Response to the Position Paper of the European Interdisciplinary Society for Clinical and Sports Application (EIScsa): Muscle imbalances – fact or fiction?

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The authors of Muscle Imbalances – Fact or Fiction, have correctly identified the complexities of quantifying muscle imbalances as related to predisposition to injury. It seems intuitive that significant muscle imbalance would predispose one to injury during high performance sport or strenuous activities common with laborers in industrial settings. However, scientific evidence in support of this impression requires prospective research paradigms involving pre-injury screening of large numbers of uninjured subjects. One good analogy is the clinical assumption that stretching and muscle extensibility reduces sports injury risk. Thacker et al. [1] conducted a systemic review and meta-analysis of the literature in an attempt to find evidence that stretching prevents or reduces injuries in sports. The authors found that stretching is not significantly associated with a reduction in injury risk, and concluded that the evidence for or against stretching is equivocal.

The authors have also correctly pointed out that single-factor-related analysis (e.g., uniplanar strength ratios) of muscle function reflects an insufficient approach to identifying a higher risk of overuse or traumatic injury or re-injury. However, I continue to contend that open chain analysis of single muscle group performance is the best way to identify pre- or post-injury deficits in torque, power, and work, that can be overlooked with more functional closed chain analysis. For example, Kowalk et al. [2] evaluated bilateral joint angles, moments, powers, and work in uninjured and anterior cruciate ligament (ACL) deficient subjects during stair climbing pre- and 6 months post-operatively. Post-operative deficits were found for peak moment, power, and work in the injured knee, yet these reductions were compensated by increases in excursion, moment, and power in the contralateral ankle. Ernst et al. [3] conducted a video analysis of ACL reconstructed and matched uninjured subjects during vertical jump, lateral step-up, and hop activities. They found that the ACL-injured side had lower knee extension moments compared to the uninjured side and matched subjects. However, no differences in hip+knee+ankle summated moments were found, and the injured side hip was found to have compensated for the knee moment deficits. These studies provide evidence that while closed chain functional analysis is important, it alone is insufficient in identifying single muscle group deficits that can be masked with proximal or distal joint, or contralateral extremity compensations.

I agree with the authors that a detailed analysis of muscle function that includes passive and active characteristics of muscle lengthening (flexibility, stiffness) and sensorimotor function parameters (e.g., stabilometry, proprioceptive aspects, reflex and electromyographic activity) would more comprehensively assess injury risk. However, this comprehensive analysis of muscle function is impractical for screening large num-
bers of athletes and industrial workers for purposes of identifying injury risk.

One alternative to single-factor-related analysis (e.g., uniplanar strength ratios) of muscle function for assessing injury risk is to determine a strength index for the major muscle groups involved in performance of sport or manual labor. For example, Injury Reduction Technology, Inc. (INRTEK) [4] uses an algorithm to determine an overall isokinetic strength rating for the knee, shoulder, and trunk flexor and extensor muscle groups. An overall strength index is calculated from a total torque index score, body weight index score, and includes an analysis of right/left ratios, body weight ratios, flexor/extensor ratios, and examination of torque curves to determine if curve shapes are acceptable. The database includes thousands of workers tested over a ten year period, and classified on one of the physical demand work levels defined by the US Department of Labor Definitions of Strength Levels (i.e., sedentary, light, medium, heavy, and very heavy). From the isokinetic strength rating algorithm, INRTEK recommends a maximum work level for each individual pre-screened.

Companies that have adopted this system of qualifying job candidates through isokinetic strength testing protocols have reported significant reductions in injury incidence and severity. For example, Gypsum Management & Supply, Inc., a drywall and building materials distributor, used the strength index to identify workers who were qualified as having the minimal strength required to perform essential functions of each job (e.g., warehouseman, driver, deliveryman, or some combination of each). Direct cost reductions were calculated based on specific reductions in injury incidence rates and average cost per injury. Tested and untreated workers were tracked at 60 locations for 33 months. The injury costs for the untreated population for knee, shoulder, and back injuries was $88,616, and 501 workers experienced a total reduction in incidence rate and average cost per injury of more than 80%. Table 1 shows the actual incidence rates and average costs per injury for tested and untreated knee, shoulder, and back strains and sprains – and the percent reductions for each. The reductions in each category compound to create the 80% cost reduction per 100 workers per year.

The use of an index of isokinetic strength scores from multiple joints, rather than a single-factor-related analysis (e.g., uniplanar strength ratios) of muscle function for assessing injury risk appears to have excellent application in the industrial work setting. The INRTEK system should be submitted for scrutiny by the scientific community, and the potential application of the system to the athletic population determined.

### Table 1

<table>
<thead>
<tr>
<th>Knee, Shoulder, &amp; Back</th>
<th>Tested</th>
<th>Untested</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Cost Per Injury</td>
<td>$853</td>
<td>$1,926</td>
<td>56%</td>
</tr>
<tr>
<td>Incidence Rate</td>
<td>3.12</td>
<td>7.69</td>
<td>59%</td>
</tr>
<tr>
<td>Cost Per 100 Workers Per Year</td>
<td>$2,661</td>
<td>$14,807</td>
<td>82%</td>
</tr>
</tbody>
</table>

I applaud the EIScsa for addressing the complex matter of muscle imbalance and its potential association with a higher risk of overuse or traumatic injury or re-injury. I agree that single-factor-related analysis (e.g., uniplanar strength ratio) of single muscle groups is an insufficient approach to predicting and reducing injury incidence and assessing muscle recovery after injury. The role of strength indexes calculated from isokinetic tests from multiple joints, and the value of more complex assessments of muscle function (e.g., stabilometry, proprioceptive aspects, reflex and electromyographic activity) in predicting and reducing injury in athletes and industrial workers deserves further study by the scientific community. Finally, the authors mentioned the lack of normative data and the problems associated with the variations in the normative data that does exist. Perhaps it would be helpful if the European Interdisciplinary Society for Clinical and Sports Application would recommend a universal method of norms gathering, to include standard methods of computing right/left, flexion/extension, and torque scores.

### References


### Disclosures

David Perrin was a member of the dissertation committee of G.P. Ernst at the University of Virginia. The Ernst et al. reference cited in this commentary emanated from this dissertation. David Perrin is currently serving as a consultant for Injury Reduction Technology, Inc.