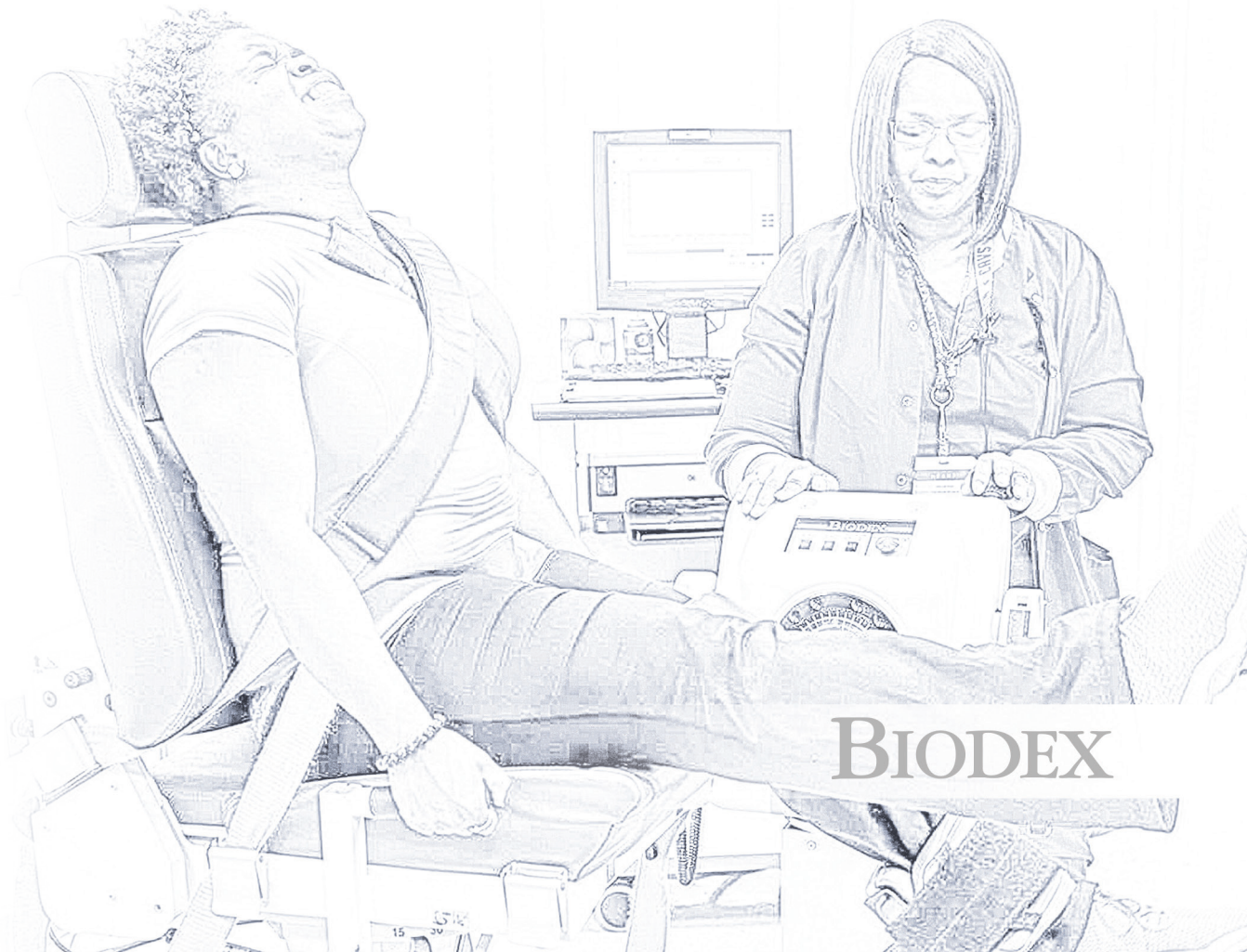


Objective Isokinetic Worker-Strength Evaluation

# Dynamometer Technology Helps Employers Meet Challenging Change in the Global Workforce



**BIODEX**

# Objective Isokinetic Worker-Strength Evaluation Dynamometer: Technology Helps Employers Meet Challenging Change in the Global Workforce

Thomas P. Gilliam, PhD  
Founder & President  
Industrial Physical Capability Services, Inc

From America to the EU to China, employers face multiple challenges in maintaining and growing their companies in the face of a range of demographic and health challenges. They increasingly recognize that they cannot afford to assume physical competence of every applicant, nor accept conventional retirement age to keep their workforce stable in health and capability.

Disorders that once forced affected workers into early retirement can now be treated, albeit with increasingly costly medications and surgical procedures. Many of those with significant physical disabilities are now members of legally protected classes, and despite those disabilities, offer skills and knowledge no employer can afford – or risk – rejecting on subjective observation.

**However, some occupations demand significant levels of physical strength in order to protect employees and others from risk of injury or even death. This white paper discusses the challenges of an aging, increasingly obese and deconditioned workforce, and how many employers are turning to the use of isokinetic dynamometers to objectively determine which employees and job candidates do – or do not – have the extremity strength their occupations require.**

Through the use of the Biodex System 4 Isokinetic Dynamometer, Industrial Physical Capability Services, Inc. (IPCS) and a wide range of companies are enhancing the performance and health of their employees from the point they apply for a position, and into their work careers. Those same dynamometer measurements can reveal inverse relationships between strength and risk of the most costly workforce disease in western societies: metabolic syndrome. This syndrome describes a combination of abdominal obesity, high cholesterol, elevated blood pressure, and insulin resistance that can put individuals at an increased risk of developing cardiovascular diseases and diabetes. Stronger employees tend to have a lower incidence of metabolic syndrome, and consequently, fewer injuries and illnesses, and fewer insurance claims.

## Background: Aging workforce is impacting injury and workers' comp claims

The American workforce has grown older over the last two decades, and employees above the age of 55 will soon

Paul Terpeluk, DO  
Medical Director, Employee Health Services  
Cleveland Clinic

represent more than a quarter of all US workers. Employers often value older workers because of their knowledge, skill, and productivity.

Among 55- to 64-year-old American workers, the labor force participation rate was 61.9% in 2002 and increased to 64.5% in 2012. The Bureau of Labor Statistics (BLS) projects their participation rate to increase further, to 67.5% in 2022. The participation rate for people ages 65 to 74 years was 20.4% in 2002 and rose to 26.8% in 2012. BLS projects the rate for this age group will grow to 31.9% by 2022<sup>1</sup> (see figure 1).

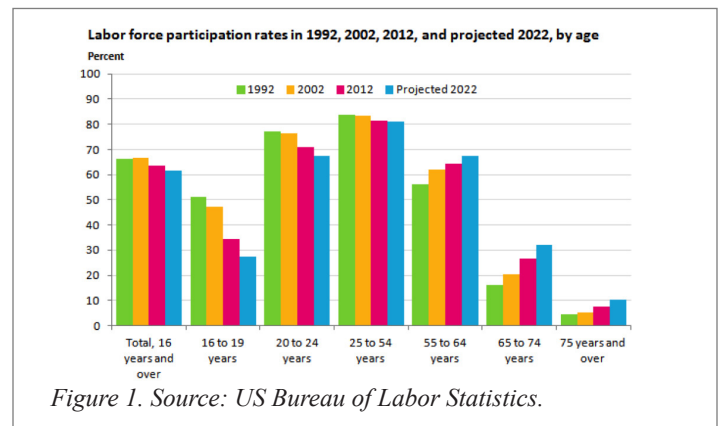


Figure 1. Source: US Bureau of Labor Statistics.

## Aging, obesity – and metabolic syndrome

The aging of the workforce carries the potential for higher workers' compensation expenses for employers, driven by more costly injuries and illnesses, and longer recovery times for older workers when injured.

- National Council on Compensation Insurance (NCCI) analysis of data from 1996 to 2007 shows that lost-time claims with temporary payments to 20-34 year-old employees were similar to those of 45- to 64-year-olds, due to earlier onset of obesity and metabolic syndrome.
- In addition to higher wages for experienced employees, much of this additional cost can be attributed to the presence of comorbidities, more commonly observed in older workers. Obesity, for example, is more common among people 40 and older.

<sup>1</sup> Bureau of Labor Statistics, U.S. Department of Labor, The Economics Daily, Labor force participation projected to fall for people under age 55 and rise for older age groups on the Internet at [http://www.bls.gov/pub/ted/2014/ted\\_20140106.htm](http://www.bls.gov/pub/ted/2014/ted_20140106.htm) (visited November 25, 2015).

Individuals between the ages of 40 and 59 are three times as likely (vs. 20- to 39-year-olds) to be affected by metabolic syndrome comorbidities.

- **These comorbidities can be costly. A 2012 NCCI study found that medical costs for claims with a comorbidity diagnosis were roughly double those of otherwise comparable claims.**
- **The monetary cost of excess lost productive time among obese U.S. workers is estimated at \$11.7 billion per year; two-thirds attributable to presenteeism and one-third to absenteeism.<sup>2</sup>**

If experienced employees are absent from work for extended periods of time – or retire as a result of injury or comorbidities – the result can be troubling, especially for industries already under stress from economic and demographic shifts.<sup>3</sup>

### **Strength & Health: The metabolic syndrome connection**

In many occupations, from healthcare to construction and manufacturing, employee strength is critical to the prevention of injuries. Those who maintain a healthy muscle mass can deliver greater performance due to their greater muscle functionality.

**As a result, stronger workers tend to experience fewer injuries, fewer disability claims, and fewer disease and mortality claims. In some healthcare occupations, such as nursing and physical therapy, extremity muscle strength can be critical in reducing risks to patients as well as professionals.**

Physical strength tends to reflect more than just an employee’s ability to perform certain challenging tasks – it often reflects a great deal about an individual’s general health, and the potential costs and risks they may pose for an employer.

The prevalence of metabolic syndrome in the U.S. ranges from 6.7% in those aged 20- 29 years to 43.5% for those 60 through 69.<sup>4</sup> Research has shown definitively that low muscular strength increases risk for metabolic syndrome. In men under 50, the odds of developing metabolic syndrome were more than twice as great as for those with low muscle strength. The strength of this association was similar for men over 50.<sup>5</sup>

### **Sarcobesity/dynapenia: When BMI fails to describe loss of strength**

While an aging, more obese workforce is well appreciated, less well understood is the importance of how age and obesity fails to fully describe a less physically strong workforce. Although sarcobesity may have significantly and visibly replaced their muscle mass with fat, simple reduction of muscle mass may not fully reflect real reduction in muscle strength: dynapenia (see figure 2). Depending on each subject’s fitness, his or her strength may be minimally – or maximally degraded (see figure 3). Only isokinetic dynamometer evaluation can objectively determine a job candidate’s physical ability to perform an occupation.

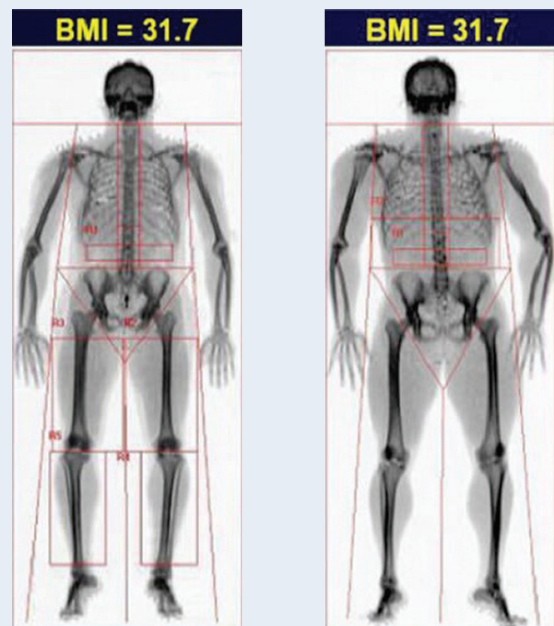
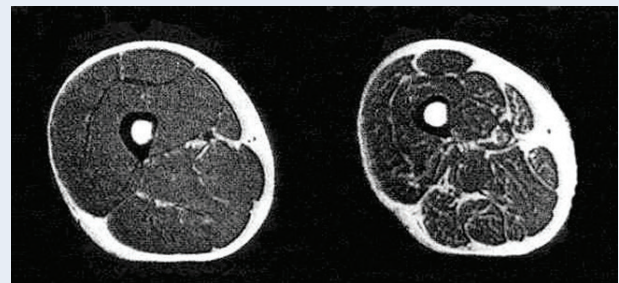


Figure 2. Thigh MRI views of a 25 year old man (left) and a 65 year old man (right) illustrate sarcopenia of increasing age.

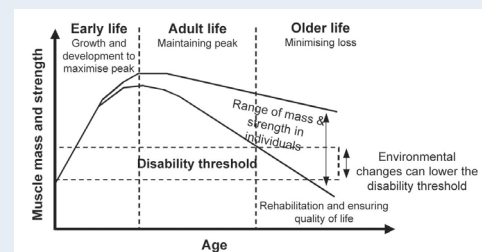


Figure 3. Two DXA scans of women with a BMI of 31.7 shows greatly different muscle/fat distribution - sarcobesity.

<sup>2</sup> J Workplace Behav Health. 2007;22(4):65–79.

<sup>3</sup> Managing workers’ compensation exposures as the workforce ages. Marsh Inc. 2014.

<sup>4</sup> JAMA. 2002 Jan 16;287(3):356-9.

<sup>5</sup> Med Sci Sports Exerc. 2014 Aug;46(8):1475-81.

## Clinical trial demonstrates exercise can reverse dynapenia-sarcopenia in obese women

At Sherbrooke University in Quebec, 38 dynapenic-obese postmenopausal women ( $62.6 \pm 4.1$  years) were randomly assigned for 12 weeks to one of four groups: Just calorie restriction (CR); just resistance training (RT); combined calorie restriction and resistance training (CR + RT); or a control group. Reference was 16 young women ( $22.9 \pm 3.1$  years). The independent variables were body weight, fat mass, and lean body mass (using dual-energy x-ray absorptiometry), waist circumference, fasting lipids and glucose, resting systolic and diastolic blood pressure, and physical capacity (6-min walk, chair stand, and one-leg stand tests).

Before and after the 12-week trial, maximum isometric strength of knee extensors (in newton meters per second) was measured using a Biodex dynamometer. Knee extension was measured with the dominant leg, with the participant in a seated position with the hips at  $90^\circ$  and the knee at  $70^\circ$ .

### Result:

*Resistance training is significant.* Body weight, fat mass, and waist circumference decreased similarly in the CR and CR + RT groups (all  $P \leq 0.05$ ). However, only changes in the CR + RT group were significantly different from the control group (all  $P \leq 0.05$ ). Physical capacity improved significantly in the RT and CR + RT groups (all  $P \leq 0.05$ ), with significant greater improvements in the RT group ( $P \leq 0.05$ ). These results suggest that the combination of resistance training and calorie restriction may maximize improvements in physical capacity in dynapenic-obese postmenopausal women.

## Four factors impact claims today

Four factors are impacting workers' comp claims today:

1. Sarcopenia (loss of muscle). Contrary to common belief, loss of muscle begins as early as age 30.<sup>6</sup>
2. Dynapenia (loss of muscular strength). Loss of muscular strength occurs at a more rapid rate than the loss of muscle.<sup>7</sup>
3. Aging workforce. Due to a variety of factors, American employers actually have more 55-year-olds and 60-year-olds in the workplace today than ever before. As our workforce ages, employers need to question whether their 55-60 year old employees are physically capable of performing the tasks for which they may have been hired a decade or more earlier, as they inevitably will be losing muscle and strength over time.
4. Obesity. In 2011-2013, 34.9% of adults aged 20 years or older were obese, defined as having a Body Mass Index (BMI)  $\geq 30$ .<sup>8</sup>

## Arguably, obesity and modern sedentary life- and work-styles represent the most challenging employee risk factors today.

- The good news: The roughly 340,000 blue-collar workers in the IPCS database shows obesity as measured by a BMI of 30 or more is now leveling off at about 40% of the population.

- The bad news: Those who are obese are moving from a BMI of 30 into morbid obesity.

Morbid obesity is defined by The National Institutes of Health as:

- Being 100 pounds or more above ideal body weight, or
- Having a BMI  $\geq 40$  or
- Having a BMI  $\geq 35$  and one or more co-morbid conditions

Common comorbidity conditions of morbid obesity include:

- Type 2 diabetes
- Heart disease, hypertension and hyperlipidemia
- Obstructive sleep apnea
- Osteoarthritis and joint pain
- Acid reflux/GERD

## While employers can do nothing about employee aging, other factors impacting injury and disability risks and cost can be reduced or reversed if an employee makes an effort to do so.

Employers who offer and incentivize employee participation in programs that maintain healthy muscle mass and strength can see workers lose as little as 4-6% of their muscle as they age, as opposed to upwards of 30%. Such programs can also lead to less absenteeism, fewer injuries, and decreased insurance claims.

## Sedentary lifestyle, morbid obesity: Major risk factors

Many of the workforce risk factors that translate into injuries, productivity loss and medical expenses are the result of Western sedentary lifestyle. Result: Employers see

<sup>6</sup>Int J Endocrinol. 2012; 2012: 127362.

<sup>7</sup>Mitchell WK, Williams J, Atherton P, Larvin M, Lund J and Narici M (2012) Sarcopenia, dynapenia, and the impact of advancing age on human skeletal muscle size and strength; a quantitative review. Front. Physio. 3:260

<sup>8</sup>JAMA. 2014;311(8):806-814.

at age 50-55 the kinds of worker disability they formerly expected from employees in their mid-sixties.

According to the National Health and Nutrition Examination Survey (NHANES), obesity prevalence in 2007-2008 was 32.2% and 35.5% among adult males and females, respectively, representing more than a 100% increase from 1976-1980 and a 50% increase from 1988-1994.<sup>9</sup>

According to a survey of global healthcare literature by Capodaglio and Associates, obesity is associated with reduced participation in the workforce, increased absence from work, disability and health costs. More specifically, it causes a 13-fold greater loss of working days and an 11-fold higher number of compensation claims. In morbid obesity (BMI > 40), healthcare costs are 69–81% higher than in normal-weight workers.<sup>10</sup>

**The Capodaglio survey concluded that reduction in work capacity of obese employees appears to be due to reduced spine flexibility, decay in endurance, limited range of movement of the major joints, reduced muscle strength and capacity to hold prolonged fixed postures, impaired respiratory capacity and visual control.**

Several corporations and healthcare organizations have studied the impact of modifiable conditions on their workforces:

- Pepsi Bottling Group studied the health and injury statistics of more than 11,000 employees, and found health risks Testing must meet EEO guidelines for hiring with the greatest impact on total costs included weight, blood pressure, blood glucose, cholesterol, stress, and depression. Stress and depression had a significant impact on presenteeism costs.

**A one percentage point reduction in the prevalence of all risks was estimated to save PBG about \$3.1 million annually.**

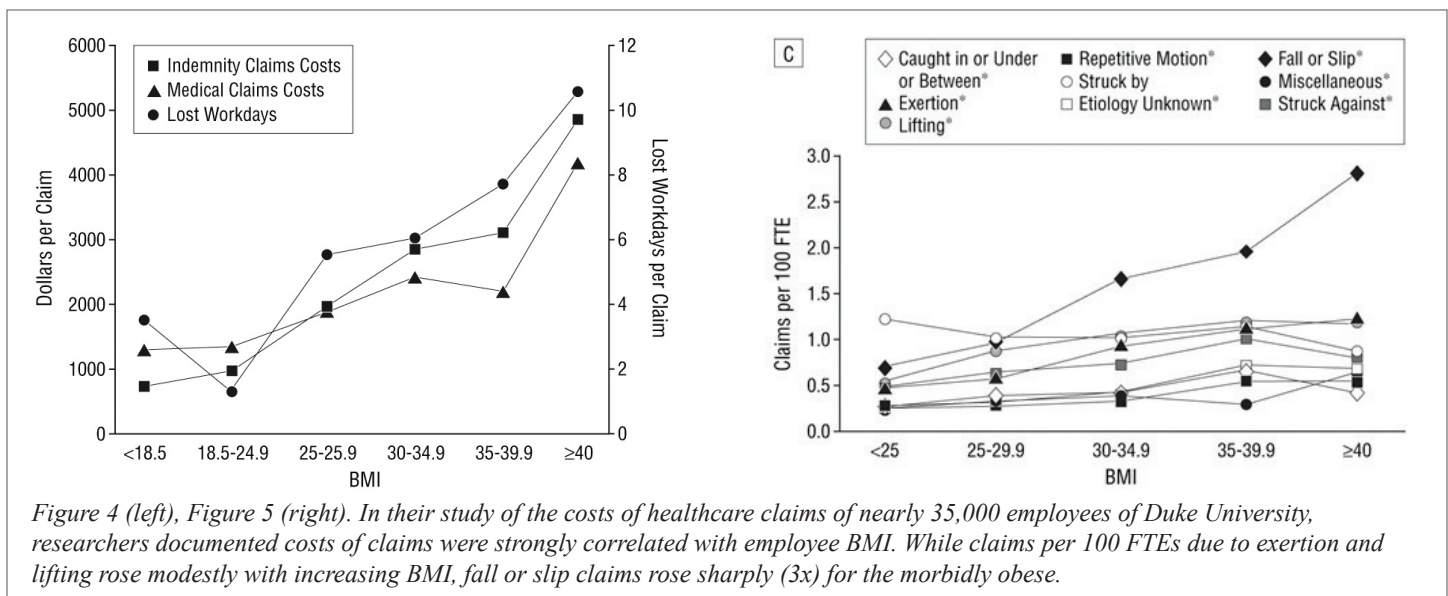
- Arguably the most exhaustive study of employee health on workers' compensation costs is a 2007-published study by Ostbye and colleagues of nearly 35,000 employees of Duke University. The study found a clear linear relationship between BMI and rate of workers' comp claims (see figure 4).
  - Employees in obesity class III (BMI ≥40) had 11.65 claims per 100 FTEs, while recommended-weight employees had 5.80; the workdays per 100 FTEs), medical claims costs (\$51,091 vs. \$7503 per 100 FTEs), and indemnity claims costs (\$59,178 vs. \$5,396 per 100 FTEs) was even stronger.

**The claims most strongly affected by BMI were related to lower extremity, wrist or hand, and back; pain or inflammation, sprain or strain, and contusion or bruise; and falls or slips, lifting, and exertion. The combination of obesity and high-risk occupation was particularly detrimental<sup>11</sup> (see figure 5).**

### Development & implementation of a validated pre-employment physical

In response to the challenge of a changing workforce and rising workers' comp claims, a growing number and range of employers have initiated pre-employment screens that identify those candidates who cannot safely meet the physical challenges of the position they seek.

To meet the needs of those employers, Industrial Physical Capability Services (IPCS) has developed its physical capability evaluation (PCE) technology.



<sup>9</sup>JAMA 303(3), 235-241.

<sup>10</sup> International Journal of Occupational Safety and Ergonomics (JOSE) 2010, Vol. 16, No. 4, 507–523

<sup>11</sup> Arch Intern Med. 2007 Apr 23;167(8):766-73.

Not all individuals can do all jobs since the physical demands of jobs vary, as well as the physical capabilities of individuals. The Department of Labor acknowledges these differences with its five occupational strength-demand categories: sedentary, light, medium, heavy and very heavy.



Thomas Gilliam, PhD  
Founder, IPCS

**Placing a worker into a physically demanding job that exceeds his/her physical capability will result in injury. If the worker is returned to the same job following the injury, the worker will get injured again, and in many cases more seriously.**

Objective, normative data-based physical tests can match the physical capability of the worker to the physical demands of the job – and thus, can prevent such injuries.

To meet anti-discrimination regulations:

- Testing must be valid and current.
- Testing must demonstrate job relatedness.
- Testing must demonstrate business necessity.

In addition, testing must measure against a defensible job task analysis (JTA) and the JTA must be current.

### Shoulder & knee flexion/extension

According to the Americans with Disabilities Act (ADA), strength evaluations are categorized as Agility Tests.

**The IPCS™ PCE™ evaluates the strength of the major muscle groups critical to performing the essential functions of the job as developed in the job analyses. It measures the force generating capability of shoulder flexion/extension and knee flexion/extension. These movement patterns are critical for lifting, carrying, reaching, climbing and bending for most industries where material handling is critical. In most industries, safe materials handling demands specific shoulder and knee strength.**

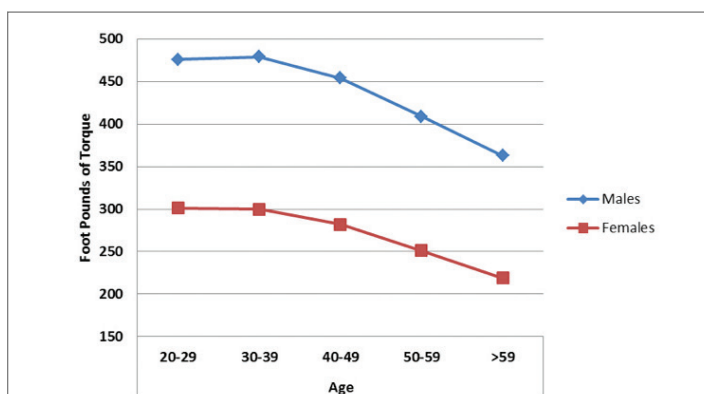


Figure 6. Comparing knee strength across age groups by gender.

To determine the appropriate cutoff score in evaluating the performance of applicants for a specific task, IPCS performs a Job Task Analysis (JTA), which is compared against the Dictionary of Occupational Titles (DOT) frequency of lifting definitions (never, rarely, occasional, frequent, and constant) and the Labor Department strength definitions (medium, heavy, and very heavy). IPCS then establishes a cutoff score for applicant performance calculated to be effective in reducing on-the-job injuries.

Because IPCS reviews and reports on more than 40,000 PCE studies each year, its database is a rich source of information on the strength of American workers today.

**The two charts (see figures 6-7) demonstrate how, among the candidates applying for physically demanding occupations at IPCS clients, there are age-related declines in shoulder and knee strength that could expose these candidates to injury risk if not assigned to strength-appropriate positions, and their employers to a series of high workers' compensation claims.**

### Validation at American Airlines

The initial isokinetic validation study was completed by Dr. Gilliam and American Airlines to confirm cutoff scores for different worker assignments (e.g., cabin cleaner – medium; fleet service clerk – heavy; shop repair person – very heavy). Reviewing the data retrospectively of new hires (4,915) in terms of injury history as it related to the new pre-employment physical capability evaluation program, it was determined that a medium job should have an isokinetic test cutoff of 1.08, heavy cutoff of 1.56, and a very heavy cutoff of 2.24.

American Airlines collaborated with Dr. Gilliam to evaluate ramp workers who load and unload aircraft:

- 1,401 were hired between January 1994 through November 1995 without pre-employment dynamometer testing of physical capability.
- 4,560 were hired between December 1995 and March 1998 after passing an isokinetic evaluation.

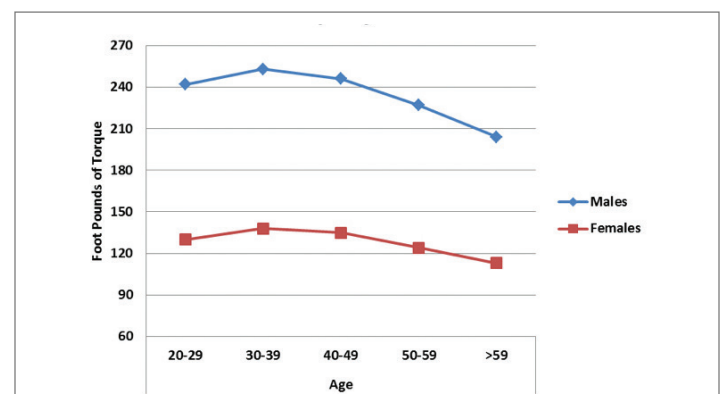
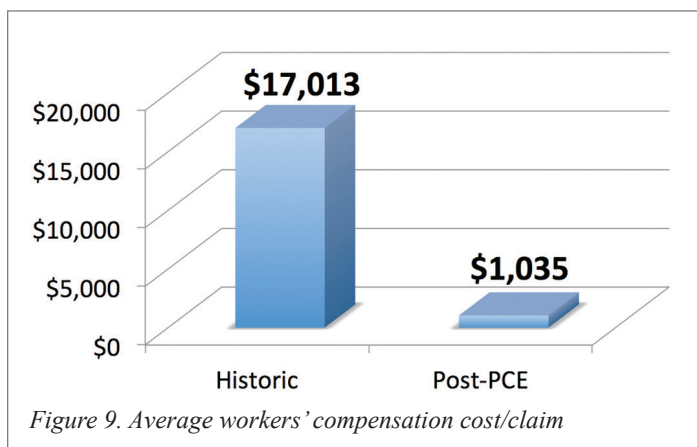
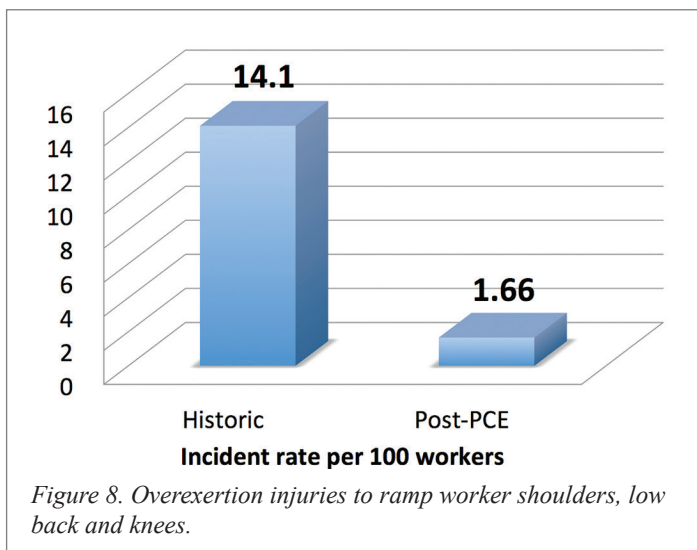


Figure 7. Comparing shoulder strength across age groups by gender.

Both before and after institution of isokinetic evaluation, all went through the same new-hire screening process, except the second group was also given an isokinetic physical capability evaluation with an isokinetic dynamometer.

Following the successful completion of the medical evaluation, the second group of candidates received a job offer contingent on successfully passing the dynamometer assessment. That evaluation consisted of two sets of flexion/extension tests at 60 degrees per second for shoulders, knees and trunk, five repetitions per set. Trunk data was discarded because its sensitivity has been challenged in pre-employment testing.

The isokinetic data was analyzed for peak torque, peak torque to body weight ratio, right/left ratio score, agonist/antagonist ratio scores and a force curve rating for each joint. The data was then combined using a mathematical model to generate a single digit physical capability score. Injury data, lost time data, medical and indemnity costs, hire/termination dates were obtained from several different American Airlines sources. Data from the two groups was compared for overexertion injuries to the shoulders, low back and knees, per 100 FTEs.



**The two graphs (see figures 8-9) show the dramatic reduction in both the incidence and the claims costs resulting from institution of pre-employment isokinetic strength testing for ramp workers at American Airlines.**

**PCE experience at Cleveland Clinic**

Cleveland Clinic is a nonprofit, multispecialty academic medical center that integrates clinical and hospital care with research and education. Today, Cleveland Clinic has



*Paul A. Terpeluk, DO  
Medical Director,  
Employee Health Services  
Cleveland Clinic*

more than 1,400 beds on its main campus and 4,450 beds systemwide. Cleveland Clinic has more than 90 outpatient care locations in northern Ohio with additional locations in Florida, Nevada, Canada, and Abu Dhabi. In 2014, there were 5.9 million outpatient visits, 152,432 admissions, and 192,646 surgical cases performed.

Cleveland Clinic employs 42,000 people, including 3,262 physicians and scientists, and more than 12,000 nurses.

They are self-insured for virtually all risks, with its own workers' compensation, group health and disability programs. A robust wellness program including incentives to help employees lose weight and take care of their diseases – has shown to be effective.

Cleveland Clinic has a culture of wellness, and that culture promotes a safer and healthier work environment. They don't hire smokers.

**Objective: Reduce total healthcare costs, including workplace injuries and workers' comp claims.**

As medical director of employee health services, Dr. Paul Terpeluk oversees the 38,000 people in the health plan. In 2014, there were \$350 million in claims, including both pharmacy and medical. And since they're overseeing all their own plans, they can tie wellness efforts to other programs like disability and workers' compensation.

Between 2008 and 2012, the workers' comp program had \$25 million in incurred liability, of which \$5 million was medical only – about \$1,000 per medical claim and \$22,000 for lost time per case. These numbers are significantly lower than costs incurred by similar institutions.

**Motivating PCE: Minimize patient handling injuries**

Like most hospital systems, our biggest single workers' comp issue is "patient handling injuries." In the 2006-2012 period, 909 patient handling injuries were recorded,

resulting in 20,000 lost workdays and \$6 million in claims. In addition, there are 23 open nursing-litigated cases involving 8,000 lost workdays, for which \$2 million in reserves has been set aside (see figure 10).

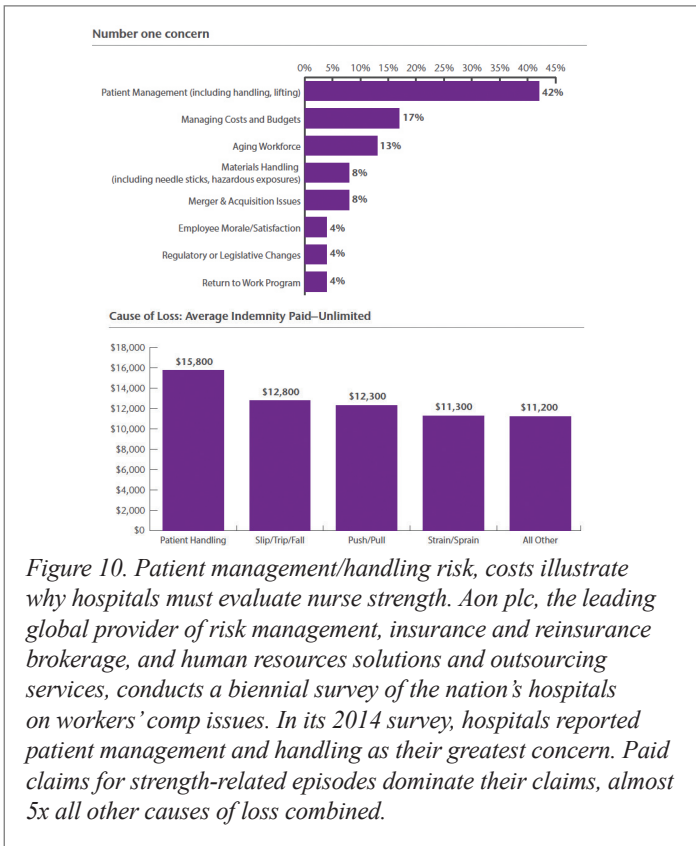


Figure 10. Patient management/handling risk, costs illustrate why hospitals must evaluate nurse strength. Aon plc, the leading global provider of risk management, insurance and reinsurance brokerage, and human resources solutions and outsourcing services, conducts a biennial survey of the nation's hospitals on workers' comp issues. In its 2014 survey, hospitals reported patient management and handling as their greatest concern. Paid claims for strength-related episodes dominate their claims, almost 5x all other causes of loss combined.

Recognized as a pioneer in hospital innovation, CEO Dr. Toby Cosgrove has long been concerned with patient-handling injuries. Concerns arise from both the perspective of employees who may be injured, but more importantly the potential for patient injury as a direct result of the injured employee's inability to protect or support a patient (see figure 11).

Nursing was an area seen as an opportunity to make sure every new patient-handling employee is strong enough to perform the job safely before they are hired. A pre-employment strength-screening program was implemented to assure matching an applicant's physical capability to the demands of different open positions.

Beginning in 2011, all nursing candidates have had to pass a physical capability examination (PCE) utilizing isokinetics to evaluate upper- and lower-body strength.

The image (see figure 12) shows a candidate being evaluated on one of Cleveland Clinic's three Biodex System 4 Isokinetic Dynamometers. It objectively measures upper- and lower-body strength of the muscle groups. A value is then processed by IPCS to determine whether or not a candidate meets the standards established for the job.

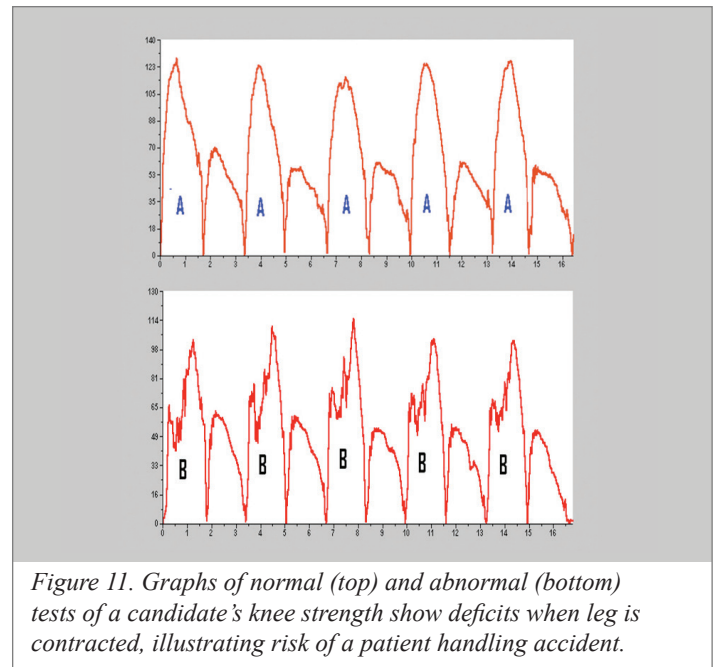


Figure 11. Graphs of normal (top) and abnormal (bottom) tests of a candidate's knee strength show deficits when leg is contracted, illustrating risk of a patient handling accident.

Pass-fail standards are based on Department of Labor standards for the challenges of the job for which candidates have applied, whether it's a medium-, a light- or heavy-duty job. Before a formal job offer can be made, each candidate's dynamometer results are evaluated to determine whether they should be recommended for the job. If they don't meet the standards, they are offered access to the Clinic's gym for 90 days, with the option to reapply and be retested if the job is still open.

After almost four years, PCE program results have been very encouraging. Between 2008 and 2010, before implementing their PCE test, Cleveland Clinic hired about 3,000 nurses. Between the beginning of 2011 and the end of 2014, they hired 6000 nurses, all of whom took and passed the PCE test. Hiring 2000-3000 nurses/year represents a fairly normal 10-20% turnover.



Figure 12. A nurse candidate performs the lower extremity test on one of the Cleveland Clinic's Biodex System 4 Dynamometers. Results are sent to IPCS for interpretation against its massive PCE database.



In studying the results of implementing PCE, an incidence rate for medical claims dropped from 53.7% to 35.3%. Pharmacy claims fell from 41.5% to 27.2%, and workers' comp fell to about a third of pre-PCE levels (see figures 13-14).

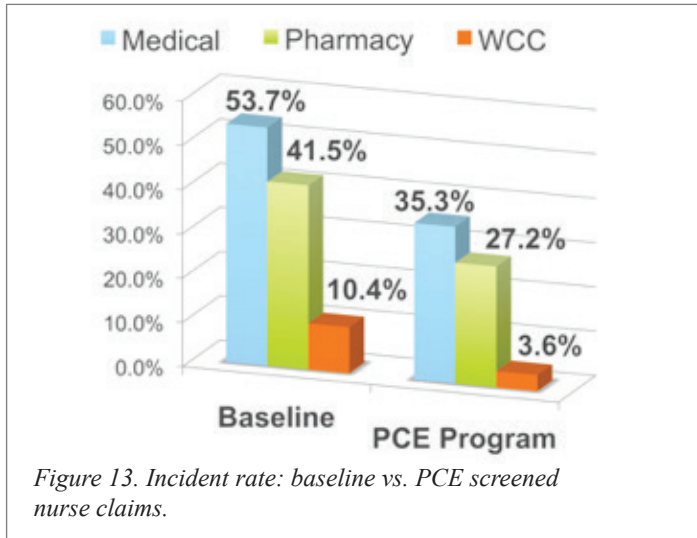


Figure 13. Incident rate: baseline vs. PCE screened nurse claims.

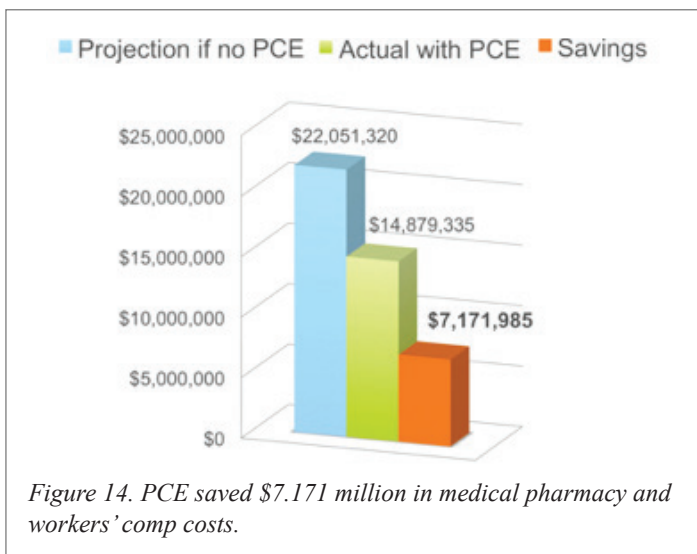


Figure 14. PCE saved \$7.171 million in medical pharmacy and workers' comp costs.

Medical, pharmacy and workers' comp costs forecasted at \$22 million per year fell to just under \$15 million, a gross savings of more than \$7 million. At a cost of less than \$400,000/year, the PCE program has a very high ROI – not to mention the improved confidence in reducing events that distress both employees and patients.

One of the side benefits of performing strength-testing PCE is that it can reduce both absenteeism and presenteeism. The correlation between physical strength and general health is well recognized. For an organization with the motto “patients first,” Cleveland Clinic needs all its employees – but especially those working directly with patients – to be at the top of their game every day. Employees need to be present and capable of taking care of the patients.

Since implementing PCE, Cleveland Clinic has realized a much healthier and happier workforce.

### Muscle strength: New vital sign for workforce

Muscle strength is a key indicator – actually, a new vital sign for the workforce. In the future, as the population gets fatter, older and weaker, employers are going to have to work harder and invest more in maintaining a top-flight employee base.

Physical capabilities evaluation – PCE – can be a powerful tool to keep those costs under control by enabling employers to select those candidates whose strength tests show they are the kind of healthy workers who can help control costs.

**Conclusion: PCE is a valid tool to measure extremity muscle strength, the new vital sign of industrial health. It provides objective data as opposed to subjective tests of the past, meets the stringent standards of the Department of Labor, and is a great investment for optimizing the health of your workforce.**

# BIODEX

Biodex Medical Systems, Inc.

20 Ramsey Road, Shirley, New York, 11967-4704, Tel: 800-224-6339 (Int'l 631-924-9000), Fax: 631-924-9338, Email: info@biodex.com, www.biodex.com