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Shoulder injury reduction with post-offer testing

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Abstract. *Objective*: This study is an interventional evaluation of a post-offer employment testing. The study is designed to determine if shoulder injury rates are lowered when employees are placed at jobs they demonstrate the physical ability to perform.
Methods: A physical capacity evaluation based testing protocol was utilized to determine if each new employee had the physical work capacity to perform the job for which they were hired. Injuries to the shoulder were specifically scrutinized. The interventional group was compared to a historical control.
Results: The incidence of shoulder injuries was 0% in the tested group and 3.8% in the untested historical control. Over a 6 year study timeframe the utilization of physical capacity testing for work placement appeared to be the major factor in decreasing work related shoulder injuries. The annual cost of administering the tests for three years was $9,543, while the net annual cost savings was $124,451. This represented a 37% decrease in medical costs for shoulder and other work-related injuries. For every dollar spent on testing there was a $14 savings in medical costs secondary to injury prevention.
Conclusion: The use of post-offer physical capacity testing resulted in a substantial and noticeable decrease in shoulder related non-accidental injuries. Furthermore, it is evident that a properly conceived and implemented post-offer testing program may help in the reduction of work-related injuries.

Keywords: Occupational accidents, work capacity evaluation, workload, fitness to work

1. Introduction

1.1. Background

One third of workers in the United States are required to exert significant force as part of their jobs [8]. There is a higher incidence of low back pain and associated injuries in jobs that require lifting of over 22.68 kilograms (50 pounds) [14,17]. Sixty percent of employees with lower back pain claim over-exertion as the cause [18]. Ergonomic modifications to the workplace may reduce the physical demands of jobs [9,18, 25]. However, regardless of ergonomic changes, there are limits to what can be accomplished. Most jobs and tasks can be redesigned and improved, but not all physical work demands can be eliminated [27]. Other important factors that cannot be completely accounted for through ergonomics are aging, medical conditions and disability issues. Physical capacity work certification testing can help minimize the risks of work injuries to these groups [7,28,29]. Job fitness evaluation and workers health surveillance for specific high risk jobs have been suggested to be the conclusive steps following ergonomic improvements [1,29].

Prior studies have shown diminished shoulder function associated with a higher episodic component to

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shoulder injuries in the working population, which emphasizes the importance on attempting to lower the initial injury rate [16,30]. One study determined the functional results of surgical intervention for impingement syndrome to be lower for work-related injuries [15], while another study has shown a slower return to work for more physically strenuous jobs [19].

Previous studies have shown a relationship between injury incidence and an individual's strength or physical capacity as it correlates to job demands [2,3,8, 12]. There is a higher rate of injury in workers whose strength and physical abilities are less than those required by their job [8,11,22]. Work-related injuries have been shown to be reduced when a testing battery based on strength is utilized to qualify an employee for a job [3,8,11,12,22].

Physical capacity is only a part of the battery of qualifying factors that should be used by the occupational medical provider or employer in making the decision on fitness to work [27]. In order to match an employees' physical capabilities to a specific job, a detailed analysis that quantifies the physical demands of the job is necessary [9,21]. A well-designed post-offer screening program that includes physical capacity testing and a correlation to job requirements, can substantially decrease the number of work injuries [8,10,13, 20,26]. An objective and systematic testing program can substantially reduce work-related injuries by assuring hired employees have the physical tools to perform their required job.

The value of a post-offer pre-placement physical assessment used as a means of reducing job injuries is a logical assumption. Designing double blind cohort studies to prove this assumption is difficult since hiring practices and job placement are under state and federal guidelines. There are federal regulations and guidelines that must be observed in implementing a post-offer pre-placement testing program. In particular, the Health and Safety at Work Act (1974) and the Disability Discrimination Act (1995) require evidence-based approaches to setting physical and medical hiring standards. These regulations need to be considered before any study or program is designed or implemented. Some European countries encourage fitness to work determination and job surveillance to help control injury rates [1,29].

The methodology and efficacy of successful physical capacity based post-offer testing protocols have been previously published [8]. A concern in the analysis of the results of pre-employment post-offer protocols is accounting for the numerous confounding factors that can potentially create variations from the presumed test model [8]. One confounding factor is that different jobs, even though they are classified as similar in lifting requirement, could potentially have different ergonomic risk factors [6]. How long an employee has been employed at the same job could also influence the injury incidence. Different employers offering similar jobs may have varied injury rates secondary to differences in policies and procedures. Other confounding factors include age, gender, socioeconomic status, education level, shift hours, overtime requirements, medical conditions, and alcohol and tobacco usage [24]. Compliance with the test protocol and adherence to testing standards can also affect the test results.

1.2. Specific aims of current study

This study was developed to evaluate the effect of a post-offer testing program on work injuries with emphasis on the shoulder. The study was designed to minimize or account for the effect of the many extrinsic factors that could potentially affect the test results. The same testing protocol used has been previously described by the author [8]. The same employer and job were utilized to assure similar work protocols, employment practices, overtime requirements, salaries and shifts. The utilization of a local government agency as the employer was to minimize the socioeconomic and educational differences that could potentially skew the results. A specific emphasis was placed on the shoulder injuries to avoid comparing injury rates between different anatomical areas.

2. Methods

All participants signed informed consent prior to participation in the study.

2.1. Study design conditions

The test model utilized an independent clinic that adhered to a previously developed physical capacity post-offer protocol [8]. The study subjects were from a metropolitan public school district with 9,000 employees (Wichita Public Schools USD 259). To further minimize possible confounding information, the study restricted itself to the custodial staff with special attention given to shoulder injuries. The risk manager for the school district compiled and analyzed all data in order to determine the effectiveness and economics

Table 1
The description of lifting categories and requirements as published by the U.S. Department of Labor in the Dictionary of Occupational Titles

Level 1	Sedentary Work	Exerting up to 10 lbs (4.54 kg) of force occasionally, and/or a negligible amount of force frequently. Involves sitting most of the time, but may involve walking or standing.
Level 2	Light Work	Exerting up to 20 lbs (9.07 kg) of force occasionally, and/or up to 10 lbs (4.54 kg) of force frequently. Requires walking or standing to a significant degree; or requires sitting most of the time but entails pushing and/or pulling of arm or leg controls.
Level 3	Medium Work	Exerting 20 lbs (9.07 kg) to 50 lbs (22.68 kg) of force occasionally, and/or 10 lbs (4.54 kg) to 25 lbs (11.34 kg) of force frequently, and/or greater than negligible up to 10 lbs (4.54 kg) of force constantly.
Level 4	Heavy Work	Exerting 50 lbs (22.68 kg) to 100 lbs (45.36 kg) of force occasionally, and/or 25 lbs (11.34 kg) to 50 lbs (22.68 kg) of force frequently, and/or 10 lbs (4.54 kg) to 20 lbs (9.07 kg) of force constantly.
Level 5	Very Heavy Work	Exerting in excess of 100 lbs (45.36 kg) of force occasionally, and/or in excess of 50 lbs (22.68 kg) of force frequently, and/ or in excess of 20 lbs (9.07 kg) of force constantly.

of the post-offer program. This allowed for specific tracking of a single work category, therefore a single job description. In summary, the study was designed to minimize confounding factors by utilizing a single employer (public K-12 school system), one job type (custodian), and one potential injury site, the shoulder.

This is a cohort study in which the interventional group is compared to a concurrent and historical control. The historical control serves the dual purpose of providing a second comparison for the cohort group as well as providing a means of assuring that the injury rate in the concurrent group is chronologically stable. The study was designed to test the effectiveness of a post-offer testing program on a homogeneous group of employees. The interventional group and concurrent and historical control groups were composed of the custodial staff employed by a metropolitan public school district.

2.2. Study participants

The concurrent and historical control group, $n = 757$, was composed of employees who were employed from January 1999 through December 2004, who underwent a medical exam and drug screening but no physical capacity testing. 497 of the 757 untested employees were hired and started employment from 1999 into 2002. The time frame for inclusion in the intervention group was from February 2002 through December 2005 (followed for injuries through July 2005). The intervention group, $n = 248$, underwent a medical exam, drug screening and a post-offer physical capacity evaluation in the same manner as the control groups. There were 402 workers who were conditionally hired and underwent post-offer screening; of those, 248 demonstrated the physical capacity to work at a DOT Level 4 job (Table 1) and were placed on the job. The testing protocol was blinded to race, gender, age, medical conditions and ethnicity. The intervention group was evaluated for shoulder injury incidence for 40 months in comparison to 36 months for both the concurrent and historical control group.

The control group ($n = 497$) had data evaluated on an annual basis for the six calendar years of 1999 through 2004. The injury data comparing the concurrent and historical control group to the test group is reviewed in Tables 2 and 4. The control group was divided into two separate thirty-six month reference periods to compare chronologically to the interventional group. The concurrent control used data for the calendar years 2002 through 2004. The historical control group comprised data for years 1999 through 2001. The comparison of 2 consecutive 3-year time intervals for injury rates helps assure that the injury incidence in the concurrent control group was stable and not influenced by policies and procedures or other outside confounding sources. If there were any extrinsic or work policy changes affecting injury rates that occurred during the test group time frame this should have been reflected when comparing in shoulder injury rates in the concurrent and historical control group (Table 2).

All data was maintained by the school district in strict compliance with HIPAA. Secondary to HIPAA rules and privacy regulations there was medical and demographic data that was not available for the historical control group. Study and privacy release forms were not possible to be obtained for the employees in the historical control group at the time the study was instituted.

2.3. Interventional group testing protocols

The test protocol utilized a process previously described by the author [8]. In the interventional group all employees hired underwent a standardized physical capacity post-offer test after a conditional hire. This test was used to determine that the hired employees had the physical strength to perform the job for which they

Table 2
This chart summarizes chronology of shoulder injuries occurring in the interventional and historical control groups. The untested employees were followed for injuries for six years, from 1999 thru 2004. The tested group was hired from February 2002 thru the calendar year 2004. Injuries in the tested group were recorded from date of hire thru July 2005

	1999	2000	2001	2002	2003	2004	Total
Injuries in untested	3	2	5	4	4	1	19
Injuries in tested	–	–	–	0	0	0	0
Injuries in first year hired	2	2	1	0	0	0	5
Total New Hires Who are tested	–	–	–	47	112	89	248

Injuries in the tested group were recorded from date of hire thru July 2005.

were hired. The control groups constituted those individuals hired following the same protocol except they did not undergo strength or physical capacity testing. Both groups had their injury records maintained for comparison purposes. In development of the study protocol, uniform guidelines on employee selection were developed to be in compliance with all local, state and federal hiring requirements.

2.3.1. Accuracy and standardization

Methods were developed for the testing protocol of the isometric and isoinertial upper and lower extremity tests. Isometric tests were analyzed utilizing calibrated load cells. All isometric tests were performed 3 times and a variance of less than 15% was required for the test to be considered valid. The isoinertial lifting was performed with a uniform protocol. The test composite scores were analyzed to provide a valid indication of maximum functional ability.

2.3.2. Test fairness

Bias was minimized by utilizing the same standardized test for all applicants. All data and result determinations were analyzed off site, remote from the test administrator. For hiring purposes all data was blinded for gender, race, age and medical conditions.

2.3.3. Hiring practices

All subjects received a standardized medical examination, urine drug test and state mandated TB skin test. Job offers were withdrawn for positive drug tests. After a negative drug screen, the interventional group underwent post-offer pre-placement physical capacity testing [8]. Job offers were withdrawn for test group members unable to demonstrate ability to meet the essential functions of the job. Any test subject not qualifying for employment secondary to physical capacity testing was given the option to retest. Interventional group members who were not hired were encouraged to apply for any other job they were physically or otherwise qualified to perform.

Table 3
The list of anthropometric and strength tests performed in the post-offer, pre-placement testing functional capacity evaluation

Height	Weight	Age	
Body Fat	Spirometry	Blood Pres	
Squats	Sit-Ups	Lumbar Rom	
Supination*	Pronation*	Biceps*	
Torso Lift*	Leg Lift*	Pinch*	
Grip*	Quads*	Pile Test	
Torso Lift*	Leg Lift*	Shoulder Flex*	Push-Pull*

*designates isometric strength.

2.3.4. Testing methods

The physical capacity work evaluation used to evaluate the intervention group is similar to FCE testing used for post-injury assessment for return-to-work status [8]. The post-offer physical capacity testing protocol was developed utilizing the concepts of the Functional capacity evaluations. Twenty-two different anthropometric, fitness, strength, and lifting tests were utilized in the protocol (Table 3). Height and weight were measured and recorded in inches and pounds. The interventional protocol was sequenced and integrated with a software program and could be completed in less than 30 minutes. The efficiency of the test protocol allowed rapid assimilation and analysis of test data, therefore minimizing the testing costs.

The post-offer test protocol was utilized to determine an employee's maximum physical capacity. The physical capacity was then related to the lifting requirements of a specific job. The lifting requirements of the job were divided into five different categories (Table 1) based on ascending order of effort as defined by the United States Department of Labor and published in the Dictionary of Occupational Titles [5].

Table 4
The following chart displays the demographics of the control and tested groups. The control group represents the combined data of the concurrent and historical control groups

Category	Concurent control	Tested and hired	Tested and not hired	Total tested
Number in study	497	249	153	402
Gender male/female	421/76	229/20	38/115	267/135
Age mean/(SD)*	43 (SD 17.2)	34 (SD11.9)	38 (SD 12.5)	35.6 (SD 12.2)
Mean age at time of hire**	35 (ND)	34 (SD 11.9)	38 (SD 12.5)	35.6 (SD 12.2)
Height mean/(SD)	NA***	1.76 (m) (SD 3.5)	1.65 (m) (SD 3.6)	1.72 (m) (SD 4.2)
Weight mean/(SD)	NA	89.86 (kg) (SD 46.0)	79.74 (kg) (SD 44.6)	85.96 (kg) (SD 46.6)
% Body fat mean/(SD)	NA	24.5 (SD 14.0)	33.9 (SD 15.1)	28.0 (SD 15.1)
Smoker	NA	85 (34.1%)	51 (33.3%)	136 (33.8%)
High blood pressure	NA	27 (10.8%)	33 (21.6%)	60 (14.9%)
Diabetes	NA	10 (4%)	4 (2.6%)	14 (3.5%)

*SD = Standard Deviation.
** mean age at hire adjusted using the mean years of service of the historical control of 8 years.
***data not available.

2.4. Ergonomic job evaluation

An occupational registered nurse and an ergonomic expert were responsible for the development of the custodial job descriptions for the school district. Custodial management and working custodians were also involved in the evaluation of the job description. Scales, direct job observation, and a digital hand dynamometer were used to develop an accurate job description. The custodial job was determined to be a Level 4 as defined by the U.S. Department of Labor's Dictionary of Occupational Titles (Table 1) [5].

Key physical functions of the job included lifting, pushing, pulling, and carrying objects up to and in excess of 22.68 kilograms (50 pounds). Folding and unfolding the hydraulic lunch tables required greater than 32.02 kilograms (75 pounds) of push and pull force as determined by a digital hand dynamometer. Attempts to reduce these forces through table repair and ergonomic job engineering were unsuccessful.

The three most common activities associated with injury were manipulating lunch tables, emptying trash containers and moving furniture. Ergonomic modifications were not successful in lowering the lifting requirements of the job to less than Level 4. The reasons for being unable to decrease lifting requirements were that furniture and supplies could not be changed, mechanical lift devices were not practical, and the job was not amenable to team lifting. Though some custodians were employed at schools with more than one custodian, there was no formal division or teaming of job duties. No differences occurred in the job descriptions during the timeframe of the study.

2.5. Job background information

During the study period there were no changes in overtime, job requirements, or employment practices. One way of evaluating workload differences that could have occurred between the historical control group and the test group is to estimate the square meters cleaned per employee. The actual amount of square meters increased by 130,064.26 square meters (1.4 million square feet), and the square meters cleaned per employee increased annually from 1999 to 2005. During the study period, there were no significant changes to the work site or ergonomic design of the facilities that affected the custodial services.

The Wichita Public Schools compiled and maintained all work and injury data. The medical, temporary disability, permanent award and legal costs were documented and assigned on a claims incurred basis. This allowed for all injuries and their associated costs to be documented and followed together in the same

Table 5
Lifting abilities of 402 employees tested as determined by FCE testing

Work levels	Number females	Percent females	Number males	Percent males	Total numbers	Total percent
Level 2	18	100%	0	100%	18	100%
Level 3	100	87%	36	100%	136	96%
Level 4	20	14%	202	86%	222	62%
Level 5	0	0%	26	10%	26	6%
Total	138	–	264	–	402	–

Levels are as described in Department of Labor's Dictionary of Occupational Titles.
Job for a custodian at USD 259 was a Level 4.
160 of 409 or 39% of conditional hires tested did not qualify for the job.

calendar year. Reserve amounts were included for any claim not yet closed. The school district had voiced concern for the increasing costs of shoulder injuries, which, for fiscal years 2001 and 2002, comprised over 50% of the work injury medical costs among custodians.

The custodial staff for the school system was composed of an average of 320 employees. All groups were composed of individuals from the same community. This allowed for minimal changes in demographics such as age, unemployment rates, and educational background during the study period (Table 5).

2.6. Statistical analysis

Statistical analysis of data was performed using Systat version 11.0. The comparison of the interventional group to the control groups was made using the fisher's exact test and the Chi-square test for equality of distribution.

3. Results

3.1. Demographic finding

There was a difference between the mean age of the historical control group (43) and the test group (34) at time of testing. The average time of employment for the control groups was 8 years. Once the age is adjusted to date of hire there is essentially no difference; historical control group 35 years and interventional group 34 years (Table 3). Utilizing the t-test with a confidence coefficient of 0.95, there was a p-value of 0.287 when comparing age at time of hire between the historical control group and the test group. This suggests that there is no significant difference between the interventional and control groups in regard to age at time of hire.

The demographics for the tested but not hired group were included in Table 3. The largest disparity between the hired and not hired group was mean % body fat and hypertension. The mean % body fat of the tested and hired group was 24.5%, while the % body fat for the tested but not hired was 33.9%. The percent body fat of the group tested but not hired with hypertension was 38.7% (SD) 19.6. The mean weight for females for the test group was 88.36 kilograms (194.80 pounds, SD 38) and mean height was 1.66 meters (65.30 inches, SD 3.0). The female group tested but not hired had a mean weight of 79.38 kilograms (175.00 pounds, SD 42.0) and mean height of 1.61 meters (63.50 inches, SD 3.0). The mean weight and height for men tested was 88.68 kilograms (195.50 pounds, SD 47.7) and 1.77 meters (69.50 inches, SD 3.2). There is a noted difference in weight and height between the females that demonstrated the ability to work at a Level 4 job as compared to those with less demonstrated strength. There was no statistically significant difference in weight between males and females in the group that showed the physical capacity to work at a Level 4 job.

The test group had a total of 402 subjects who were tested in a post-offer, pre-employment, conditional hire arrangement. Of the 402 subjects tested, 248, or 62%, matched by demonstrating the physical abilities required for the custodial job (Table 4). Only 6% of the 402 employees tested demonstrated the physical abilities to perform a Level 5 job (Table 5). The incidences of work-related injuries among the two groups were significantly decreased during the study time period (Table 2). There were no claims for sprains and strains in the shoulder or other anatomical sites in the tested group.

Both control groups had a higher incidence of reported injuries than the interventional group. The average cost of a claim was 7 times higher in both control groups in contrast to the test group (Table 5). The claims for the interventional group were comprised only of injuries or accidents, with no claims for overuse injuries.

3.2. Functional lifting demographics

The differences in lifting abilities for the male and female hires are demonstrated in Table 4. Physical capacity testing demonstrated that 87% of the females and 100% of the males had the capacity to work at a Level 1 or Level 2 job. There were 264 males who applied for the job, which constituted 65% of the applicants accepted for the job. Of the males tested, 76% demonstrated the physical ability to work at a Level 4. Of the 138 females that were accepted for the job, 15% had the physical capacity to work at a Level 4 job.

3.3. Injury results

The major mechanism associated with shoulder injuries was sprain/strain due to over-exertion, followed by slips and falls. Activities associated with shoulder sprain and strain injuries included trash handling, manipulation of lunch tables and moving furniture.

The results in Table 5 show there was a substantially lower shoulder injury rate in the test group. The overall injury rate was also lower in the test group. There were no shoulder injuries in the group that had been matched for their job. There were 19 shoulder injuries occurring in the 497 individuals hired to the custodial staff prior to testing. There was no shoulder or musculoskeletal strain injuries over the 3 years for the 248 employees who were tested and hired into the custodial staff.

There were 10 shoulder injuries in the 3 years of the historical control and 9 injuries in the concurrent control group. For the first three years of post-offer testing, there were no shoulder injuries, therefore substantially reducing the medical costs (Table 6). The results comparing the incidence of injury between the non-tested and the tested individuals show a $P < 0.025$ for the chi-square for both the concurrent and historical control groups. The Fisher's exact test shows the two tailed P value 0.0358 for the concurrent control group and 0.0332 for the historical control group. This would suggest there is a statistically significant difference in injury rates between the tested and non-tested groups. The incidence of shoulder injuries was 3.8% for the untested group and 0% in those tested and qualified for their job. Because there were no shoulder injuries in the interventional group, it was not possible to develop a linear correlation of strength to injury rate.

The injury incidence per 100 hours worked was 0.0018. There were no overuse injuries in the interventional group. The rate of shoulder injuries was 0.00 per 100 hours worked for the tested full time custodial staff. The injury rate for non-tested full time staff was 0.0216 per 100 hours worked.

3.4. Injuries in first year staff

Historical analysis of the historical control group showed a higher incidence of all injuries among first year staff (Table 2). Implementation of testing during 2002 resulted in a significant decrease of injuries among new hires including first year staff. There were six shoulder injuries in the untested historical group. There were 0 shoulder injuries in the tested group. In statistically comparing the historical groups first year staff to the tested first year staff, the Chi-square $P = 0.10$ and Fisher's exact test two tailed $p = 0.1867$, which may indicate a weak correlation but not a statistically significant correlation.

3.5. Workers compensation costs

With the onset of testing in the first quarter of 2002, there was a decline in worker's compensation expenses. The annual costs, when recorded for all injuries on a claims incurred basis, averaged $367,998 for the four years before the implementation of the physical capacity based post-offer testing program. The costs incurred and reserved for all injuries during the 3 years of testing averaged $234,004 per year. This resulted in an average annual gross direct cost savings of $133,994 for the Wichita school district (Table 6). With the implementation of post-offer testing, the custodial work-related medical costs dropped from 60% to 25% of the total school district's worker's compensation costs. Injury claims for the tested custodial staff during the 3 year study period included a cut, ocular injury, two falls, and an aggravation of a non-work related strain during a motorized accident.

The cost to the school district for testing was $70 per employee. There were 402 employees tested of which 249 qualified for the job and were placed. The cost of 402 physical capacity tests was $28,630. With the estimated $133,994 in gross annual savings through injury prevention (Table 6) there was an estimated total cost savings of $401,982 over three years. There was a realized net savings, after the cost of post-offer testing, of $373,352 for all work-related injuries among the custodial staff for the three years of testing. This would

Table 6
Demographics and claim costs of comparison and tested groups

Category	Historical control group	Study or tested group
Mean years of service	8.0	1.8
Mean age	43	34
Mean age at time of hire*	35	34
Gender males/females	421/76	229/20
Shoulder injuries per 100 hrs worked	0.0216	0.000
Average cost per claim with reserve	$7,156	$874

*Mean age at hire adjusted using the mean years of service of the historical control of 8 years.

result in an annual net savings after the cost of testing of $124,451, with the average cost of testing $9,543. For every dollar spent in post-offer testing, the school district saved $14 in work-related medical costs. All custodial claims were closed at the time of assessment of the data, making the yearly medical costs accurate. The annual medical cost for shoulder injuries dramatically decreased after the implementation of the testing program (Table 6).

For the three years prior to the implementation of the physical capacity based testing program, the average cost for all claims was $7,156 and was $5,434 for shoulder injuries. With no shoulder injuries in the 3 years of post-offer testing, it was not possible to estimate a cost per injury for shoulder injuries.

4. Discussion

This study was performed to validate and substantiate a previous study on post-offer testing in industry through an independent collaborative testing program [8]. The prior study involved one industry, but there were several job types and descriptions within each lifting level [8]. There were some concerns over comparing the results of different jobs, even if they were basically similar in physical demand. Confounding factors include job differences even in the same level, differences in work environment, job dissatisfaction, prior work experience and different geographical locations of the worksite. In order to minimize the number of confounding factors that could influence the results, one specific job was evaluated with a single employer, and focus was placed on one specific anatomical site (shoulder). The public school system self-funds and self-administers claims, minimizing any reporting bias concerning the testing protocol.

There were no differences between the interventional group and the control groups in job descriptions, equipment, job security, supervision or salary policies. The school district's employment policies were unchanged. Community demographics were stable. For comparison purposes, the three groups were similar; therefore, the concurrent control closely reflected the test group and serves as a good baseline comparison.

No shoulder injuries occurred in the group of employees tested who demonstrated they had the physical capacity to perform their job requirements. In the untested groups there were 10 shoulder injuries that occurred in the first three years and 9 in the second three years for a total of 19. The p-values using the chi-square and the fisher's exact test indicated a statistically lower incidence of shoulder injuries in the interventional group. The consistency of shoulder injuries in the control groups over 6 years indicates the lack of extrinsic factors influencing the work related injury rates. The only major difference between the interventional group and the two control groups was the implementation of the physical capacity testing program.

The annual worker's compensation costs (in USD), when recorded on a claims incurred basis, averaged $367,998 per year prior to testing. The decrease in work-related injuries and associated medical costs dropped an average of approximately $234,004 yearly for the first three years of post-offer physical capacity testing. Considering the annual cost of the post-offer testing program for custodians was $9,543, there was an annual $133,994 cost savings directly attributed to conditional hires and post-offer testing. The annual net savings were $124,460, or a 37% reduction of the average medical costs of work injuries prior to establishment of a testing program.

During the three years that post-offer testing was utilized, there were no lifting injuries that could be attributed to a mismatch in physical capacity and job demands. The injuries that occurred were accidents including a laceration, a fall from a height and an ocular injury. In this study, 39% of those tested for the job did not have the physical qualifications required to meet the essential functions of the job. Therefore, it is logical to infer that if injuries occur in those that did not have the physical ability to perform the job before being hired; it would be unlikely they would be capable of performing their job after an injury. This may also account for the higher average cost per claim in the untested employees.

There are a substantial number of work-related injuries that can lead to permanent impairment and dis-

Table 7
Displayed is the comparison of medical costs (MC) for work related injuries before and after the implementation of a pre-employment testing program for the custodial department of a metropolitan school district

Year	1998	1999	2000	2001	2002	2003	2004
MC cost for all injuries	$349,016	$398,254	$333,323	$391,401	$237,077	$171,981	$292,954
MC cost for shoulders	N/A	$50,000	$40,000	$240,000	$200,000	$10,000	$5,000

ability. The injured employee who sustains a permanent impairment may not be able to return to his/her previous job and may lack the skills to change to a less physically demanding job. Despite worker's compensation payments, this situation can often lead to family problems, financial losses and mental stresses which are often not fully recoverable. Therefore, the financial savings for the employer are only part of the benefit of injury reduction. Assuring that the employee has the capacity to work at his or her job without excessive risk of musculoskeletal injury is more important.

Studies indicate that work injury rates correlate to the intensity or strength demands of the job [16,23,30]. When an individual is required to lift more than they are physically capable of, there is an increased incidence of musculoskeletal injuries [8,23]. The percentage of the working population that is capable of lifting a particular amount of weight decreases as the lifting requirements increase [8]. Many jobs, due to their specific requirements, will inherently require greater physical demands. Due to changes in the work force, secondary to aging and medical conditions, assessment of fitness to work is important in order to match the functional capacity of a changing workforce to the demands of their jobs [4,28].

The ergonomic aspect of the job is highlighted by the fact that physical capacity testing indicated that a significant proportion of the working population did not have the ability to work at DOT Level 4 or 5 jobs. There were only 10% of the males and 0% of the females tested that demonstrated the ability to work at a Level 5 job. There were 15% of the males and 86% of the females tested who were accepted for the job but did not have the physical capacity to work at a Level 4 job. Of those tested, 87% of the females and 100% of the males demonstrated the ability to work at Level 1 or 2 jobs. Ninety-five percent of the entire working population demonstrated the physical capacity to work at Level 1 or 2 jobs. These figures illustrate the importance of ergonomic modifications to the workplace to decrease the individual work demands as well as expand the application base from which an employer can draw their employees (Table 5).

Even with evidence that ergonomic modifications may reduce work injuries, the necessity to determine the physical and psychological capacity of a worker for a specific job is still necessary [27]. When the jobs cannot be more efficiently designed, then testing in order to assure appropriate placement is important. Fitness to work assessments focused on job requirements appear to be better predictors of future health outcomes than those based on medical diagnosis. Pre-employment testing is most effective in jobs with high physical demand [27].

Testing employees for jobs that have been optimally ergonomically engineered to minimize their lifting requirements is necessary to assure a safe work environment. Some European countries, under the European Union Directive, have developed directives that require fitness for duty certification and work surveillance to minimize the risk of work related injuries [1,27,29]. They have suggested the use of testing to assess workers for certification for a specific job [1,29]. High demand jobs that cannot have their work demands decreased by state of the art ergonomics may overburden a worker's bodily capacity, increasing the risk of injury [28]. Diminishment of functional capacity of the aging worker may increase his or her risk of injury, emphasizing the importance of proper placement in this specific group on employees [7,28].

The decrease in work-related injuries provided through physical capacity testing and appropriate job placement creates a safer work environment. With fewer injuries, there is a proportionally less chance for injuries to become a chronic condition. The social and familial ramifications associated with chronic injuries are best avoided by preventing injuries in the first place. This study shows the injury prevention and cost effectiveness of post-offer physical capacity testing.

However, even though a testing and job-matching program can decrease injuries, the ergonomic approach should be considered the first line of work injury prevention. Re-engineering jobs can make them less strenuous, therefore decreasing the potential of injury. This effort substantially increases the pool of potential employees who will be qualified for the job. A larger pool of available candidates will make it much easier for an industry to find qualified applicants, therefore decreasing the costs of hiring. Physical capacity testing demonstrated that 39% of the potential employees did not demonstrate the physical ability to perform the Level 4 job requirements. The fact that there were no shoulder injuries over a 3-year period in the test group would suggest that the majority of shoulder injuries occurring before post-offer testing may have been secondary to their inability to physically perform the essential functions of their jobs.

This study demonstrates that a physical capacity based post-offer testing program appears to decrease the incidence of work-related injuries. There were no injuries to the shoulder in any of the employees tested and matched to their job requirements. A comparison of the tested employees to the control group's testing reflects a diminishment in work related injuries. In summary, there were 0% shoulder injuries in the 248 employees of the test group who were tested and matched to their job. There was a 3.8% injury rate in the 497 employees in the historical control group that were not tested prior to job placement.

5. Conclusion

In this study, a post-offer testing program designed to appropriately match physical capacity to job demands, demonstrated a lower incidence of shoulder injuries in comparison to an untested control group. A well-implemented post-offer physical capacity testing program can potentially decrease the incidence of work-related injuries. Creating a work place with lower injury rates will result in a safer work environment for the employee while simultaneously decreasing the monetary expenses associated with work injuries for the employer.

References

[1] L. Alessio and G. Farina, Work capacity evaluation: the final step of health surveillance, *Med Lav* **92** (2001), 227–238.

[2] D.B. Chaffin and K.S. Park, A longitudinal study of low-back pain as associated with occupational weight lifting factors, *Am Ind Hyg Assoc J* **34** (1973), 513–525.

[3] D.B. Chaffin, G.D. Herrin and W.M. Keyserling, Pre-Employment strength testing: an updated position, *J Occup Med* **20** (1978), 403–408.

[4] G. Chan, V. Tan and D. Koh, Ageing and fitness to work, *Occup Med* **50** (2000), 483–491.

[5] Dictionary of Occupational Titles (DOT): Part 1 – Current Population Survey, April 1971, Augment with DOT Characteristics, and Part II – Fourth Edition of Dicitonary of DOT Scores for 1970 Census Categories [Computer file]. Washington, KC: U.S. Dept. of Commerce, Bureau of the Census [producer], 197?. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor] 1981.

[6] M. Feuerstein, S. Callan-Harris, P. Hickey, D. Dyer, W. Armbruster and A.M. Carosella, Multidisciplinary rehabilition of chronic work-related upper extremity disorder, Long-term effects, *J Occup Med* **35** (1993), 396–403.

[7] B. Gall and W. Parkhouse, Changes in physical capacity as a function of age in heavy manual work, *Ergonomics* **47** (2004), 671–687.

[8] G. Harbin and J. Olson, Post-offer, pre-placement testing in industry, *Am J Ind Med* **47** (2005), 296–307.

[9] G.D. Herrin, M. Jaraiedi and C.K. Anderson, Prediciton of overexertion injuries using biomechanical and psychophysical models, *Am IndHyg Assoc J* **47** (1986), 322–330.

[10] E.P. Horvath, Jr., The preplacement evaluation, *Med Clin North Am* **83** (1999), 1583–1596.

[11] W.M. Keyserling, G.D. Herrin and D.B. Chaffin, Isometric strength testing as a means of controlling medical incidents on strenuous jobs, *J Occup Med* **22** (1980), 332–336.

[12] W.M. Keyserling, G.D. Herrin, D.B. Chaffin, T.J. Armstrong and M.L. Foss, Establishing an industrial strength testing program, *Am Ind Hyg Assoc J* **41** (1980), 730–736.

[13] W. Kuijer, S. Brouwer, M.F. Reneman, P.U. Dijkstra, J.W. Groothoff, J.M. Schellekens et al., Matching FCE activities and work demand: an explorative study, *J Occup Rehabil* **16** (2006), 469–483.

[14] J.S. Lawrence, Rheumatism in coal miners, III. Occupational factors, *Br J Ind Med* **12** (1955), 249–261.

[15] J.G. Lopez, M.D. Ernst and T.W. Wright, Acromioplasty: comparison of outcome in patients with and without workers' compensation, *J South Orthop Assoc* **9** (2000), 262–266.

[16] J.J. Luime, B.W. Koes, H.S. Miedem, J.A. Verhaar and A. Burdorf, High incidence and recurrence of shoulder and neck pain in nursing home employees was demonstrated during a 2-year follow-up, *J Clin Epidemiol* **58** (2005), 407–413.

[17] V. Mooney, K. Kenney, S. Leggett and B. Holmes, Relationship of lumbar strength in shipyard workers to workplace injury claims, *Spine* **21** (1996), 2001–2005.

[18] National Institute for Occupational Safety and Health: A Work Practice Guide for Manual Lifting, 1981; U.S. Dept. of Health and Human Services No. 81–122: NIOSH: 1981.

[19] G.P Nicholson, Arthroscopic acromioplasty: a comparison between workers' compensation and non-workers' compensation populations, *J Bone Joint Surg Am* **85-A** (2003), 682–689.

[20] D.C. Randoph, Use of functional employment testing to facilitate safe job placement, *Occup Med* **15** (2000), 813–821.

[21] M.P Rayson, Fitness for work: the need for conducting a job analysis, *Occup Med Lond* **50** (2000), 434–436.

[22] D.S. Reimer, B.D. Halbrook, P.H. Dreyfuss and C. Tibiletti, A novel approach to pre-employment worker fitness evaluations in a material-handling industry, *Spine* **19** (1994), 2026–2032.

[23] S.H. Rodgers, Job evaluation in worker fitness determination, *Occup Med* **3** (1988), 219–239.

[24] P.I. Sallay, P.J. Hunker and L. Brown, Measurement of baseline shoulder function in subjects receiving workers' compensation versus non-compensated subjects, *J Shoulder Elbow Surg* **14** (2005), 286–297.

[25] S.J. Scheer and A. Mital, Ergonomics, *Arch Phys Med Rehabil* **78**(3 Suppl) (1997), S36–S45.

[26] L.R. Scott, Post offer screening, *AAOHN* **50** (2002), 559–563.

[27] C. Serra, M.C. Rodriguez, G.L. Delclos, M. Plana, L.I. GómezLópez and F.G. Benavides, Criteria and methods used for the assessment of fitness for work: a systematic review, *Occup Environ Med* **64** (2007), 304–312.

[28] J.K. Sluiter, High demand jobs: age-related diversity in work ability? *Appl Ergon* **37** (2006), 429–440.

[29] L. Soleo, C. Romano and P. Apostoli, Fitness for work: the SIMLII Health Surveillance Guidelines, *Med Lav* **97** (2006), 491–500.
[30] R.W. Viola, K.C. Boatright, K.I. Smith, J.A. Sidles and F.A. Matsen, III, Do shoulder patients insured by workers' compensation present with worse self-assessed function and health status? *J Shoulder Elbow Surg* **9** (2000), 368–372.