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Injury Prevention in an Industrial Environment via Strategic Job Placement

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Abstract

Objectives. This study investigated the effects of an injury prevention program, specific to work related musculoskeletal disorders (WMSDs), which placed employees into jobs based on their physical abilities compared to the physical demands of their prospective jobs.

Methods. Employee injury data (N=3550) from a large auto manufacturer in the U.S. was analyzed to examine changes in injury rates for employees that were hired pre versus post-strategic placement. Bivariate and multivariate analyses were used to determine dependence between placement, injury within 120 days of hire and gender.

Results. Chi-square tests of independence revealed that injury rates and job placement may be dependent. Injury rates within 120 days of hire decreased by nearly half ($P<0.001$) during the post-placement phase. With this decline, injury reduction was most notable if employees were matched to at least 81-100% of job rotations ($P<0.01$). Injury rates were also discovered to be dependent on gender, as females had higher injury rates than males during the pre and post-placement phases ($P<0.001$).

Conclusions. Job placement based on physical abilities may significantly reduce the risk for work related musculoskeletal injuries in jobs with physically exhaustive duties, such as auto manufacturing. Manufacturing companies should consider refocusing energies on the environmental changes as a means to decrease WMSDs and the high costs associated with these types of injuries.

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INTRODUCTION

Injury prevention in the workplace is a significant public health problem in the United States (U.S.) with more than 3 million employees injured annually.[1] Workplace injuries are burdensome, costing the employee dependable income and leading to decreased quality of life. Although some workplace injuries are preventable, 33% of these injuries are caused by overburden and repetitive motion[2], known as work-related musculoskeletal disorders (WMSDs). WMSDs contribute to high healthcare and employer costs, absenteeism, lost productivity, and an unnecessary decline in quality of life for employees.[3] In fact, WMSDs attribute to approximately $45 billion in direct and indirect costs to the healthcare system and employers.[3] WMSDs include sprains, strains, tears, and injuries caused by excessive and repetitive use of body parts. Common WMSDs include back strain, shoulder impingement, and carpal tunnel; they do not include any injury caused by slips, trips, and falls. WMSDs account for an estimated 130 million total health care encounters per year and the Centers for Disease Control and Prevention (CDC) reports that half of all WMSDs result from service and manufacturing jobs.[3]

In 2013, the manufacturing sector employed over 12 million Americans, representing 9% of total U.S. employment.[4] In recent years, there has been a large shift in automotive manufacturing companies building in the South.[5] Hill et al. suggests this shift can be attributed to a number of factors including the lack of similar manufacturing plants in the area, higher numbers of available workers, and general population growth in southern states.[5] Due to the population growth, there has also been an increase in motor vehicle sales in the South, therefore, companies have taken advantage of decreased freight costs to transport parts and cars to their strongest markets.[5]

Although this job growth is beneficial to these communities, public health professionals need to maintain awareness of the South's poor health status, including high rates of overweight and obesity,[6] and thus, consider research that suggests workers with increased body mass index (BMI) are at an increased risk for workplace injury.[7-9] Though there have been few investigations completed, studies have shown that traditional workplace wellness initiatives may be unsuccessful in decreasing WMSD severity.[10] Similarly, there are numerous studies that conclude that workplace health programs struggle to decrease weight or BMI.[11,12] Because investigations have shown that excess fat and a high BMI contributes to increased injury risk, research supports the suggestion that attempting to change worker's health behaviors may not be enough to decrease risk of injury. As the automotive manufacturing industry expands in the South where obesity rates are highest, injury reduction interventions in these areas may need to focus on matching worker's abilities to job demands, rather than concentrating solely on individual health behavior approaches.[7]

In addition to differences in health measures (e.g., BMI), there have also been reports of gender differences in WMSDs. The Bureau of Labor Statistics has consistently reported women as having fewer incidences of injury compared to men in the manufacturing of durable goods industry.[2] It was assumed that women were inherently safer workers until Smith et al. discovered that reclassifying occupations based on physical demands showed that women working manual jobs actually had a higher risk for chronic WMSDs.[13] Based on these findings, one study investigated injury risk by gender in manufacturing facilities over a 10-year period and found significantly higher injury risk for women.[9] One possible explanation given by the researchers was that there are physiological differences between men and women during repetitive tasks. Studies have shown that women exhibit higher muscular activity while doing identical tasks as men.[14] Tessier-Sherman et al. suggest that even though biological and social roles for men and women overlap, many manufacturing jobs were traditionally designed to fit male traits and may require greater effort for female workers.[9]

In recent years, manufacturing companies have taken notice of increased WMSD risks and many have begun implementing countermeasures and trainings to minimize damage. New technology and equipment advances using hydraulic lifts, zero-gravity tools, automation, and robotics have led to a decreased burden on workers. Manufacturing companies also focus heavily on participatory ergonomic (PE) interventions. The intent of PE interventions is to identify solutions in the workplace to minimize injury risk and maximize productivity.[15] Ergonomic designs engineered to fit the job to the worker have been successful; however, there is no one job design that can be sufficient for all people and abilities.[16] When considering many process engineers may rarely rely on ergonomic design *guidelines* when designing workstations, it is easy to understand that many jobs are designed outside of basic guidelines in order to achieve the company's main goal: to build a product in the most efficient manner. This leads to many jobs being extremely physically demanding in order to meet company build requirements. Laing et al. also suggests that frequent changes to staffing and workstations can render many PE modifications useless because the process may change before the worker experiences any effect.[15]

Major workplace safety organizations, such as the National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA), have also placed emphasis on accommodating the worker through engineering. However, these PE programs have shown repeatedly that they can be difficult to sustain and are rarely effective long term.[17] Because production demands usually drive the design of workstations, it is difficult to make sustainable changes to job design that directly benefits the worker.

Given the limited benefits from PE interventions, one recommendation has been to consider the workplace environment and a more holistic approach to decreasing WMSDs by focusing on matching workers to their physical job demands. Thus, controlling the environment in which the employee is required to work.[7,18-19] Environmental-oriented programs have the advantage over behavioral-focused programs for two main reasons. One is that environmental changes rarely require behavior change by the person. And second, most environmental changes affect numerous persons.[19] In the workplace, not only would the employees be positively affected by injury reduction, but the management teams, human resources officials, medical team, and legal groups may see improvements in policy that is focused on finding a successful environment for all employees. In effect, this type of environmental approach would do the opposite of most PE programs – instead of fitting the job to the worker, programs can fit the workers to the physically demanding jobs based on physical abilities. If designed correctly, these comprehensive interventions can be used during the initial employee hiring process to predict success in a particular job placement, decrease the potential for WMSDs, justify hiring decisions from a legal standpoint, and ultimately save the company money. In fact, systematic reviews of ergonomic practices have shown that best practices are not centered on tools or procedures. Instead, most successful injury reduction programs have focused on reducing risk exposure.[20-22]

As a result of an identified need to assess worker's job-fit in attempt to decrease injury trends, company costs, and attrition rates and increase overall employee well-being, one international automotive manufacturer located in the southeastern U.S. implemented a "day of work" simulation and physical abilities test to determine if job applicants have the physical and mental stamina to be successful in the automotive manufacturing industry. The purpose of this study was to determine if strategic job placement based on physical abilities decreases injury rates, by comparing injury rates pre- and post-implementation of the simulation and testing.

METHODS

Study Population

The automotive manufacturer plant in this study employees about 7,000 workers directly and is the company's largest vehicle manufacturing plant in the U.S. This plant builds two sedan model cars and one crossover model; specifically, the plant is responsible for producing approximately 500,000 cars annually or 2,000 cars daily.[23] The plant has onsite healthcare and a rapidly growing safety, medical, and ergonomics presence. Safety and medical teams track all injury and illness incidents based on OSHA standards.[24] When the manufacturer explored injury rates over time, the employer reported that increased injury rates for new employees led to high workers' compensation claims, high attrition, and the need to invest more money in hiring and training new employees. Subsequently, all jobs in the plant were analyzed to quantify physical demands and a battery of tests was implemented to gather physical abilities data to use for job placement. These tests were implemented during the pre-hire phase of the hiring process.

All data for this project was collected from the automotive manufacturer or the company contracted to develop and implement the job fit testing program. All applicants who apply for a production job are required to attend a physical abilities test in conjunction with the "day of work" simulation test. The entire assessment lasts approximately 5 hours. There are four stations in which the applicants rotate, each station's test lasting 1 hour. The stations are divided into two sections: work simulation and physical abilities. The work simulation tests require applicants to follow precise directions to achieve three tasks, including spot weld simulation, weight wall/lifting simulation, and assembly simulation. The physical abilities station has four individual tests, including critical reach, static force measurement, lifting, and a reach tolerance/peg board test. (See Appendix 1.)

All physical abilities test results are compared to the physical demands of all jobs and the Job Fit system determines which teams (group of jobs) the employee matches. For example, if a job in a team located under the car requires a vertical reach of 82 inches, an employee that exhibited a max vertical reach of 79 inches would not qualify for that team. The company's staffing departments then present a certain number of job openings and the hiring service presents the same number of employees. Using the job fit data, the system manually recommends best-fit placement for employees based on current job openings. Because a “first-in-first-out” method was used for hiring, it was possible that an employee was placed in a group (typically four to five teams) where they did not match any team rotations. Employee’s placement recommendations are then given a percentage score based on how many teams they match in their assigned group. Job placement groups were categorized into four groups to stratify placement from worst-fit to best-fit, with the best-fit having the lowest injury rate while the other rates appear comparable. These percentage groups (0-20%, 21-50%, 51-80%, 81-100%) were used for injury data tracking purposes. All employees were also given identification numbers upon hire. These numbers were used to track injury data, gender, and job fit results. Data for this study included the 3,550 employees who were hired between August 2013 and June 2015.

Measures

Data on job fit testing, injury, and gender was collected for 3,550 employees. The employer’s database was missing some gender data; therefore, 172 employees’ gender was imputed based on name.

Although job fit data was recorded starting August 2013, strategic placement using the data began July 30, 2014. Therefore, for this study, two groups were created to examine job fit placement effectiveness. The groups were titled Pre-placement, if the employee had job fit data but was not placed accordingly, and Post-placement, where the employee was placed based on job fit data. For this intervention, data from the physical abilities station only was included in the evaluation of job fit placement. In addition, for those who were placed according to their job, the appropriateness of the placement was evaluated. Investigators created four placement percentage groups that represent the percentage of job rotations that an employee qualified for based on their physical abilities.

Injury data was available for all employees, including those who were hired before the implementation of physical abilities testing. Injury was analyzed in two ways: 1) ever experiencing a work-related injury during employment by the automotive manufacturer; and 2) experiencing a work-related injury within 120 days of hire by the automotive manufacturer due to a trend in high injury rates during the first 120 days of employment. Injuries that occur within 120 days of hire are also more likely to have occurred due to poor job placement, rather than repetitive use injuries that occur over time.

Analysis

Bivariate cross tabulation (x^2 distribution) was used to evaluate outcome variables. The outcomes were injury rates within 120 days of hire (overall and by gender), job fit placement percentage group (0-20%, 21-50%, 51-80%, and 81-100% match), and injury rates between Pre-placement versus Post-placement groups. Multivariate cross tabulation analysis was conducted to examine the significance of gender, strategic placement, and injury within 120 days of hire. Using SPSS software (version 22; IBM), data collected by the employer was analyzed to evaluate the strategic placement program and highlight any relationships between gender, likelihood of injury, and strategic versus blind placement.

RESULTS

Of the total sample of workers, 73% were male and 27% were female. The Pre-placement group consisted of 57% of the sample who were hired prior to Job Fit placement implementation; the other 43% were hired after job fit testing began on July 30, 2014 (Post-placement). In total, approximately 46% of employees endured an injury, and of that group, nearly 51% suffered an injury within 120 days of being hired.

Table 1 – Sample Characteristics (N=3,550).

	N	%
Total Sample	3550	100
Gender		
Male	2589	72.9
Female	961	27.1
Intervention group		
Pre-placement	2026	57.1
Post-placement	1524	42.9
Injury ever reported?		
Yes	1648	46.4
No	1902	53.6
Days to Injury (among those with an injury)		
<120 days from hire	838	50.8
>120 days from hire	810	49.1

Gender differences in injury rates were observed: 33% of females were injured within 120 days of hire, while only 20% of males were injured within the same time frame ($p<0.001$). Further, a larger percentage of females were injured at a higher rate than the population as a whole (24%).

A statistically significant relationship existed between job fit placement group and being injured within 120 days of being hired ($x^2[1]=99.22$; $p<0.001$). Prior to the implementation of Job Fit strategic placement, 29.8% of employees in this study were injured shortly after being hired. In the post-placement group, only 15.4% of employees were injured within 120 days after being hired.

Bivariate analysis also illustrated the placement threshold in which strategic placement was most effective. Table 2 shows that among employees who were placed strategically, the percentage of injuries in the 0-20%, 21-50%, and 51-80% groups remained relatively close (24.7%, 21.3%, and 21.5%, respectively). However, there was a significant decrease in likelihood of injury with the 81-100% placement group at 16.6% ($p=0.01$).

Table 2 – Relationship Between Gender, Strategic Placement, Job Fit Placement Percentage and Being Injured Within 120 days of Hire (N=3,550).

	Number of Injured Employees Within 120 Days N (%)	Chi-square
Gender		$x^2[1]=70.14$; $p<0.001$
Male	517 (20)	
Female	321 (33.4)	
Pre-placement	603 (29.8)	$x^2[1]=99.22$; $p<0.001$
Post-placement	235 (15.4)	
Job Fit Placement Percentage Groups[a]		$x^2[1]=11.402$; $p<0.01$
0-20%	80 (24.7)	
21-50%	57 (21.3)	
51-80%	51 (21.5)	
81-100%	146 (16.6)	

[a]Placement percentage groups are defined as the percentage of job rotations an employee qualified for in their assigned workgroup. Typically, a workgroup consisted of five teams and each team consisted of four to five jobs.

Because of the strong relationship between gender and injury, the relationship between strategic placement and likelihood of being injured within 120 days of hire was examined by gender. Overall, the incident rate was nearly half after the intervention, declining from 29.8% to 15.4% (Table 3). Comparing the pre-placement injury rate to the the post-placement phase, the incident rate for males and females dropped from 26.0% to 12.4% and from 39.1% to 26.6%, respectively. All of these differences were statistically significant.

Table 3 – Relationship Between Gender, Likelihood of Being Injured Within 120 Days of Hire and Strategic Placement (N=3,550).

	Number injured within 120 days of hire N (%)	Chi-square
Male		$x^2[1]=73.886$; $p<0.001$
Pre-placement	375 (26.0)	
Post-placement	142 (12.4)	
Female		$x^2[1]=21.688$; $p<0.001$
Pre-placement	228 (39.1)	
Post-placement	93 (26.6)	
Total		$x^2[1]=99.222$; $p<0.001$
Pre-placement	603 (29.8)	
Post-placement	235 (15.4)	

DISCUSSION

Overall, in this study, there was a reduction in injury rates following the implementation of the strategic job fit placement: injury rates within 120 days of hire decreased by half following less than one year of strategic placement. Similar to studies that explored the effectiveness of pre-employment physical abilities testing[7], this study suggests that objectively evaluating the physical capabilities of job applicants, in regards to job demands, and placing employees based on their measurements may significantly reduce WMSDs. By placing employees in work areas that do not exceed their physical limitations, employers may decrease exposure to injury risk. Although there will always be inherent risk to manufacturing jobs, successful steps may be taken to reduce exposure by making changes to the employees environment.

Consistent with other literature[9,13], injury rates by gender in the current study suggest that women are more likely to be injured in a physically demanding field such as automotive manufacturing. Because these jobs require high push, pull, and lift forces at high frequencies, it is not uncommon to see women suffer from WMSDs at a higher percentage than men in a manufacturing setting.[13] Considering the consistency of these findings, manufacturing process engineers may want to reevaluate common process designs to better accommodate female workers. Notably, we did observe a significant decline in early onset injury rates for both men (26% to 12.4%) and women (39.1% to 26.6%). Investigators in this study were concerned that the physical abilities testing would not significantly affect women's injury rates due to the burdensome demands of all manufacturing jobs and the fact that women are generally more susceptible to injury in this setting.[13] Based on results from this study, it appears that this type of environmental intervention significantly affects injury rates for both genders. Given that gender diversity demands careful attention for all employers, this is a positive finding for the intervention design and implementation.

Another noteworthy finding relates to placement accuracy and possibility of injury. Based on this study, results suggest that there is an association between placing employees in areas where they match 80% or less of job rotations and decreased likelihood of injury within the first few months of employment. Additionally, these results may indicate that strategic placement in general may not significantly decrease injury. Alternatively, the better the placement match, the less likely an employee could be injured within the first 120 days of employment. There was a noticeable spike in injury rate for women in two of the placement groups (21-50% and 51-80%). Investigators believe this spike may have been attributed to the low number of women placed during the post-placement phase (n=26 in the 21-50% group and n=18 in the 51-80% group). Though not statistically significant, investigators noted that the first-in-first-out method of hiring created an inherent disadvantage for women who scored well overall. If a high performing female was hired at the same time as many low performing employees, the high performing female would tend to be placed in more physically challenging workgroups to accommodate the lower performing employees that required placement in easier workgroups. Thus, the high performing female, though she matches her workgroup, is more at risk by working in a more burdensome job rotation. In the future, it would be ideal for employers to avoid first-in-first-out hiring methods and focus on hiring the right person for the current openings based on their demonstrated physical abilities. However, this is a problem that individual employer's legal departments would need to further examine.

Findings from this evaluation may help guide employers in determining if strategic job placement based on physical abilities can aid in decreasing injury rates and therefore workers' compensation claims, particularly early on in the employee's career. This information will be particularly important to other companies in similar industries striving to reduce direct and indirect costs of WMSDs.

Limitations

This study has limitations that are important to discuss because they resulted from real world application of the intervention. First, data provided by the employer had missing components and therefore gender was imputed for 172 employees based on name. The system used by the employer is managed by Human Resource and Staffing departments and relies on data entry by many different individuals. Thus, there will always be a risk for human error. Similarly, data collected and recorded during the physical abilities tests and placement was completed by different individuals. However, the physical abilities testing application has built-in measures that aid in identifying data that could have been added in error. This function was vital in ensuring the most accurate measures were being used for placement purposes.

This manufacturing site in particular created two limitations that warrant discussion. First, during the Post-placement phase, the employer used a first-in-first-out hiring method. This meant that some employees that were eligible for placement might have been forced into areas where they were not a partial or full match. For example, Staffing Coordinators and Job Fit Managers were given 20 job openings and 20 people to match, regardless if the people matched the current job openings. This system created cases of poor (or 0%) placement that could have been avoided if Staffing Coordinators were able to select the best-fit employees for the current job openings. Second, there was no guarantee given to investigators that employees continued to work in the areas they were originally placed. In some instances, the employer would move new employees to fill other demands. Though this circumstance was rare, it is possible that employees were injured in a different area and therefore their job match placement data could have been reflective of a different workgroup. Nevertheless, limitations such as these are unavoidable at times due to the company's production demands and corporate hiring practices.

The length of time for study is another limitation to be considered. Although investigators attempted to normalize findings by focusing on injuries occurring within the first 120 days of employment (i.e., when injuries were more likely to be associated with poor job placement), it would be noteworthy to investigate long(er)-term injury rates to assess overall success.

Other factors, such as age, previous manufacturing experience and other comorbidities could have had an impact of individual's performance during the pre-employment testing. Due to employer request, this test was performed pre-hire. Therefore, no personal, biological or past medical history information was collected. For this study, all data was collected from the employer and was limited. In future studies, investigators should organize data collection with the employer ahead of time to ensure more demographic information can be included in analysis. Ideally, the testing should take place post-offer so that more relevant data may be collected for better analysis.

CONCLUSION

This study indicates that strategic job placement based on employees' physical abilities may significantly decrease WMSDs early in one's career in an automotive manufacturing setting. These findings may lead to substantial reduction in attrition and costs to employers to hire and train new employees. With rising healthcare costs, this intervention serves as a framework for other manufacturing companies to consider in an effort to decrease workers' compensation claims and hiring and training costs. This study also shows that traditional methods of health behavior change and classic ergonomics that have dominated the industry for years[16] may need to be reassessed, or used secondarily, after changes to the individual's environment have occurred. Due to early success, the company in this study has begun discussion and planning to implement the "Job Fit" program as the company's hiring standard nationwide. Studies of similar nature in other companies are needed to confirm effectiveness and reproducibility of results.

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Appendix 1.

A team made up of exercise physiologists (EPs) collected data to create physical demand analyses for each production job in a large automotive manufacturing plant. Each physical demand analysis (PDA) captured the maximum physical requirements as well as the frequency required for each task. In addition to exertional tasks, the PDA also captured the postural frequencies required to perform the jobs. The PDAs are created using a tablet device and a specific application (app) created in partnership with a worksite health company and the large automotive manufacturer. The EPs used the tablet and app to record video of each job from start to finish. Each video generally lasts 55 seconds. Using the recorded video in the app, the EPs analyzed the following requirements: mobility, neck posture, upper extremity reaching, elbow/wrist posture, hand tools used, low back posture, lower extremity posture, pushing, pulling and lifting.

Physical Demand Definitions

Name of Demand	Description
Mobility	Time spent walking, standing and/or sitting
Neck posture	Time and max degrees of neck flexion >20, extension > 0, lateral flexion >25 and rotation >25
Upper extremity reaching	Time spent reaching in the overhead zone, below bench zone and reaching horizontally
Elbow and wrist posture	Time spent in elbow flexion >90, wrist flexion/extension >45
Hand tools	Time spent using hand tools, weight of tool, vibratory or non-vibratory
Low back posture	Time spent in low back flexion >20, extension > 0, side bending > 25, twisting > 25
Lower extremity posture	Squatting, getting in/out of car, kneeling, climbing, crawling
Pushing	Number of pushing repetitions and max force in three different zones; below bench, bench to shelf, overhead
Pulling	Number of pulling repetitions and max force in three different zones; below bench, bench to shelf, overhead
Lifting	Number of lifting repetitions and max force in three different zones; below bench, bench to shelf, overhead

Biographical Sketch

Michelle Cooper is a graduate student at the University of Kentucky working toward obtaining a Master's of Public Health degree (MPH). She graduated from the University of Kentucky in 2009 with a BS in Human Nutrition. Since, she has completed certifications in fitness and job evaluation (NASM Certified Personal Trainer, NASM Corrective Exercise Specialist, Back School of Atlanta Certified Essential Functions Evaluator). Cooper is currently working as a supervisor of the ergonomic and safety team with Premise Health at Toyota Motor Manufacturing Kentucky located in Georgetown, KY. She has been working in this role for six years and was heavily involved in the development and implementation of the Job Fit testing and placement program.

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