6. Conclusion

In spite of advances in measurement techniques and an explosive increase in the volume of research, our understanding of human strength remains in its introductory stages. It is clear that muscle strength is a highly complex and variable function that depends on a large number of factors. It is not surprising, therefore, that large differences in strength exist not only between individuals, but even within the same individual tested repeatedly on a given piece of equipment. The issue is compounded by the fact that correlations of strength among different muscle groups in the same individual are generally low, and tests of isometric strength do not necessarily reflect the strength an individual might exhibit in a dynamic test. As a result of these and other influences, great care needs to be exercised in designing, evaluating, reporting, and interpreting muscular strength assessments.

Traditionally, tests of muscular strength were in the domain of the orthopaedist, physical therapist, and exercise physiologist. Such tests are also an important tool for the ergonomist, however, because of the high strength demands on workers in manual materials-handling tasks. In some cases, task demands may approach or even exceed the strength that an individual is voluntarily willing to exert in a test of strength. In such cases, evidence suggests that the likelihood of injury is significantly greater than when the task demands lie well within an individual's strength capacity. Because the relationship among strength capabilities, job demands, and musculoskeletal injury has been established, it is apparent that tests of muscular strength may benefit the ergonomist both in designing jobs and in ensuring that individuals have sufficient strength to safely perform physically demanding jobs. Several strength assessment techniques have been employed for these purposes, each possessing unique characteristics and applicability to job design and worker selection procedures. Our main purpose has been to elucidate these strengths and weaknesses, so that tests of strength may be properly applied in designing jobs and selecting workers.

One of the crucial points we have emphasized is that any test of strength used in job design or worker selection *must be directly related to the demands of the job*.[1] For example, if an occupational lifting task has a high dynamic component, a test of isometric strength is not likely to provide the data necessary for proper design of the job. Of course, dynamic strength tests would also be misapplied in assessing a job requiring isometric exertions. Another potential pitfall is using tests of strength on isolated muscle groups and assuming that they are indicative of whole-body strength. For example, one might mistakenly assume that dynamic trunk extension strength represents a person's capability to perform a lifting task. However, an individual's lifting capacity may be entirely unrelated to trunk extension strength. It may, instead, be limited by an individual's arm or leg strength, depending on the task being performed.

A final point on strength assessment should be made. An individual's strength capability cannot be considered a fixed human attribute. Strength training regimens can increase an individual's strength capability by 30%–40%. Whether

such changes have a preventive effect when a person performs heavy physical work has yet to be established in epidemiologic studies; however, some anecdotal evidence supports the possibility.[1]

It should be clear from this publication that muscular strength tests are tools that can be used to prevent occupational musculoskeletal disease. However, if these techniques are to be applied successfully, it is imperative that they be applied with a clear understanding of the advantages and limitations associated with each strength assessment procedure.

Reference

1. **Chaffin, D.B., and G.B.J. Andersson:** *Occupational Biomechanics,* 2nd Ed. New York: John Wiley & Sons, 1991. p. 518.

Appendix

Typical Written Instructions for Isometric Strength Testing

"The strength tests you will participate in today will be isometric — that is, there will be no actual movement of the body during the test. Instead, you will be exerting a force against [*here enter the description of the interface between the testee and the testing hardware*]. The attached photographs (sketches) show examples of people doing the tests."

"The test procedure will be conducted as follows:

1. Each test will be explained to you.
2. Each motion you will be asked to perform will be demonstrated. If there is anything you do not understand, please ask questions.
3. You will be placed into position at the [*interface*].
4. The test motion you are to perform will be demonstrated again.
5. You will try the test motion. If you have an questions about the test motion, please ask questions.
6. You will be given a 1-minute rest.
7. You will perform the first trial of the test.
8. You will be a given a rest of at least 2 minutes.
9. You will perform the second trial of the test. In some cases, you will receive additional 2-minute rests and perform additional test trials."

"During each test, I will position you for the test. I will tell you to 'begin when you are ready.' You can begin your exertion any time after that. While you are performing the test, I will be giving you a slow four count 'one, two, three, four, relax.' Do not stop your exertion until I tell you to relax."

"Do not jerk against the interface. Gradually increase your strength to the maximum you feel comfortable exerting, and then hold that force level until you are asked to relax. It is important for you to maintain your maximum exertion during the entire test. When the relax command is given, you may relax as fast as you want to."