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SCIENTIFIC TREATISE ON THE BASES, PRINCIPLES, VALIDATION AND PROTOCOLS FOR ISOKINETIC TESTING IN THE WORKPLACE

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INTRODUCTION

When implementing a new protocol for testing human function, information on test rationale, the development of test protocol, and how the information is related to the occupational employee population is important. This treatise is intended to provide the scientific reviewer or medical practitioner with background information on the basis and principles of testing with a state of the art, electronic, isokinetic dynamometer in assessing human function relative to the work environment. The information contained in this treatise is based on the scientific literature that includes the use of statistical procedures applied to experimental and correlational data across independent studies addressing a related set of physical therapy research questions, experience of and research directed by this author, and generally accepted professional standards as represented in multiple physical therapy textbooks presently used in universities. Additionally, research and testing data from the ET 2000 dynamometer manufactured by Cost Reduction Technologies (CRT) was used to form some of the university-based analyses.

BACKGROUND TO THE DEVELOPMENT OF THE TEST PROCEDURES

Selection of isokinetic testing, as a preferred form of assessing human function in an occupational work environment, was based on numerous factors and considered with respect to the other options (isoinertial, isotonic, or functional capacity evaluations). Issues of safety, validity, reliability, practicality, predictive ability of the data, and time

required for testing were all considered. Based on these criteria, I believe that isokinetic testing is the best of all the alternative procedures available, and meets generally accepted professional standards of measuring human performance. In addition, there is increasing scientific literature that test results of isokinetic testing are related to functional abilities.

The relationship of isokinetic testing of joint function to results of functional capacity evaluations (FCEs) is often of interest to those testing occupational human performance. The isokinetic test battery is usually performed on isolated joints and is capable of conveniently testing the most frequently injured joints: the knee, shoulder and spine. FCEs use a test battery as described in the name, that is, they are functional and attempt to evaluate capacity of overall human performance.

Isokinetics vs. Function

There have appeared in the literature some works that indicate that isokinetic testing is related to functional performance. There are no known academic treatises on the inter-relationships of FCE and isokinetics. Most of the peer-reviewed works that are available are in journals specific to sports or other performance criteria and not to the everyday work environment (Wilk, Westblad, Barber, Karlsson, Noyes, Sachs, Swarup, Tegner, Wiklander). Wilk does make the point that reciprocal testing of the knee joint appears to be "crucial" in the relation of test results to functional ability. Thus, testing of reciprocal motions would be recommended. In sum, there has been little interest in the topic of the relationship of isokinetics and FCEs in the work environment, leading to few research results reported in the medical literature on this topic. There are some studies that do not establish the relationship between isokinetics and function in the sports sciences. This finding has been verified through attempts at literature searches of these topics with other computerized search engines. There is, however, a gathering pool of data that is supportive of the relationship of isokinetics to functional performance, and even though most of the evidence comes from the sport science literature this establishment of the relationship should carry over to testing that is germane to the work environment.

Also in need of consideration are the other issues associated with testing for work performance. In a comparison of test forms there are certain advantages and limitations associated with any system of choice. The summary table that follows compares these systems.

MATCHING CRITERIA WITH TEST FORMS

Criterion	Isokinetics	Isoinertial (isotonic)	Simulated FCEs
Safety	+++	++	+++
Reliability	+++	+	+
Validity	+++	++	+
Practical	+++	+++	++
Meaningful	+++	++	+++
Predictive	++	+	++

While the system of assigning one to three pluses is arbitrary, this method allows for making a comparison across the three most commonly used systems for assessing human performance in the work environment. One might note, however, that no category for "functionality" is included, but only for the reason that there is no information on which to base a comparison. Specific research that will establish the isokinetic/FCE relationship is likely to be forthcoming. There has only been a short time since the advent of isokinetic (and even other forms of) testing for the worker, and thus some time is needed to secure and publish the data to establish such a relationship.

THE ISOKINETIC DYNAMOMETER AND VALIDITY

A key feature of any of the test instruments is validity. This concept of ***actually testing what you are purporting to test*** is extremely important when considering how appropriate your data are from any given test. In the research and development of the next generation electronic dynamometer, designed and manufactured by Cost Reduction Technology, LLC (CRT) as the ET 2000, the validity of isokinetic testing was addressed. To do so the scientific literature was thoroughly reviewed, which revealed that the matter has not been very completely investigated or reported. For example, of the 34 references in one text to validity of five dynamometers only five citations include validity in the title. Of these five, four are only abstracts and thus not published in peer reviewed journals. (Davies) The remaining published article deals with the validity and reliability of one specific dynamometer.

Many would argue that the isokinetic test is intuitively valid, as this procedure directly tests muscle and joint function. Results from isokinetic testing are in fact comparable to the results of true and very scientific experiments on muscle performance published as early as the 1930's (Hill and others). The data of these investigators have been reproduced by many other researchers who have applied isometric, isotonic and isokinetic tests to human function, verifying that the mechanical output of human muscle is similar to that of other animal forms. For example, there are convincing data that maximum effort from shortening muscle generates less tension as the muscle shortens at faster velocities.(Soderberg) The opposite is true when lengthening contractions are required. Considered across the spectrum of research that has evaluated muscle performance there is a great amount of agreement of the results of the testing of human

function with isokinetic dynamometers. This type of validity would likely be considered as construct validity.

Other specific examples of research addressing the validity of isokinetics can be found in the scientific literature. Examples appear in peer-reviewed publications by Dvir and Keating, and Westblad et al. with a summary in Gaines and Talbot. It is also very important to realize that isokinetic testing is considered to be valid by members of the practicing health care and clinical community. This is because of the history of use of such testing devices, the common occurrence of articles in published scientific literature, and the meaningfulness that can be applied to the data generated from the joint testing.

Validity of the simulated FCE has been more difficult to establish and the literature is too detailed to include a comprehensive summary here. An example paper by Lechner et al. is specific to one test (which most papers of this type are) and a summary of validity and other issues can be found in the publication of King et al.

Because a statistical relationship can be shown between the test scores and job safety some would conclude that isokinetic testing has criterion-related validity, but because of the variability in definitions and how they are applied disagreement may be offered by some. That isokinetics measures the degree to which candidates have identifiable ability to exert joint torques, which have been determined to be important in successful performance on the job, also lends credibility to this type of validity.

A substantial number of employers have reported on the high predictive validity of isokinetic testing as a pre-employment physical strength assessment tool. There is little incentive, however, for corporations to advance their injury reduction findings to the level of academic research.

ISOKINETICS – RELIABILITY

Results from testing completed with ET 2000 models in the Southwest Missouri State University, Department of Physical Therapy's laboratory supported the durability and objectivity of the device as well as the reliability of the results from tests of the shoulder, knee and spine. Repeated trials demonstrated a high degree of replication, particularly at the test velocity of 60 degrees per second, the velocity adopted by CRT for testing protocols. The human joint torque curves produced by the subjects were consistent with literature published in peer-reviewed journals.

The actual engineers who designed the CRT ET 2000 dynamometer tested by the university have certified their calibration standards for testing velocity of 60 degrees per second to within plus or minus 0.06 degrees per second accuracy. The overall machine torque accuracy is to within plus or minus 0.5% (2.5 lb-ft) over a CW/CCW range of 500 lb-feet. The torque sensor is a Transducer Techniques strain gage torque cell certified to within plus or minus 0.25 % accurate over a 600 lb-foot range. These specifications clearly demonstrate the exactness of today's newest generation of dynamometers

compared to the previous generation of mechanical mechanisms with potentially substantial degrees of error.

To address reliability, a specific study was formulated and conducted by Southwest Missouri State University's Department of Physical Therapy Research, to determine the reliability of the torque measures generated by the trunk, shoulder and knee joints in a normal population. The procedures included multiple repetitions testing for 28 subjects between the ages of 25 and 62. Results indicated that five repetitions yielded the most reliable results without invoking fatigue in the subjects tested. Copies of this study are available on request.

PROTOCOL DEVELOPMENT - SINGLE PLANE EVALUATION & WEIGHTING

CRT's protocol tests joints of the knee, shoulder and trunk in only one of three planes of movement. The peak torque and work volumes are then correlated to all joint movements in all joint planes, as each joint's structure work in concert to successfully complete the movement.

The protocol was determined from the scientific literature, the experience of knowledgeable isokinetic testers, and this university's recommendation. The complexities associated with performing and interpreting diagonal movement or combined plane data led to the selection of sagittal plane movements for the trunk, as this is likely the most important movement for workers to be able to "control" during work assignments. The results from the trunk also have a greater "weighting" in determination of worker capability due to the physical demand of the lumbar musculature within the work environment. Muscle weakness in the sagittal plane may help identify all lumbar weaknesses, including rotation problems, which are a major preceptor to herniated discs in the lumbar spine. The largest muscle group in the low back is the erector spinae. Their major responsibility is one of trunk extension, but also must be a strong trunk stabilizer for all motions of the trunk. Therefore, by testing in the sagittal plane, variables of motion of the trunk are evaluated.

For the shoulder the flexion-extension motion was considered the most important. One might question how testing in the sagittal plane for the shoulders would identify rotator cuff pathology. However, when evaluating the arthrokinematics of the shoulder joint, it is identified that the rotator cuff, while it is the major internal/external rotator of the shoulder, also is responsible for providing depression of the humeral head in the glenoid fossa. Testing in the sagittal plane identifies weakness and shows a decrease in the peak flexion torque with rotator cuff injuries and other pathologic conditions. While testing of the other planes for this joint may be meaningful in at least selected circumstances, time and cost for testing would likely not result in meaningful benefits.

Knee sagittal plane motion is also the most relevant to test as it is the only major motion of the knee.

A further reason to test in the sagittal plane is that much if not most movements required in work settings require a primary component of action in the sagittal plane. Further, the common activities of walking, rising from a chair and other activities are primarily sagittal plane motions. Coupled with considerations that all joints cannot be tested in all planes (as a practical matter) led us to the use of the best tests with a minimum amount of testing. As a result, five repetitions of maximal effort trunk, shoulder and knee motion in the sagittal plane are the data collected and evaluated.

CLIENT ASSESSMENT

The CRT normative database to which pre-employment applicants are compared consists of a population of subjects ranging in age from 13 to 69. Both males and females were included and each subject gave no report of previous injury. As testing continues in settings across the country data is continuously added to the database for the determination of the categories of work placement. Data have established that CRT test data are consistently able to predict injuries.

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