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A review of international countermeasures for the prevention of musculoskeletal disorders: The mountain to Mohammed syndrome

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My research reviewing various nations' handling of their musculoskeletal disorders (MSDs) problem originated with the objective of presenting a paper on the subject to an international audience at the recent 18th Annual World Safety Organization's Environmental, Safety and Health Conference in Denver, CO. This review of the MSD problem from industrial nations was mostly concentrated in comparing regulations and activities between the US and the European Union member states. The investigation's target was to evaluate how progressive the international community has been in complimenting ergonomic interventions with employment physical ability testing as a holistic approach toward the reduction of MSDs. Following a rather exhaustive investigation, the results were startling. Matching prospective workers to their physical job demands does not even appear on the radar screen in well over 20 nations.

MSDs, injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal column, are the overall leading nature of occupational injuries around the world. They are a serious problem requiring scientific, non-partisan, action to design and implement a lasting solution. From my perspective as an active risk professional of over 30 years, the present ergonomic approach as a solution, in and of itself, has been and will remain inadequate.

While there is a consensus of opinion in the world ergonomic and risk control communities that strain and sprain injures are caused by a mismatch between the physical abilities of the worker and the physical demands of the job, for the most part, the international risk community appears to understand the problem and proposed countermeasures from rather narrow parameters.

In the United States, when OSHA focused its attention on the issue of MSDs, it concentrated on ergonomic solutions. OSHA's proposed tiered rule encompassed five specific areas of countermeasure from hazard analysis and engineering controls to medical management of those injuries that do occur. I have had no argument with OSHA's technical direction to counteract MSD-related injuries. My only problem with the agency to date has been its limited approach to correct a complex problem. For example, in the development of the proposed ergonomic rule, there was only one paragraph in the commentary addressing physical employment screening. Even the scientific documentation in support of the 1991 Revised NIOSH Lifting Equation devoted only 1.5 pages out of 270 to pre-employment strength testing where it stated: "It is clear... that the inability to demonstrate a lifting strength equal to that required on the job is a significant risk factor". OSHA's

subrogation of its technical direction principally to ergonomists is not bad, just inadequate.

It was optimistic to assume that somewhere among the international community there had been momentum to think outside the box and approach the problem of MSDs from a more holistic scientific perspective. North America is certainly the hub for ergonomic thinking, education, training, and industrial interventions. It can be understood that the US and Canada's approach to prevention will be skewed toward a solid ergonomic perspective as this sector of the safety community has taken leadership in tackling the problem. It simply appears that the rest of the world is imitating North America's lead.

This has been a nearsighted and narrow approach to a complex problem. Ergonomics intervention is critical to control work-related musculoskeletal disorders. But, ergonomics alone has not been universally successful in North America or elsewhere. It has met with especially strong government and industry resistance among the European Union member countries. A much broader and more comprehensive observation of the problem will conclude that eliminating musculoskeletal disorder injuries from the workplace is most effective through the combination of aggressive ergonomics intervention, physically matching the abilities of employees to the physical demands of their jobs (individual coping skills), and addressing psychosocial contributors.

Let me use an analogy to address the problem. When Muhammad (Mahomet) told his people that he could call the mountain to him where from he could offer his prayers, his people bowed their heads and assembled before him. And Muhammad called to the mountain to come to him, but the mountain did not. And repeatedly again, Muhammad called to the mountain, but the mountain stood still. Finally, appearing neither perturbed nor in the least abashed, Muhammad turned to his people and conceded: "If the mountain will not come to Muhammad, Muhammad will go to the mountain" [4]. I believe that we are still in the stage of the ergonomic specialists' community attempting to move the mountain (re-engineering the workplace) as our primary objective of reducing MSDs. Ergonomists are concentrating on reducing the physical job demands to levels wherein *most all workers* can safely do the job without threat of injury. Unfortunately, this is irrational and scientifically impractical as a sole remedy.

As more effective ergonomic interventions are employed, risk factors that include exposures to repetitive motion, high force, contact stress and overexertion demands are reduced. Figure 1 shows that as applicants for physically demanding jobs are properly matched to the work demands, their ability to meet or exceed these demands is equalized.

Regardless of ergonomic intervention, a small population of employees will consistently create a disproportionate frequency and severity of MSD injuries due to their physical inability to meet even the lowest of physical job demands. There is a large segment of the American population, unable to perform any work above the US Department of Labor's definition of "sedentary" work (exerting up to 10 pounds of force occasionally/negligible amount of force frequently). I estimate, based on credible normative data that in the vicinity of seven percent of the US workforce falls within this category.

1. The universal MSD problem

My review of the MSD problem from over 20 nations included the US, member states of the European Union, Taiwan, Philippines and Australia. The US is the only nation it appears, that engages, with any significance, in pre-employment strength and agility testing, as a proactive countermeasure toward the prevention of MSDs. Let me categorize them simply as physical capability evaluations or PCEs. In the US, the Bureau of Labor Statistics consistently shows MSDs account for nearly one-half of all non-fatal occupational injuries and illnesses; nearly one-third from overexertion. MSDs in Europe account for 0.5–2% of the GNP of member nations [11,19]. Asia and Australia all reported MSDs as one of their top types of occupational claims [2,3,10].

While OSHA has ignored PCEs as an effective countermeasure option for employers, the concept is certainly well-integrated into America's equal employment opportunity regulations such as the Americans with Disability Act or ADA. It is addressed statutorily under 29 CFR Part 1630.12 (a). The Act permits an employer to make inquiries or ask a prospective employee to demonstrate his or her abilities for a particular position without being discriminatory. Employers can legally refuse offering employment to applicants when they are not physically capable of performing the essential physical demands of the job. I could find no such directive in any other of the more than 20 nations reviewed.

There are no nationally published records of how many strength and agility tests are conducted of applicants in the US, but it is my experienced judgment that it is in the range of two to five million annually. They

No Ergonomic Intervention	**High Risk**	**Moderate**
Effective Ergonomics	**Moderate**	**Low Risk**
	No Physical Abilities Matching	**Physically Matched to Work Demands**

Fig. 1. Although both ergonomic interventions and physical abilities matching do have individual benefits, the most effective method of reducing risk is a combination of the two.

range from physical therapy practices' "home grown" versions of work simulation testing to regional and national providers of more sophisticated isometric, isoinertial, functional capacity and Isokinetic evaluations. [1]

It was a rather simplified process to summarize the larger EU member states' common and prioritized countermeasures directed toward the prevention of MSDs, as well as their recent MSD injury data. In October of 2000, 15 member nations participated in a "European Week for Safety and Health at Work". Their activities, themes, and regulatory directives were documented in various European Agency for Safety & Health at Work, "FACTS" publications [6,7].

The EU nations and organized trade unions have adequately addressed the aggravating factors typically associated with MSDs, from overexertion, poor postures and repetitive work to psychosocial contributors.

However, many of these contributors, specifically those associated with overexertion and cumulative trauma, are only aggravating factors and not root causes of MSDs. The primary cause of the vast majority of musculoskeletal disorders is the mismatch between workers' physical abilities and their physical work demands. By properly matching workers abilities to job demands, MSDs will typically be eliminated, most often in spite of these contributing factors. The essential value of ergonomic intervention is that reducing these contributors to MSD development will significantly expand the labor pool available to meet the essential physical work demands.

[1]Isometric: Measures muscle peak torque in one static position only, such as pulling against an unmovable bar. Isoinertial: Measures the lifting of progressively heavier weights at a set frequency over a specific range of motion. Functional capacity: Measures human performance by work simulation and some Isoinertial testing. Isokinetic: Measures maximum muscle torque throughout the entire range of motion of the respective joint at set speeds.

Clearly, the root causes of most of those injuries classified as RSI (repetitive stress injuries) are from prolonged distal upper extremity contact, mechanical stress, awkward postures, vibration, temperature extremes, and uninterrupted repetitive movement. While many of these RSI injuries may be minimized by more physically matched workers, I do concur that ultimately most of the injuries will surface regardless of the employee matching process. The extent of RSI's can not be understated. They are ubiquitous throughout industry, in every nation, and a very serious problem. The proposed countermeasures suggested by ergonomists and trade unions are certainly on target. Unfortunately, all of the countries surveyed tend to lump MSDs into a single overall category with a fixed and universal approach toward their prevention.

It is evident that the EU's exclusive remedy to "effectively" prevent MSDs is to identify workplace risk factors and execute proactive measures to prevent or reduce these risks. On the surface, this approach is entirely logical. Unfortunately, it is a limited solution. From reviewing about a dozen of the main European directives relevant to preventing musculoskeletal disorders, all are centrally lumped into risk identification, materials handling, video displays, lighting, machinery and PPE. Nothing addresses matching the worker to his job demands.

There is an adage in medicine that broadly says that to a hammer, everything looks like a nail. When applied to the prevention of MSDs, regardless of nation, ergonomists have, in general, only applied ergonomic solutions to the problem. The Scandinavian countries should be recognized for some well-deserved credit in their elevation of psychosocial factors as significant contributors to MSDs (job content, work pace, stress, lack of influence of worker over his own work). This falls outside the normal sphere of ergonomic consid-

erations and should be integrated into any holistic approach to the problem [9].

2. Understanding MSD etiology from the European perspective

In reviewing Sweden's revised provision of their AFSI 1998:1 directive: "Ergonomics for the Prevention of Musculoskeletal Disorders", it gives an insight into this country's, and as it seems, all of the EU's, understanding of the etiology of MSDs and the commonly favored approach to their prevention.

For example, one of the 12 mandatory clauses of this directive aimed at employers, Section 3 states [17]:

The employer shall ensure that work requiring the exertion of force is, whenever practically possible, ordered and designed in such a way that the worker can work with a work object, working equipment, controls, material, or movement of persons without being exposed to physical loads which are *dangerous for health or unnecessary fatiguing* (emphasis added).

Here is a partial fault with this directive. What is "dangerous" (acute trauma) or "fatiguing" (repetitive motion disorder) to one worker may not affect another who is physically matched by strength, flexibility, and endurance to the job's demands. By what objective metric does the employer gauge compliance with both the intent and letter of the law?

Without a well-defined analysis documenting the extent and frequency of each job's strength, flexibility and endurance demands and objectively matching applicant's physical capabilities to those demands, there is no way an employer can come close to meeting the intent of this directive.

3. Ergonomics and workers' aging

The facts are universally clear that older workers, those 55 and older, typically experience more severe MSDs. Industry must take this into consideration in the design of work processes. To what extent, however, does the job require modification to the age of the worker? There is credible scientific opinion from the physical therapy community that humans, beginning in their late 30's, lose approximately 10% of both strength and agility each decade, unless consistent strengthening and flexibility conditioning are self-employed to counteract the aging process. Is the employer responsible to modify the job to meet the lowest potential physical ability of the oldest worker so as not to present an undue risk? If a workplace is initially comprised of younger workers, as the workforce matures, do previously acceptable work practices require ergonomic intervention as this workforce ages? Do we continuously attempt to bring the mountain to Mohammad or begin to see the value of moving toward the mountain by first matching workers to their job and taking the initiative to keep them strong and flexible as they age? Certainly, the continuous process of enhancing workplace ergonomics should remain a high priority and kept current with technological advances. Maintaining employee fitness is just beginning to take some shape in America but does not appear to be addressed by the rest of the world.

The underlying systems defect that creates these injuries is the increasingly de-conditioned workforce. From my personal observations, employers ultimately have to take responsibility for maintaining a fit labor force. Employees will not take their own initiative to remain fit as nature works against them. Workers do not need to lose significant strength and flexibility over time. It just happens to be the modus operandi of much of the Western World. Employers can assist workers in maintaining requisite strength and agility through on-site fitness, or through augmenting an existing employee assistance program (EAP) with incentives to maintain fitness and agility. Those identified as becoming mismatched to physical work demands may be transferred to less demanding positions without loss of wages, benefits or seniority.

These are not easy solutions. The aging workforce is a reality and effective countermeasures need to be employed very soon. Employers now have the technology to routinely, effectively monitor the progressive gap between worker strength, agility and job demands to identify injury potential before it occurs. It is just finding the right solution for the specific work culture.

4. The holistic solution to the prevention of MSDs

While my findings are critical of all of the industrialized world nation's approach to MSD prevention, US legislation fares none the better. With that said, the US is at least a decade ahead of other nations in addressing the matching of workers to physical job demands. All of this activity has been spearheaded, not by government or ergonomists as an organized body, but by industry's direct action to find its own workable solution to the MSD problem.

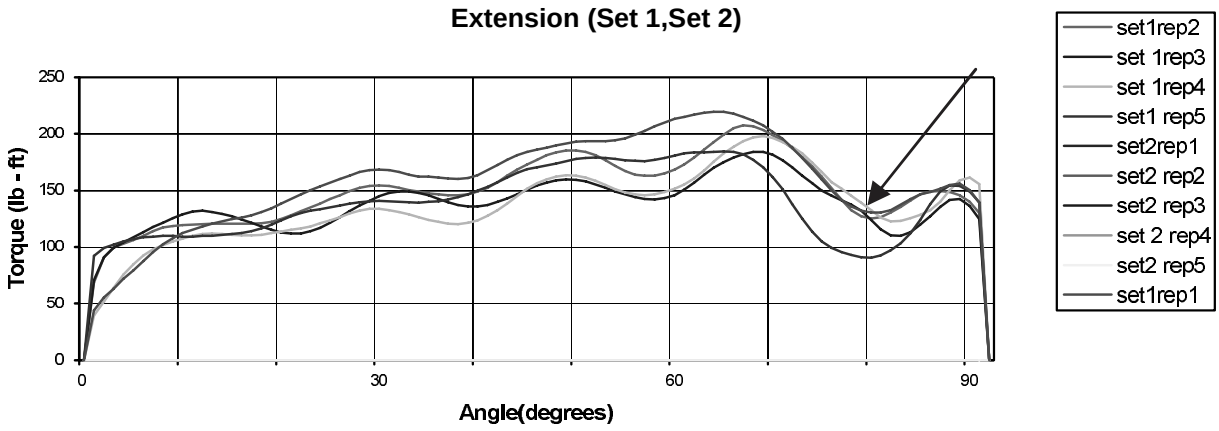

Fig. 2. Isokinetic Evaluation of the Truck Extension at 60 Degrees per Second [Courtesy of Cost Reduction Technologies, LLC (CRT)].

While the peer-reviewed scientific literature is considerably limited in formal prospective studies on the success of pre-employment PCEs, there is a large body of employer and screening vendor-produced studies with MSD cost reduction results ranging from 20–90%+ [15,16]. While non-peer reviewed data meets with considerably less credibility by impartial observers, some of these results come from my own Fortune 500 clients and are unmistakably reflective of screening benefits.

From my years of testing experience, combined with discussions involving a large number of employers engaged in physical ability employment screening, and a review of the limited available research on the various forms of measuring prospective human performance, I have found that nearly all, with the possible exception of functional capacity evaluations, have some merit as a pre-employment PCE in predicting MSDs involving physically demanding jobs [1,12,14,18,21]. From my extensive work over the last five years with some of America's largest employers, it is my opinion; isokinetics clearly leads in technology [8]. Isokinetic testing measures a muscle's maximum strength (torque) throughout its entire range of motion at a controlled speed. Figure 2 represents an Isokinetic force curve report of a trunk extension from an uninjured subject who presented for a pre-employment strength and agility evaluation for a physically demanding job. The graph represents extension of the joint when the subject is bent over at the waist 90 degrees and then raises upright to zero degrees.

The muscles of the hamstrings and buttocks support the first 20–30 degrees of the extension of the back (from 90 degrees to about 60–70 degrees). They have a mechanical advantage before the back muscles kick in. If these muscles are relatively weak (as noted in the area represented by the arrow), the back has to engage the load earlier, without its mechanical advantage, which can result in either an acute or a cumulative trauma disorder. This is just one observation that can be made from objective Isokinetic data, yet overlooked by work simulation, isoinertial and isometric testing.

This is not to suggest that some isoinertial test protocols and combinations of isoinertial/isometric evaluations can not predict prospective injury potential. It has been my experience using every form of human performance measure in predicting MSDs that these other forms are too subjective, have significant interrater reliability issues, can cause disabling injuries (and law suits) and are just not too impressive. I cast "work simulation" testing into its own category of "truly ineffective" physical ability screening. For example, take one of America's newest federal agencies, the Transportation Security Agency, which, in about two year's time, has created the worst employee injury record of any federal agency and pretty much all of the private sector [20]. What is their pre-employment physical ability model? Work simulation.

The following scenario is how I believe the process works best. An employer begins with an ergonomic job task analysis conducted of each job classification subject to employment screening. With test vendor assistance, the push, pull, lift and carry forces are recorded along with task frequencies and correlated to US labor standards for physical work ranging from sedentary to very heavy, with intermediate classifications. Applicants are subjected to a standardized Isokinetic PCE whereby isolated muscle groups are tested for peak torque along their entire extension/flexion range of motion. Isokinetic vendors, using proprietary for-

mulas correlated to large normative databases, evaluate these independent groups working functionally as a whole body. Then, the test results are compared to the minimum threshold standards for each specific job and applicants meeting the minimum standard are offered employment meeting ADA guidelines.

US results with pre-employment Isokinetic technology have been remarkable in every industry sector even when employers are not engaging in ergonomics intervention. Now, combine this countermeasure with effective ergonomics intervention, and most overexertion disorders can be prevented.

Early in the injury process, American employers can utilize the same Isokinetic technology to initially identify the nature, extent and legitimacy of MSDs. Non-congruent Isokinetic force curves quickly alert the tester to sub-maximal patient effort. Unfortunately, the standard, subjective, post-injury functional capacity evaluation still dominates in the US and around the world.

5. Conclusion

Musculoskeletal disorder injuries are universal in every industrial nation throughout the world. Their frequency and severity represent a measurable impact on each nation's gross domestic product. The international response has been largely focused on ergonomic solutions to the very complex problem of MSDs. Even with years of ergonomic intervention experience, the problem continues to represent the primary nature of injury among workers. Ergonomics intervention alone is not the solution.

Science has afforded employers the opportunity to identify physically mismatched workers to job demands with relative ease and low cost. It is a simple process that is best implemented at the applicant stage of the hiring process. Isokinetic physical capability screening, one among four separate technologies to measure and predict human performance, appears to be the most promising in reducing MSDs. Incumbent and aging employees present a unique exposure but one that can be effectively addressed through implementation of an aggressive, employee-centered, surveillance program to identify widening gaps between strength and flexibility and physical job demands. To optimize workforce performance, the best approach to the elimination of musculoskeletal disorder claims is the combination of ergonomics intervention, addressing psychosocial contributors, and the application of physical abilities employment screening. It will take the unbiased participation of ergonomic specialists throughout the world to ensure a lasting solution to a very serious problem.

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