the lower extremity muscle pain in the "sometimes" (OR: 3.897, 95% CI: 3.140–4.836) and "rarely/never" groups (OR: 4.648, 95% CI: 3.666–5.894) with prolonged standing for almost all working hours was relatively higher than that in the "always/often" group (OR: 2.179, 95% CI: 1.775–2.673).

Less than half of the workers in the study population (41.7%) were able to relax when they wanted. In the group with prolonged standing for almost all working hours, the risk of lower extremity muscle pain increased with a decrease in the frequency of "rest when the worker wants" (always/often, aOR: 2.220, 95% CI: 1.918-2.569; sometimes, aOR: 2.815, 95% CI: 2.408–3.291; rarely/never, aOR: 3.074, 95% CI: 2.584–3.657). Conversely, as the proportion of prolonged standing time increased, the risk of whole body fatigue also increased, regardless of the frequency of "rest when the worker wants" (Supplementary Table 3, only online).

OR for MSP and whole body fatigue in multivariate analysis

Table 4 shows the results of multivariate logistic regression analysis performed by adjusting for variables related to LBP, lower extremity muscle pain, and whole body fatigue, with increases in prolonged standing work hours. As the proportion of prolonged standing work hours increased, the risk of MSP increased significantly in both male and female. Even after adjustment for related variables, the trend of an increase in the risk remained significant for the overall study cohort. The highest risk was observed for lower extremity muscle fatigue in the adjusted model for female (proportion of working hours spent standing: one quarter, aOR: 1.238, 95% CI: 1.068–1.436; one

Table 4. ORs and 95% CIs of Musculoskeletal Pain and Fatigue with Reference to the Proportion of Prolonged Standing Time at Work Adjusting for Related Factors

Proportion of time spent standing up to total hours worked (quartile)	Male			Female		
	Low back pain	Lower extremity muscle pain	Whole body fatigue	Low back pain	Lower extremity muscle pain	Whole body fatigue
Crude Model	**Crude OR (95% CI)**	**Crude OR (95% CI)**	**Crude OR (95% CI)**	**Crude OR (95% CI)**	**Crude OR (95% CI)**	**Crude OR (95% CI)**
Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
One quarter (1/4)	1.233 (1.073–1.415)*	1.380 (1.217–1.564)*	1.276 (1.154–1.410)*	1.574 (1.349-1.836)*	1.776 (1.550–2.036)*	1.561 (1.390–1.753)*
One half (1/2)	1.463 (1.268–1.688)*	1.925 (1.697–2.184)*	1.571 (1.415–1.744)*	1.936 (1.666–2.250)*	2.510 (2.201–2.863)*	2.109 (1.883–2.362)*
Three quarters (3/4)	1.495 (1.271–1.758)*	2.148 (1.868–2.469)*	1.768 (1.572–1.988)*	2.050 (1.754–2.396)*	2.660 (2.321–3.048)*	1.979 (1.755–2.231)*
Almost all working hours	1.887 (1.638–2.174)*	2.476 (2.183–2.808)*	1.970 (1.772–2.191)*	2.498 (2.171–2.875)*	3.383 (2.989–3.828)*	2.231 (2.000–2.488)*
Adjusted Model†	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Rarely stand and work	1.0	1.0	1.0	1.0	1.0	1.0
One quarter (1/4)	0.970 (0.838–1.122)	1.049 (0.917–1.199)	1.097 (0.987–1.218)	1.130 (0.958–1.333)	1.238 (1.068–1.436)*	1.288 (1.139–1.456)*
One half (1/2)	1.043 (0.895–1.215)	1.332 (1.162–1.528)*	1.231 (1.101–1.377)*	1.368 (1.160–1.614)*	1.691 (1.462–1.955)*	1.662 (1.468–1.881)*
Three quarters (3/4)	1.080 (0.909–1.284)	1.528 (1.314–1.777)*	1.407 (1.241–1.595)*	1.497 (1.260–1.779)*	1.821 (1.564–2.119)*	1.557 (1.364–1.776)*
Almost all working hours	1.332 (1.143–1.552)*	1.723 (1.501–1.978)*	1.514 (1.349–1.700)*	1.812 (1.545–2.127)*	2.253 (1.956–2.595)*	1.700 (1.503–1.924)*

OR, odds ratio; CI, confidence interval.
*$p<0.05$, †Adjusted for age, education, monthly income, occupation, business size, and weekly working hours.

half, aOR: 1.691, 95% CI: 1.462–1.955; three quarters, aOR: 1.821, 95% CI: 1.564–2.119; almost all working hours, aOR: 2.253, 95% CI: 1.956–2.595).

DISCUSSION

This study aimed to investigate the effect of prolonged standing time during work on LBP, lower extremity muscle pain, and whole body fatigue among Korean workers. We found that as the proportion of prolonged standing hours increased, the presence of lower extremity muscle pain increased, and this was statistically significant even after adjusting for related variables. In addition, there were demographic and working environment differences in the proportion of prolonged standing hours during work, and a relatively elevated ORs for lower extremity muscle pain was found for stationary prolonged standing without exposure to additional musculoskeletal disease risk factors. We also found that taking a break whenever the workers wanted could reduce pain and fatigue.

All workers want to earn while being comfortable and safe. However, they typically choose jobs according to their socio-economic level and their own work history, dealing with various situations, including occupational disease occurrence, pain, and fatigue, as a result of their work. Socio-economic factors, such as education level and income, have been reported to be associated with disabling pain.[23] In this study, the proportion of prolonged standing time during the working hours was high in participants with low education and low monthly income, and such participants experienced poor working conditions for business size and extended weekly working hours. The difference in prolonged standing time according to occupation was low in participants at a high socio-economic level.

A fixed or constrained standing posture could be a risk factor for MSP, such as LBP.[24] To maintain a standing position, continuous muscle contraction needs to be maintained in the lower extremities, hips, and spine. This condition causes stress to the ligaments and spine, and the intervertebral disc impinges on the nerves, causing pain.[25] In addition, lifting and transporting heavy objects, bowing the upper body, working in an unstable position, and repetitive movements are considered risk factors for MSP.[21] In this study, the ORs for LBP and whole body fatigue were higher when the overall proportion of prolonged standing time increased. LBP also increased with prolonged standing when the workers were required to carry heavy objects as part of their work activities. Additionally, the ORs of LBP increased with the proportion of prolonged standing time when the work required repetitive movements. These results indicate that exposure to risk factors that exacerbate the burden on the musculoskeletal system increase the presence of LBP associated with prolonged standing, which is consistent with the results of previous studies.[21,24,25] However, for lower extremity muscle pain, the OR was higher in the group not exposed to risk fac-

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tors that exacerbate the burden on the musculoskeletal system. We speculate that this observation may be explained by fatigue caused by continuous co-contraction of agonist and antagonist muscles of the lower limbs to maintain an upright posture.[26] In this study, the high risk of lower extremity muscle pain in the non-exposed group regarding the exposure of musculoskeletal risk factors is presumed to be due to the result of temporary relaxation of the muscles that maintained co-contraction by stopping persistence in the prolonged standing posture. This observation may also be related to the relatively low risk of whole body fatigue observed when the proportion of prolonged standing time was high in workers carrying heavy objects or in those performing repetitive movements. This suggests that sustained muscle contractions to maintain a prolonged standing posture may increase whole body fatigue. Additionally, our results show that efforts to lower continuous prolonged standing time, including taking rest or performing other movements, such as stretching, may alleviate overall body fatigue. Additional experiments are needed to determine the relationship between maintaining a prolonged standing posture and performing other movements intermittently to relieve an upright body posture.

Taking intermittent breaks while working may relieve fatigue, help with pain recovery, and increase work efficiency. Taking regular breaks also helps the body recover from discomfort.[27] In this study, we observed that an increase in the frequency of a worker's self-imposed rest was associated with a decrease in the presence of pain and fatigue. However, because of the nature of a particular job, it may be difficult to obtain sufficient rest during work. In this study, less than half of all participants were able to rest when they wanted, and those who rested as per their needs had a lower presence of pain and fatigue, even though the proportion of prolonged standing time on the job was high. Our results confirmed that the provision of rest could alleviate lower extremity muscle pain in female, even if the proportion of prolonged standing time was high. Further research is needed to determine the appropriate level of rest according to the type of work.

In multivariate logistic regression analysis adjusted for various factors, prolonged standing showed a significant relationship with lower extremity muscle pain. In this study, the prevalence of prolonged standing exposure was relatively high, and the OR based on logistic regression might be overestimated, requiring careful interpretation. A work environment requiring prolonged standing was associated with fatigue of the lower extremity muscles, such as those of the anterior leg (tibialis anterior) and posterior leg (gastrocnemius).[28,29] Lower extremity muscle pain is inevitable if the prolonged standing time extends throughout the working hours. To prevent this, it is necessary to employ measures to lower the burden of muscle contraction, such as the use of standing aids.[18]

This study is meaningful because it analyzed the practical aspects of the working environment and data from a large group of workers surveyed at a national level were used for analysis, making it representative of Korean workers. Workers in Korea are well known for working long hours, and musculoskeletal disorders account for 65.8% of all occupational diseases,[30] which is higher than 41% in the UK.[31] For this reason, it is necessary to adjust the work environment to lower the level of systemic fatigue and lower the risk of musculoskeletal diseases. The overall working environment was examined, and the presence of MSDs related to prolonged standing was evaluated and confirmed in the context of exposure to relevant risk factors. Nevertheless, there were some limitations. First, because the participants provided subjective answers, prolonged standing time not related to work activities could have also been reported. Thus, we could not accurately ascertain the effects of prolonged standing time related to work activities alone. Second, the provision of safety interventions for work involving prolonged standing, such as floor mats, was not investigated. Hence, the presence of pain and fatigue may have differed depending on the presence or absence of such interventions. Also, since variables for underlying health conditions were not included, the association between pain and physical fatigue according to job type might not be strong. Third, because the data reflected the subjective responses of the participants to muscle fatigue or pain, we were unable to objectively assess muscle fatigue.[28] Fourth, we were unable to identify causality, which is an inherent limitation of cross-sectional studies. The MSP that the study participants responded may be a temporary symptom independent of the type of work. Longitudinal studies of panels or cohorts and experimental studies are needed to evaluate this aspect. Fifth, the results of this study were presented as unweighted results even though the KWCS was designed to represent the general population of workers in Korea. However, previous studies that used the KWCS to derive meaningful results have drawn sufficient implications without weighting,[32-34] and since we found meaningful results even within a small pool of study participants, they have greater implications.

This study was conducted to investigate the association of MSDs and physical fatigue in relation to the proportion of time spent in a prolonged standing posture while working using representative survey data from Korean workers. Our results showed that the addition of musculoskeletal burden to prolonged standing increased LBP and whole body fatigue. Additionally, our results showed that continuous prolonged standing increased the presence of lower extremity muscle pain and that proper active rest could reduce the presence of the LBP, lower extremity muscle pain, and whole body fatigue. It is therefore necessary to further improve the working environment, including the provision of sufficient rest, to prevent MSP and fatigue.

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AUTHOR CONTRIBUTIONS

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