[1]THE FUNCTIONAL CAPACITY EVALUATION

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INTRODUCTION

In recent years, there has been an increased emphasis on development of the scientific basis of functional capacity evaluation (FCE). This has been stimulated by a growing awareness of its utility, and supported by major investments in research by large insurance providers and by state, provincial, and federal governmental agencies such as the United States Social Security Administration. [36] The most important development has been the application of a taxonomic approach to FCE to organize and focus this research. [72] This chapter employs this taxonomic approach, using it to organize both conceptual and applied information. The material presented in this chapter is informed by findings from a research project that was funded by the Social Security Administration [2] (SSA) to develop methods to use information about the patient's functional limitations to improve the SSA disability determination system. In order to render the task manageable within the limitations of a textbook format, this chapter is focused on FCE with persons who have musculoskeletal impairments.

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This chapter will emphasize the evidentiary basis of functional capacity evaluation, in which results and opinions derived from FCE measures must be qualified in terms of science. It is clear today that FCE must be based on standardized functional capacity evaluation measures that have acceptable psychometric properties [6, 7]. Further, to be accepted as evidence in courts in the United States, FCE data must be based on the "existence and maintenance of standards controlling the technique's operation" [23] including administration by trained and qualified personnel, using tests that have been demonstrated to be scientifically valid. This chapter presents the basic framework for the scientific practice of functional capacity evaluation, including a model of work disability, and definitions of major terms and concepts.

DEFINITION

Functional capacity evaluation (FCE) is a systematic method of measuring an individual's ability to perform meaningful tasks on a safe and dependable basis. [144] FCE includes all impairments, not just those that result in physical functional limitations. [127] In general, the purpose of FCE is to collect information about the functional limitations of a person with medical impairment. Beyond this general purpose, functional capacity evaluation has three specific purposes:

- Improve the likelihood that the patient will be safe in subsequent job task performance. [83, 157] Routinely, the comparison of a patient's abilities to a job's demands is made in an attempt to diminish the risk of re-injury that is associated with a mismatch. Shortfalls in the relationship between the patient's resources and the environment's demands result in stress [224] or increased risk for injury. [8, 11, 12, 35] Numerous researchers point to the importance of properly matching the worker's capacity to the job's demands. [1, 13, 62, 65, 68, 203, 225]

- Assist the patient to improve role performance through identification of functional decrements so that they may be resolved or worked around. [95, 154, 177] Health care professionals use this information to triage patients into proper treatment programs and to measure treatment progress.

- Determine the presence (and, if present, the degree) of disability so that a bureaucratic or juridical entity can assign, apportion, or deny financial and medical disability benefits. [5, 155]

The term functional connotes performance of a purposeful, meaningful, or useful task that has a beginning and an end with a result that can be measured. Functional limitations are the effect of the patient's impairment on his or her ability to perform meaningful tasks. Function is the focus of this type of evaluation process because functional limitations translate the effect of impairment on disability. [144] Functional limitations are the proximal cause of disability. Several authors have described models of disablement. [107, 166, 167, 169, 171, 227, 233, 234] Models of disability have been developed that focus on the person as a worker. [42, 131] A model of disability for industrial rehabilitation has been proposed, [154] as has a model to measure work disability for benefit entitlement as it is defined by the United States Social Security Administration. [72] A composite model, depicted in Figure 1, is used as a schematic for this chapter, employing the definitions presented in Table 1.

Figure 1. Conceptual model of bureaucratic work disability.

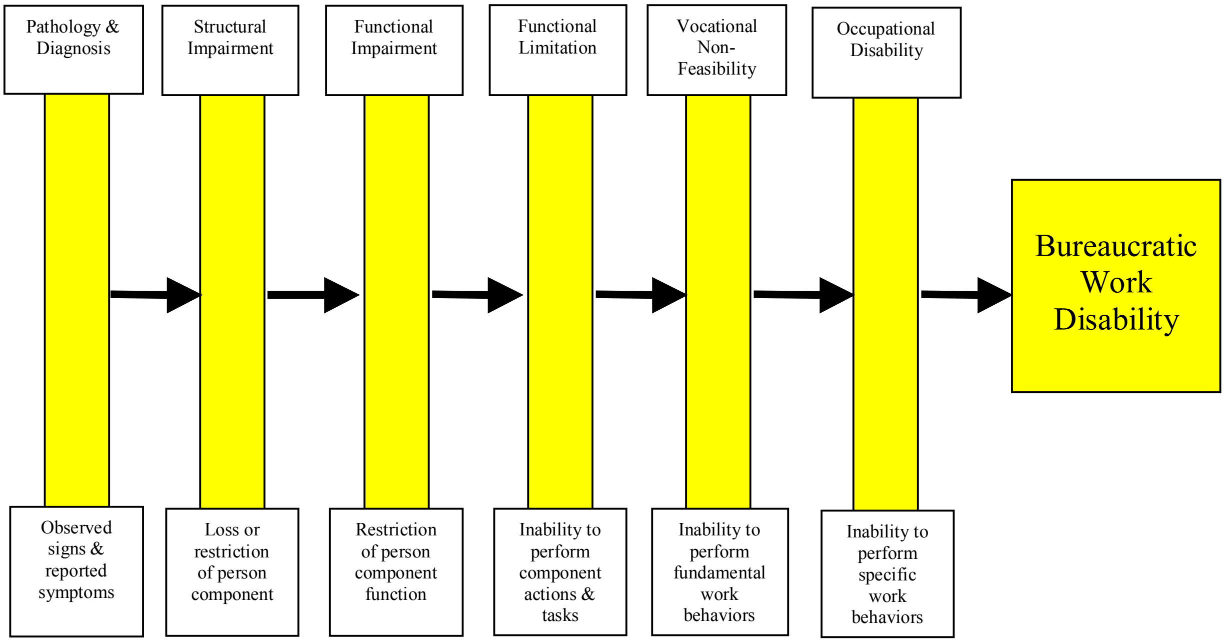
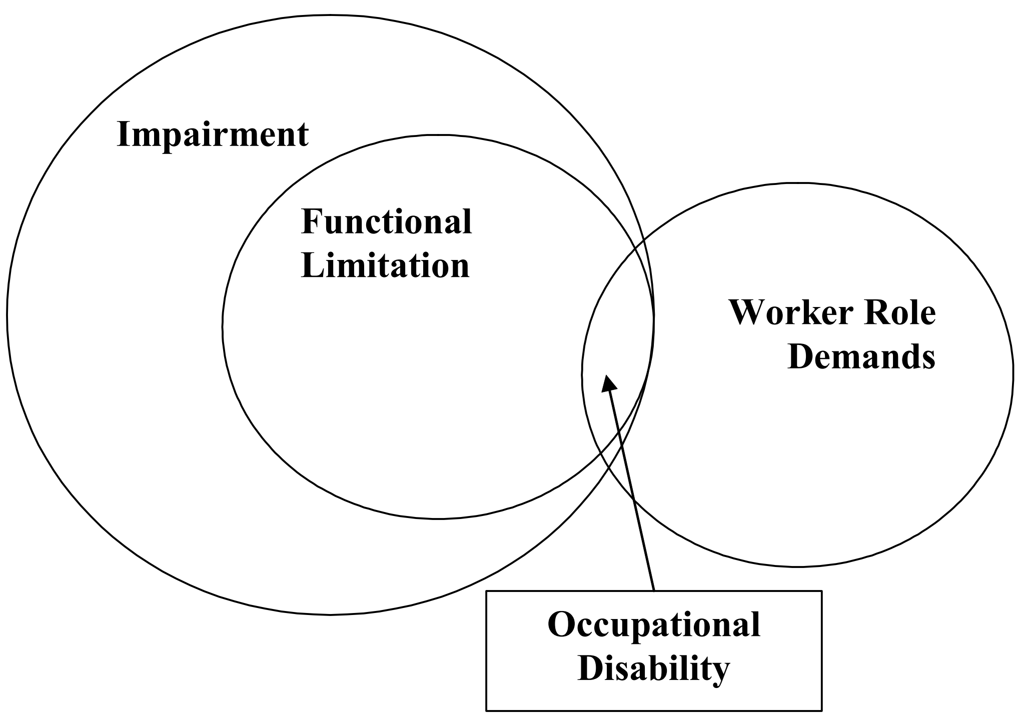


Table 1. Definitions used in the conceptual model of bureaucratic work disability.

Pathology & Diagnosis	Medical abnormality.	Observed signs and reported symptoms.
Structural Impairment	Loss or restriction of the organic or psychological component.	Loss or restriction of the organic or psychological component compared to normal.
Functional Impairment	Loss or restriction of the organic or psychological component's ability to perform.	Loss or restriction of the organic or psychological component's performance compared to normal.
Functional Limitation	Restriction of ability to perform simple observable behaviors that share a common purpose.	Inability to perform actions and tasks.
Vocational Non-Feasibility	The acceptability of the patient as an employee in the most general sense.	Inability to perform fundamental work behaviors.
Occupational Disability	Any restriction of ability resulting from functional limitation to perform an activity within the range considered normal for the occupation.	Inability to perform specific work behaviors.

This is a deterministic model with six related stages, across which causality is posited. Although the author recognizes that unidirectional causality is too simplistic for general use, [29, 171, 234] this model is designed to address bureaucratic needs for causal links between diagnosis and work disability, in which each succeeding stage is dependent on all preceding stages. This simple system is an example of those employed by most entities that administer disability determination systems to provide disability benefits, including the United States Social Security Administration. Disregarding the context of the individual's environmental and personal resources, this model describes pathology and impairment as factors that are the precursors of functional limitation, and thereby, disability. It is silent on the issue of proportional linearity, the degree of impairment does not necessarily dictate the degree of functional limitation or disability; this hotly debated issue [45, 47, 108] is unresolved. [38] To implement this model of work disability, the physician uses a medical diagnostic evaluation to address pathology and impairment. If the structural or functional impairment is sufficiently severe, functional limitations can result. Beyond the evaluation of impairment, functional limitations are measured by physicians, occupational therapists, physical therapists, vocational evaluators, kinesiologists, psychologists, and exercise physiologists in a functional capacity evaluation. If the functional limitations are sufficiently severe and are pertinent to role tasks, disability with regard to that role can result. Disability can be described in terms of the role consequences of functional limitations. [53, 107, 169, 171] Disability can be operationally defined as the patient's uncompensated shortfalls in responding to role demands. [144] Figure 2 represents this definition in graphic terms.

Figure 2. Assessment of work disability requires knowledge about the demands of the worker role and the functional limitations of the worker.



Functional capacity evaluation of disability is based on the measurement of the functional consequences of impairment in tasks that are pertinent to the particular role under consideration. In order to evaluate disability, one must measure functional limitations in terms of a particular role. Individuals assume several roles in society, such as spouse, parent, or worker. Functional limitations that are measured in terms of, for example, parental role tasks are not as useful in determining whether or not an patient can return to work as are functional limitations that are measured in terms of worker role tasks. The emphasis in this chapter is on determining the presence or degree of work disability. In order to do so, it will focus on tasks in the worker role found within the work environment. [218] There are several contexts of measurement outside of the worker role focus that medical professionals are often concerned about, including measurement of the patient's ability to participate in activities of daily living and the patient's perception of his or her quality of life. Only if the functional consequences of the medical impairment are significant and occur in tasks that are critical to the performance of the job, the patient can be described as having an work disability. [154]

The term capacity connotes the maximum ability of the patient, beyond the level of tolerance that is measured. Capacity is the patient's potential. The use of this term in the phrase "functional capacity evaluation" can be somewhat confusing because capacity rarely is measured in a performance task unless the patient is highly trained to perform that particular task. Examples of maximum task performance are found when experienced athletes compete. When the patient is an injured worker, functional capacity usually is inferred from evaluation of task performance. Even when the evaluation task is designed to measure the patient's maximum performance level, this is achieved rarely. The maximum level of performance that usually can be measured is termed the patient's tolerance for the demands of that task. [66] Further, the maximum dependable ability of the patient usually is less than his or her tolerance. Finally, many functional capacity evaluations are concerned only with adequacy for task performance rather than the patient's maximum dependable ability in that task. That is, if the patient is under consideration for a particular job, the task demands of that job may be substantially less than the patient's potential level of demonstrated ability. In this circumstance, as the evaluation progresses with increasing loads placed on the patient, the evaluation will conclude when the job demand is reached. This may be at a lower performance level than the patient's maximum dependable ability, which is lower than his or her tolerance, which is lower than his or her capacity.

The term evaluation describes a systematic approach to measuring ability that requires the evaluator to administer a test, collect data, interpret the data, and report the patient's ability to perform a task. [83] Functional capacity evaluation includes many different modalities of measurement, including performance tests, [25, 98, 115, 125, 215] expert ratings from observation [43, 77, 88, 123, 130, 164, 179] collateral ratings or reports, [76] and the patient's self-report. [47, 52, 55, 150] A recent study [146] identified more than 800 functional capacity evaluation instruments and devices, including structured performance protocols using test equipment, simulated activities to measure functional performance, and structured behavior rating scales to rate observations or self-perceptions.

FUNCTIONAL CAPACITY EVALUATION STANDARDS OF CARE

Professionals who use functional capacity evaluation measures to evaluate work disability must meet criteria for performance tests that are found in professional guidelines, state and federal legislation, and case law. Guidelines for testing have been developed and published by the American Psychological Association, [6] American Physical Therapy Association, [190] the American Academy of Physical Medicine and Rehabilitation, [109] and the American College of Sports Medicine [3]. Federal guidelines for employment testing are found in the *Uniform Guidelines for Employee Selection*. [53], while in Daubert v. Merrill Dow [23], the rules of evidence for scientific opinions based on tests were established. When the testing procedure involves a qualified individual with a disability, the Americans with Disabilities Act of 1990 [214] is pertinent. Taken together, these guidelines and laws create a framework for the standard of care for functional capacity evaluation. These criteria can be summarized in a simple hierarchy:

1. Safety - Given the known characteristics of the patient, proper administration of the functional capacity evaluation measure should not be expected to lead to injury.

2. Reliability - The score derived from the functional capacity evaluation measure should be dependable within the test trial and across evaluators, patients, and the date or time of test administration.

3. Validity - The decision based on interpretation of the score derived from the functional capacity evaluation measure should reflect the patient's true ability.

4. Practicality - The cost of administration, interpretation, and reporting of the functional capacity evaluation measure should be reasonable.

These criteria provide the underpinnings for the utility of functional capacity evaluation measures. The most important characteristic of a measure is its utility. Utility represents the overall value of the measure to its users. Utility is difficult to achieve and is threatened by many factors. [7, 142, 181, 182] In disability evaluation, the most serious threats to utility are posed by problems with reliability of the instrument that will put a ceiling [40] on the instrument's validity for all applications, thereby decreasing its utility. Mathematically, the validity coefficient of a score cannot exceed the square of the reliability coefficient of the measure multiplied by the reliability coefficient of the criterion. [69] To the degree that there are limitations on the safety, reliability, validity, or practicality of the instrument, utility will be limited. [45, 83]

IMPORTANT THREATS TO RELIABILITY

Excellent reviews of the reliability and validity of work-related assessments recently have been published, [93, 94] to which the reader is referred. Although a full explication of the many potential threats to reliability in FCE is beyond the scope of this chapter, two specific threats that are of particular importance, test reactivity and less than full effort performance, will be addressed briefly.

Test Reactivity

The threat to the reliability of a measure having to do with the instrument's reactivity is the effect of the measurement process on the evaluee's response to testing [181]. A test instrument is said to have reactivity when the evaluee's experience of taking the test affects test performance. This can occur in the absence of change due to treatment effect, directly affecting the measurement of both clinical validity [45] and prescriptive validity [109]. For example, a patient who participates in functional testing on two occasions may perform better on the second occasion simply because the first test resulted in skill development or addressed safety concerns that limited performance on the first occasion of testing. If a therapeutic intervention were administered between the two occasions of testing, apparent improvement on the second test could not be allocated to either the intervention or to the reactivity of the test. The effect of reactivity on the test is to limit its temporal stability. This limit on its reliability places a ceiling on its validity as a measure of therapeutic effect. It is becoming increasingly important to measure therapeutic effect in terms of the functional consequences of impairment. [171, 205] Serial testing prior to treatment and after treatment can be a useful strategy to measure the effect of therapeutic intervention only if the test's reactivity is taken into account. Unfortunately, reactivity is rarely addressed in the rehabilitation literature. Reactivity is not listed as a consideration in the selection of either performance tests or self-report instruments in medical rehabilitation. [109, 190 44, 46] In the medical literature, issues such as sensitivity to change and reactivity are only rarely studied or referenced, [45, 47, 153] although they are widely recognized as important aspects of reliability. [6, 7, 181] In vocational rehabilitation, the situation is somewhat better, [26] in that several widely-used functional performance tests have adjustments for reactivity that allow the test to be used on a serial basis. [215]

Less Than Full Effort Performance

The patient's full effort performance during the functional capacity evaluation is receiving increasing attention. [37, 51, 87, 105, 111, 117, 124, 148, 184, 186] Full effort is important for the reliability of the score [155] and thereby a necessary underpinning of the validity of the assessment decision. It is imperative that the patient gives his or her best effort, and that less than full effort is identified when it occurs. Failure to identify less than full effort performance may result in exaggeration of disability findings and a false positive determination of disability. There are many reasons for less than full effort performance, some of which are components of medically determined impairments and thus should be considered as legitimate factors contributing to valid performance. [142] Other reasons for less than full effort performance are contaminants of the disability determination process; their effects must be minimized. Still other reasons are fraudulent attempts to circumvent the disability determination process and must be identified for subsequent legal action. A comprehensive literature review [4] identified 11 causes for less than full effort performance during the disability determination process: [3]

1. Malingering syndrome;
2. Factitious disorder;
3. Learned illness behavior;
4. Conversion disorder, pain disorder, or other somatoform disorders;

3 It is important to note that there are causes other than less than full effort for test performance to be less than optimal. These include the patient's misunderstanding of instructions, poor test administration technique, and the use of poorly calibrated equipment. This paper focuses on causes of less than optimal performance that are related to less than full effort.

5. Depressive disorders;
6. Test anxiety;
7. Fear of symptom exacerbation or injury;
8. Fatigue;
9. Medication and psychoactive substance effects;
10. Lowered self-efficacy expectations; and
11. Need to gain recognition of symptoms.

Often, several these causes of less than full effort performance are found to occur simultaneously. Some of these are transient and, once addressed properly, will not recur. Some are, not surprisingly, consequences of mismanagement of the disability experience by the patient, professionals, and bureaucrats that will be less prevalent as the healthcare system becomes better attuned to needs of the person with a disability. Others are more insidious and require sophisticated processes to identify and ameliorate.

There are several methods to identify persons who are unusually symptomatic or for whom symptoms are unusually disruptive that will not be addressed here. [141, 180, 221-223] These methods are used to screen persons for symptom behaviors that may lead to less than full effort performance, due to concern about, fear of, or attention to symptoms. In contrast, focusing directly on identification of less than full effort during functional capacity evaluation, two principal themes characterize the methods that have been developed:

- Intra-test inconsistency that exceeds normal error values is assumed to be an indicator of less than full effort, if a well-designed test has been administered properly.

- Absence of expected relationships among related measures. Identification of several dependable measures of related attributes has allowed rational standards for inter-test comparisons to be developed as indicators of less than full effort.

There have been many rational implementations of these strategies. This important topic has been a focus of research in the neuropsychological literature for many years. [17, 20, 101, 128, 189] As a consequence, methods that are used to identify less than full effort in cognitive tests and self-report measures have been more thoroughly investigated than those that are used with persons who have musculoskeletal impairments. Although scientists in neuropsychology have made notable progress, it must be emphasized that most of the current tests have been adopted without being studied empirically. In particular, many of the physical performance measures continue to be used without any attempt to confirm that they possess adequate psychometric properties. [124, 148] This has occurred for several reasons, chief of which is the professional community's undisciplined adoption of procedures that address this issue. There are many procedures in popular use that unfairly identify patients who are not performing at maximum as "malingerers." An opinion such as this rendered by a professional has tremendous negative consequence for a person with a disability, including loss of access to necessary medical services and loss of financial support. Such an opinion should not be rendered without a clear idea of the sensitivity and specificity of the test that is used to support this opinion. Unfortunately, a central problem with scientific study of this topic is that empirical testing is quite difficult because the base-rate of less than full effort behavior is unknown. Without knowledge of the base rate, the sensitivity and specificity of identification methods cannot be determined, nor can we determine positive predictive values or negative predictive values.[4] Randomized and blinded studies of less than full effort assessment that use persons with a disability as subjects are almost nonexistent. Although the scientific community has urged caution and restraint in this area, [124, 148] the pressure from some stakeholders in the disability determination system is so great that current practices in most areas include wholesale adoption of unproven tests. This places individual professionals, their employers, and to a significant extent, the whole enterprise of functional capacity evaluation at risk of legal and societal censure.

It is important to recognize that almost any indicator of less than full effort can be volitionally defeated, and that some tests are more robust than others are. The ease with which a person can misrepresent ability varies with the volitional control and transparency of the attribute being measured and with the method of measurement. The easiest method to contravene is one that is most transparent, such as a grip strength test or pulmonary function measure.[37, 73, 90, 117, 121, 172, 184-186, 201] Those that are more difficult to contravene are more complex, subtle, and depend on non-volitional responses, such as blood pressure and heart rate. There are a few performance tests that have been designed to be sensitive to less than full effort, with reasonable utility. In the only randomized blind study of persons with a disability to date, [105] evaluators who were blinded to the status of the subjects (performing at full effort or less than full effort) were able to identify volitional less than full effort performance with 94 percent positive predictive value, and 80 percent negative predictive value. Other widely-used tests that have been promoted as effective in identifying less than full effort have been much less successful [148] and should be considered of limited utility.

4 The sensitivity and specificity of a test are measures of its validity. In this case, sensitivity is the probability that a person who is performing at less than full effort will test positive. Specificity is the probability that a person who is performing at full effort will test negative. Positive predictive value is the likelihood that a person who tests positive will be identified and negative predictive value is the likelihood that a person who tests negative will be identified.

TYPES OF FUNCTIONAL CAPACITY EVALUATION

There are five different types of functional capacity evaluation processes, defined by the purpose to which the information derived from the evaluation will be put. The primary issues that differentiate among the types of FCE are presented in Table 2.

Table 2. Different types of functional capacity evaluation.

Type	Question	Compared to …	Example Output	Duration
Functional Goal Setting	Ability to perform key task	Pre-injury ability	"Limited ability to lift from knuckle to shoulder level"	30 minutes
Disability Rating	Loss of work capacity	Normal values	"35% loss of work capacity"	90 minutes
Job Matching	Adequacy for job	Specific job demands	"Adequate for demands of Fitter at ACME, Inc."	3-6 hours
Occupation Matching	Adequacy for occupational group	General occupational demands	"Inadequate for demands of Fitter occupational group"	4-8 hours
Work Capacity Evaluation	Maximum dependable ability	Competitive employment standards	"Feasible for competitive employment at the Medium PDC level"	2-8 days

Each of the five types of functional capacity evaluation is described below, arranged along a hierarchy of increasing complexity, time, and expense:

Functional Goal Setting

If the patient's medical impairment is sufficiently severe to warrant referral to therapy, measurement of the functional status of the component(s) affected by the impairment in order to set recovery goals is useful. This type of functional capacity evaluation measures the usual functional consequences of the impairment at the component level. For example, in the case of a musculoskeletal impairment, joint range of motion or segmental strength could be measured. [85, 86, 129, 168] The information that is collected is used in consultation with the patient to set functional goals. [157] It is also used to provide objective indices of performance to gauge the progress of therapy.

Disability Rating

If the functional consequences of the patient's impairment are sufficiently severe to potentially result in limitation of ability to work, measurement of the loss of ability in key functional areas of work can be used as an estimate of disability. [118, 131] This method is analogous to the measurement of percent impairment of the whole person described in the *Guides to the Evaluation of Permanent Impairment*. [5] This method is used frequently in forensic evaluations to provide an estimate of the effect of the injury or illness on the patient's lifetime earning capacity. In the workers' compensation arena, most state and provincial systems have adopted the *Guides'* rating of permanent impairment as an ersatz disability rating in spite of the official position of the American Medical Association that this is inappropriate. [5] This has created problems with the validity of the *Guides*, given validity's dependence on the context within which a measure is applied. [7] In a rare but important exception, the State of California [235] uses a bonafide disability rating procedure, invoking an algorithm that includes impairment, a constant that is related to functional loss, and an "occupational variant." The components of this model are shown in Table 3, as they are applied to typical case examples.

Table 3. Sample disability ratings using the California Workers' Compensation model.

Occupation	Age at Injury	Diagnostic or Impairment Category	Disability Category	Standard Rating	Occupational Group	Occupational Adjustment	Age Adjustment	Disability Rating
Carpenter	60 years	Amputation of arm at or above elbow, not above shoulder joint, reasonably satisfactory use of prosthesis possible, major arm.	7.121	70%	380	75%	6%	81%
Medical Front Office Clerk	45 years	Low back Injury, resulting in disability precluding heavy work, contemplating the individual has lost approximately 50 percent of pre-injury capacity for bending, stooping, lifting, pushing, pulling, and climbing.	12.1	30%	212	28%	2%	30%
Elementary School Teacher	36 years	Hand injury resulting in limited motion of the thumb and index finger of the major hand.	9.2111	25%	214	30%	-2%	28%
Carpenter	36 years	Hand injury resulting in limited motion of the thumb and index finger of the major hand.	9.2111	25%	380	33%	-1%	32%
Judge	36 years	Hand injury resulting in limited motion of the thumb and index finger of the major hand.	9.2111	25%	370	25%	-1%	24%
Parking Lot Attendant, Booth	36 years	Hand injury resulting in limited motion of the thumb and index finger of the major hand.	9.2111	25%	370	23%	-1%	22%

In this approach, physician-generated data are used with occupational and age data to develop a percent disability rating. This method is based on collection of information about the patient's diagnosis, medical impairment, and prophylactic work restrictions [5] obtained through a medical examination. Using this information, a tabular algorithm is employed to derive the disability rating, presented as a percent of total disability, which determines the amount of disability indemnity that is to be paid. The treating physician is permitted to base opinions about work restrictions on inference, without formal functional testing, although this practice is coming under increasing scrutiny and, on an individual basis is often successfully challenged. In two studies in which the author has participated, [138, 155] a substantial minority of California workers' compensation disability claimants that were provided benefits based on physician's opinions without benefit of FCE were found, based on subsequent functional capacity evaluation, to not be valid. The benefits had been awarded unnecessarily. As the scientific basis of FCE develops, and functional data are used in these decisions more often, rational allocation of workers' compensation benefits will be commonplace.

5 An important assumption for disability rating is that the functional limitations are a consequence of the impairment. This assumption requires substantial judgment on the part of the physician, that can be informed by data collected during an FCE. Without confirmation of this assumption, attribution of measured functional limitations to a particular impairment is difficult to achieve.

Job Matching

Matching the adequacy of the worker's abilities to the essential functions of the job is the next most complex type of functional capacity evaluation. Information concerning the physical demands of a particular job is obtained through a job analysis, while information concerning the worker's impairment is obtained through a medical examination. A comparison of these two sets of information leads to the identification of the physical abilities that require an evaluation of functional adequacy. This FCE usually employs a standardized test battery, although the new taxonomic FCE approach allows selection of only those tests that are necessary. The performance targets of this standardized test battery are different from the Occupation Matching FCE test battery below in that the level of demand of the job is more specific (and usually lower) than the demand level of the occupational group.

Occupation Matching

Matching of the patient's functional capacity to the demands of an occupational group is a separate type of functional capacity evaluation. Information concerning the physical demands of an occupation is obtained from a source such as the United States Department of Labor's Dictionary of Occupational Titles [212] or the O*NET system [81] for typical jobs in the occupational group. The FCE tests and level of demand are based on this information. The physical demand level is often described in terms of the system used by the Dictionary of Occupational Titles, as depicted in Table 4.

Table 4. Dictionary of Occupational Titles system for classifying the strength demands of work.

Physical Demand Level	Occasional 0-33% of the workday	Frequent 34%-66% of the workday	Constant 67%-100% of the workday	Typical Energy Required
Sedentary	10 lbs	Negligible	Negligible	1.5 - 2.1 METS
Light	20 lbs	10 lbs and/or walk/stand/push/pull of arm /leg controls	Negligible and/or push/pull of arm/leg controls while seated	2.2 - 3.5 METS
Medium	20 to 50 lbs	10 to 25 lbs	10 lbs	3.6 - 6.3 METS
Heavy	50 to 100 lbs	25 to 50 lbs	10 to 20 lbs	6.4 - 7.5 METS
Very Heavy	Over 100 lbs	Over 50 lbs	Over 20 lbs	Over 7.5 METS

This type of FCE is more complex than Job Matching because the occupational classification contains all job tasks that might be required in the variety of jobs that are found within the classification. It is usually more physically demanding than the Job Matching FCE because the full range of job demands within the occupational classification must be considered.

Work Capacity Evaluation

Matching the patient's functional capacity to the demands of all occupations in the competitive labor market is the most comprehensive type of functional capacity evaluation. Because there is no occupational target, the focus of the Work Capacity Evaluation is very broad, encompassing all of the frequently encountered task demands and worker behaviors. Behaviors are assessed through observation of performance in a simulated work environment. This type of evaluation uses structured work simulations that often can be constructed based on descriptions found in published resources. [30, 137, 177] The duration of the Work Capacity FCE is very broad because it is possible to quickly determine that a patient is unable to meet basic criteria, such as work place tolerance and sustained activity tolerance. Conversely, if the patient is able to meet these criteria, it is difficult and time consuming to determine which vocational assets the patient should subsequently use to enter the labor market.

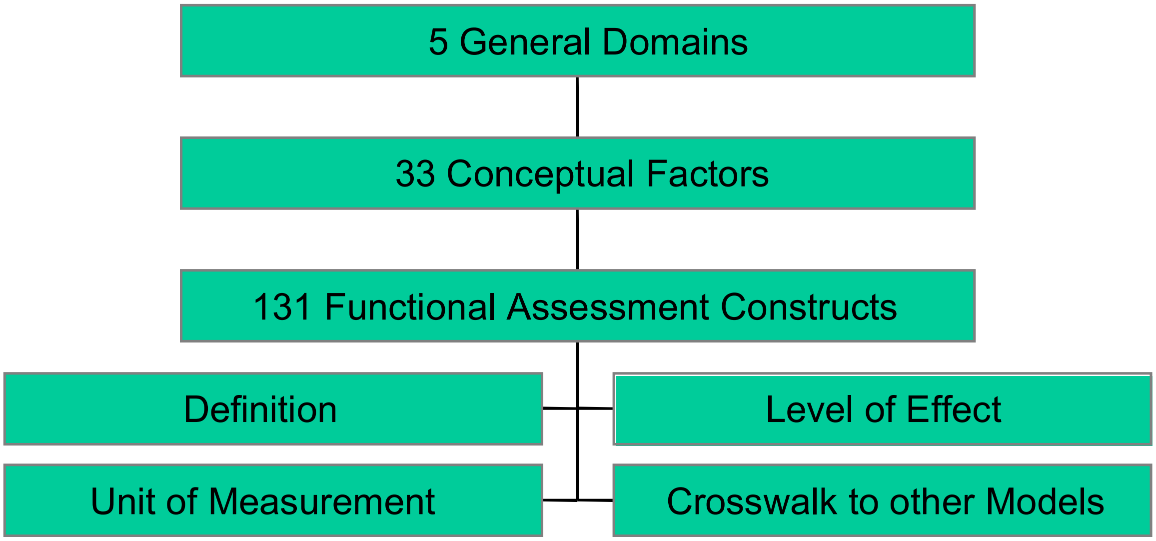
FCE Test Batteries versus the Focused Test Approach

Triage into the FCE that is appropriate for the patient is guided by joint consideration of the probable functional limitations that are naturally consequent to the patient's impairment and the performance demand targets that are contemplated. In recent years, most functional capacity evaluations have been conducted through the use of a standardized FCE test battery, several of which are available within each FCE type described above. Although the administration of complete test batteries is generally regarded as not being the most efficient approach, it is employed by all but a small number of the more experienced evaluators who select to evaluate only those specific functional assessment constructs that are pertinent to the case at hand. The focused test approach is preferred over the test battery approach as long as the safety, reliability, and validity guidelines presented above are addressed adequately. However, the focused test approach requires an evaluator who is usually more experienced; this approach is beyond the ability of most test battery administrators. Research conducted recently [70-72, 146] is likely to make the focused test approach more available, with the advent of expert systems that employ the taxonomic approach.

TAXONOMY OF FUNCTIONAL ASSESSMENT CONSTRUCTS

In the most generic sense, functional capacity evaluation considers the consequences of numerous impairments on numerous work demands. As a consequence, the interface between impairment and work demands is broad and complex. More than 800 functional capacity evaluation measures used to evaluate the work disability of adults have been identified. A database of these measures organized through the use of the functional assessment constructs taxonomy [72] has been developed [146]. The "FAC Taxonomy" includes 131 constructs that have been grouped into 33 conceptual factors, which themselves have been grouped into five domains. Each construct has been cross-referenced in terms of impairment, functional limitation, vocational feasibility, and occupational disability. In addition, each construct has been defined in terms of level of effect, reflecting ability factors along a continuum of increasing complexity. Figure 3 describes these relationships.

Figure 3. Organizational hierarchy of the Functional Assessment Constructs Taxonomy



The constructs in this taxonomy represent attributes of the person that are pertinent to the demands of work. Initial development of the taxonomy was based on a thorough literature review of constructs that are currently measured by professionals who evaluate disability. This was followed by an expert judgment exercise in which assessment professionals considered a matrix of approximately 18,000 combinations of constructs to identify factors, groupings, and voids. This was followed by a focused literature review designed to resolve inconsistencies and voids. Finally, the taxonomy was edited while being used to organize information on approximately 800 instruments containing more than 3,000 scales. Each scale was linked to one or more constructs, conceptual factors or domains in the taxonomy.

The FAC Taxonomy includes constructs that originated in various taxonomies of human performance and job demands. Prominent sources were those provided by the United States Department of Labor in the Dictionary of Occupational Titles and the O*NET system, as well as the recognized human performance taxonomies described in Fleishman and Quaintance [63]. The relationships between the five domains and the 32 conceptual factors are presented in Table 5.

Table 5. Relationship between Domains and Conceptual Factors in the Functional Assessment Constructs Taxonomy.

Conceptual Factor	Construct	Definition	United States DOT [a]	United States SSA [b]	Great Britain	The Netherlands
Hand Use	Hand Range of Motion	Ability to move the hands through a full range of motion.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Sensitivity	Ability to use the hands to sense by touch and temperature.	Feeling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Speed	Ability to use the hands in rapid movement.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Coordination	Ability to use the hands in a coordinated manner.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Dexterity	Ability to use the hands for fine coordinated movement.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Strength	Ability to use the hands in a forceful manner.	Handling	Lift and Carry	Lifting and Carrying	Lifting
	Hand Endurance	Ability to use the hands in a sustained or repetitive manner.	Handling			
	Eye-Hand Coordination	Ability to coordinate fine movements using visual information.	Handling		Manual Dexterity	Hand-Finger Dexterity
	Manipulating Objects	Ability to seize, hold, grasp, or turn objects with hands and fingers.	Fingering	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
Manual Material Handling	Reaching	Ability to stretch arms and trunk in a coordinated manner to grasp or manipulate objects.	Reaching	Lift and Carry	Reaching	Reaching
	Lifting and Lowering	Ability to lift and lower objects.	Strength	Lift and Carry	Lifting and Carrying	Lifting
	Pushing and Pulling	Ability to push and pull objects.	Strength			Pushing and Pulling
	Carrying Objects	Ability to carry objects while ambulating.	Strength	Lift and Carry	Lifting and Carrying	Carrying

As noted earlier, the taxonomy focuses on "work disability" as a subset of disability, using the model described in Figure 1. It is remarkable that, even with this narrowed focus, 131 distinct constructs were identified that currently are measured to determine disability. A review of all of these constructs is beyond the scope of this chapter, which will focus on several of the constructs that are encountered when evaluating persons with musculoskeletal impairment. This chapter will address 13 of the 32 physical domain constructs that would normally be of concern with impairments of this type, focusing on those in the Hand Use and Manual Material Handling

Conceptual Factors. [6] The constructs are presented, with comparisons to constructs found in the taxonomies of various systems in the United States, Great Britain, and The Netherlands.

Table 6. Comparison of the disability determination systems in the United States, Great Britain, and The Netherlands in terms of constructs in the Physical Domain of the Functional Assessment Constructs Taxonomy.

Conceptual Factor	Construct	Definition	United States DOT [a]	United States SSA [b]	Great Britain	The Netherlands
Hand Use	Hand Range of Motion	Ability to move the hands through a full range of motion.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Sensitivity	Ability to use the hands to sense by touch and temperature.	Feeling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Speed	Ability to use the hands in rapid movement.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Coordination	Ability to use the hands in a coordinated manner.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Dexterity	Ability to use the hands for fine coordinated movement.	Handling	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
	Hand Strength	Ability to use the hands in a forceful manner.	Handling	Lift and Carry	Lifting and Carrying	Lifting
	Hand Endurance	Ability to use the hands in a sustained or repetitive manner.	Handling			
	Eye-Hand Coordination	Ability to coordinate fine movements using visual information.	Handling		Manual Dexterity	Hand-Finger Dexterity
	Manipulating Objects	Ability to seize, hold, grasp, or turn objects with hands and fingers.	Fingering	Lift and Carry	Manual Dexterity	Hand-Finger Dexterity
Manual Material Handling	Reaching	Ability to stretch arms and trunk in a coordinated manner to grasp or manipulate objects.	Reaching	Lift and Carry	Reaching	Reaching
	Lifting and Lowering	Ability to lift and lower objects.	Strength	Lift and Carry	Lifting and Carrying	Lifting
	Pushing and Pulling	Ability to push and pull objects.	Strength			Pushing and Pulling
	Carrying Objects	Ability to carry objects while ambulating.	Strength	Lift and Carry	Lifting and Carrying	Carrying

6 Constructs related to pain and other symptoms are considered in the Vocational Behavior domain and will not be presented here.

The data in Table 6 are of interest because they depict the incomplete nature of the systems that are reviewed. Not one system currently includes all constructs in the FAC taxonomy, although every construct in the taxonomy is addressed by at least one system. The absence of uniformity across systems is also noteworthy.

REPRESENTATIVE FUNCTIONAL ASSESSMENT MEASURES

The functional assessment constructs taxonomy was used in the development of a database of more than 800 functional assessment measures [146] that are currently used to determine disability. Data about the measures' psychometric properties and other pertinent issues were collected. This research confirmed the findings of an earlier study [192] that there was no standard procedure to evaluate functional limitations. The recent study found that this stems in part from the fact that, while some FCE procedures have been developed specifically for medical practice, many have been borrowed from the fields of education, psychology, or vocational rehabilitation. The confusion in the professional literature about how the attributes of the person should be organized led to development of the model of work disability (Figure 1), the units of analysis system (Table 1), and to the functional assessments constructs taxonomy. These will be useful in future efforts in the United States and elsewhere to develop scientific methods to determine disability.

In order to develop a database of functional assessment measures, development of definitions to assist the project scientists to distinguish between test batteries, test instruments, test scales, test protocols, and test equipment was necessary. Measurement of functional assessment constructs typically is performed at the scale level. Most instruments have several scales; five to six scales were found in each of the approximately 620 instruments that could be studied closely. Every scale was measured through the use of a test protocol. Some of the test protocols measured several scales. Some of the protocols required test equipment, often composed of mechanical or electronic devices. Many of the test protocols used only a test booklet and required only paper and pencil to record either the patient's own responses or observations made by others, including both professionals and family members. Confusion often occurs when both the test protocol and test equipment are not specified in reports and scientific papers. For example, it is common to read that "hand strength was measured by the Jamar Hand Dynamometer". The Jamar dynamometer is test equipment with which isometric hand strength is measured, using one of several test protocols. In this example, static force can be measured in terms of one handle position, two positions, or all five positions, providing different spans of grip, using single trials, three repeated trials, based on a mean score, or the highest of the repeated scores. The protocol endorsed by the American Society of Hand Therapists [160] is the most broadly adopted test protocol, but by no means the only protocol in use. It is necessary to specify the test protocol and equipment. Confusion also occurs when the mode of testing is inaccurately linked to the functional assessment construct. For example, it is common to read that "lift capacity was determined by isometric testing." Isometric strength testing is not a mode of lift capacity measurement. Lift capacity is predicted by isometric strength measurement only under very special circumstances. [149, 151, 226]

In the sections that follow, global test batteries and functional assessment measures that are used with two clusters of constructs, those having to do with hand use, and those having to do with manual material handling are presented. These measures are grouped according to constructs that share common characteristics. This is a representative list that is not exhaustive. The functional assessment measures and test batteries that are presented below are in widespread use.

Global Test Batteries

In research on the functional assessment measures database, a small number of global test batteries were identified, each comprised of one dozen to three dozen scales, using a combination of scales and instruments. Some of the scales in these batteries can be used on a stand-alone basis, with prior studies identifying the psychometric properties of each. However, confusion occurs when psychometric properties derived for individual scales are applied to a test battery as a whole, rather than to the scales and instruments that comprise the battery. It is important to differentiate the psychometric properties of scales from the psychometric properties of batteries.

Table 7. Representative global test batteries frequently used in functional capacity evaluation.

Battery or Instrument	Source or Developer	References
Blankenship Functional Capacity Evaluation	Blankenship, Inc.	24, 25, 111, 127
BTE Work Simulator	Baltimore Therapeutic Equipment, Inc.	18, 21, 22, 32, 54, 84, 114, 116, 117, 127, 173, 228, 230
California Functional Capacity Protocol (Cal-FCP)	Mooney & Matheson	155
DOT Residual Functional Capacity Battery	Fishbain & Abdel-Moty	57, 58
ERGOS Work Simulator	Work Recovery, Inc.	39, 50, 149, 200
Isernhagen Functional Capacity Evaluation	Isernhagen Work Systems, Inc.	96, 97, 99, 100
Key Method Functional Capacity Assessment	Key Functional Assessments, Inc.	115
LIDO WorkSET Work Simulator	Baltimore Therapeutic Equipment, Inc.	64, 147, 195, 231
Matheson Work Capacity Evaluation	RMA, Inc.	137, 139, 140
Physical Work Performance Evaluation	ErgoScience, Inc.	125, 126
Valpar Component Work Sample System	Valpar, Inc.	15, 33, 78, 110, 188, 193, 194, 215
WorkAbility Mark III	Heyde & Shervington	197-199
WorkHab	Roberts & Bradbury	28

Functional Group: Hand Use

Definition: Ability to use the wrists and fingers in coordinated and purposeful movement.

This group of functional assessment constructs has a wide variety of strategies that are used to measure performance, with some of the measures developed in the 19th century. Many of the best developed tests in this area, those supported by the greatest amount of research, were used and studied extensively during World War II to select recruits. In the last 30 years, several work samples have been developed to measure these constructs in persons with a disability.

Table 8. Eye-hand coordination functional capacity evaluation scales.

Representative Scale	Battery or Instrument	Disability Model Level	Source or Developer	Reference
Eye Hand Coordination	APTICOM - Eye Hand Foot Coordination	Functional Limitation	Vocational Research Institute	82
Screws	Crawford Small Parts Dexterity Test	Functional Limitation	The Psychological Corporation	19, 178
Coordination	Flanagan Aptitude Classification Test	Occupational Disability	National Computer Systems, Inc.	60, 165
Coordination	Flanagan Industrial Test	Occupational Disability	National Computer Systems, Inc.	61, 229
Copy Geometric Form	Loewenstein Occupational Therapy Cognitive Assessment	Occupational Disability	Western Psychological Services	34, 112, 113
Placing	MESA System 2000	Functional Limitation	Valpar International Corporation	27, 102-104, 207
Soldering and Inspection	VALPAR 12 - Soldering and Inspection	Functional Limitation	Valpar International Corporation	215
Eye Hand Foot Coordination	Vocational Interest Temperament and Aptitude System	Occupational Disability	Jewish Employment & Vocational Service	2
Use of Compass and Circle Template	VALPAR 16 - Drafting	Functional Limitation	Valpar International Corporation	215

Table 9. Finger dexterity functional capacity evaluation scales.

Representative Scale	Battery or Instrument	Disability Model Level	Source or Developer	Reference
Assembly	Purdue Pegboard Test	Occupational Disability	Science Research Associates Inc.	134, 219
Fine Finger Dexterity	VALPAR 204 - Fine Finger Dexterity	Functional Limitation	Valpar International Corporation	215
Finger Dexterity	General Aptitude Test Battery	Occupational Disability	U.S. Department of Labor	16, 122, 208, 220
Manual Speed and Dexterity	Career Ability Placement Survey	Occupational Disability	Educational & Industrial Testing Service	89, 120
O'Connor Finger Dexterity Test	O'Connor Finger Dexterity Test	Occupational Disability	O'Connor & Johnson	75
Pins and Collars	Crawford Small Parts Dexterity Test	Functional Limitation	The Psychological Corporation	19, 135, 178
Sequential Occupational Dexterity Assessment	Sequential Occupational Dexterity Assessment	Functional Limitation		216, 217

Table 10. Hand coordination functional capacity evaluation scales.

Representative Scale	Battery or Instrument	Disability Model Level	Source or Developer	Reference
Aiming	Comprehensive Ability Battery	Occupational Disability	Institute for Personality & Ability Testing	79, 80, 119
Hand Dexterity	Valpar 4	Functional Limitation	Valpar International Corporation	215
Hand Tool Dexterity Test	Bennett Hand Tool Dexterity Test	Functional Limitation	The Psychological Corporation	132
Motor Coordination	General Aptitude Test Battery	Occupational Disability	U.S. Department of Labor	16, 49, 122, 208, 220
Grasp	Action Research Arm Test	Functional Limitation	Lyle	41, 56, 59, 67, 91, 92, 133
One Hand Turning and Placing Test	Minnesota Rate of Manipulation Test	Functional Limitation	American Guidance Service	14, 170
Rods and Caps	Roeder Manipulative Aptitude Test	Occupational Disability	Lafayette Instruments Co.	187

Table 11. Hand strength and endurance functional capacity evaluation scales.

Representative Scale	Battery or Instrument	Disability Model Level	Source or Developer	Reference
Continuous Torque	WEST 4A	Functional Limitation	Work Evaluation Systems Technology	9, 230
Isometric Grip Strength Test	JAMAR Hand Dynamometer	Occupational Disability	Therapeutic Equipment Corp.	48, 74, 158, 160
Isometric Grip Test	ARCON Grip	Functional Limitation	Applied Rehabilitation Concepts, Inc.	48, 74, 158, 160
Isometric Pinch Test	Hanoun Medical Pinch	Functional Limitation	Hanoun Medical, Inc.	156, 158, 160, 202, 232
Key Pinch	B & L Isometric Pinch Gauge	Functional Impairment	B and L Engineering	156, 158, 160, 202, 232

Table 12. Hand speed functional capacity evaluation scales.

Representative Scale	Battery or Instrument	Disability Model Level	Source or Developer	Reference
Alphanumeric Speed and Accuracy	CRT Skills Test	Occupational Disability	National Computer Systems Inc.	[10, 175]
Both Hands	Purdue Pegboard Test	Occupational Disability	Science Research Associates Inc.	[134, 159, 183, 210, 219]
Card Turning	Jebsen Hand Function Test	Functional Impairment	Jebsen	[31, 106, 196, 204, 206]
Manual Speed and Accuracy	Employee Aptitude Survey	Occupational Disability	Psychological Services, Inc.	[191]
Precision	Flanagan Aptitude Classification Test	Occupational Disability	National Computer Systems, Inc.	[60, 165]
Precision	Flanagan Industrial Test	Occupational Disability	National Computer Systems, Inc.	[61, 229]
Turning Test	Minnesota Rate of Manipulation Test	Functional Limitation	American Guidance Service	[14, 170]

Functional Group: Manual Material Handling
Definition: Ability to lift, handle, and transport objects of various weights and sizes.

Most of the tests that are used to measure these functional assessment constructs have been developed in the last 30 years, often specifically for use with persons who have medical impairments. These tests usually were developed with reference to ergonomic standards, especially those developed by the National Institute of Occupational Safety and Health. [174] Additionally, tests of this type often were developed with reference to the United States Department of Labor standards for strength demands of work as described in the *Handbook for Analyzing Jobs* [211, 213].

Table 13. Manual material handling functional capacity evaluation scales.

Scale	Battery or Instrument	Disability Model Level	Source or Developer	Reference
Carrying & Climbing Balance	WEST EPIC 5	Functional Limitation	Work Evaluation Systems Technology	143
Dynamic Physical Capacities	VALPAR 19 - Dynamic Physical Capacities	Functional Limitation	Valpar International Corporation	15, 215
Dynamic Strength	VALPAR 201 - Physical Capacities and Mobility Screening Evaluation	Functional Limitation	Valpar International Corporation	215
Lift Capacity	ARCON Lift Capacity	Functional Limitation	Applied Rehabilitation Concepts, Inc.	
Lift Capacity	EPIC Lift Capacity	Functional Limitation	Employment Potential Improvement Corporation	105, 145, 152, 153
Lift Capacity	Hanoun EPIC Lift Capacity	Functional Limitation	Employment Potential Improvement Corporation.	105, 145, 152, 153
Lift Capacity	Progressive Isoinertial Lifting Evaluation	Functional Limitation	Mayer, et al	161-163
Range of Motion Under Load	WEST Standard Evaluation	Functional Limitation	Work Evaluation Systems Technology	136, 138, 176, 209

THE FUTURE OF FUNCTIONAL CAPACITY EVALUATION

Driven by both market demands and the needs of large insurance carriers and governmental agencies, the scientific basis of functional capacity evaluation will continue to develop. Organizational tools such as the Model of Work Disability, and the Functional Assessment Constructs Taxonomy that have been presented in this chapter will facilitate this development. Although the future is always difficult to predict, several issues seem clear and readily predictable:

- Given the wide variety of functional assessment measures already available, it is unlikely that many new measures will be developed. Currently available measures will be more extensively studied and the psychometric properties will be improved and formally demonstrated, with results published in peer reviewed scientific journals.

- Interdisciplinary standards that are as technical as those offered by the American Psychological Association [6] and as clinically applicable to this type of assessment as those offered by the American Academy of Physical Medicine and Rehabilitation [109] will be developed.

- Certification of health-care professionals who provide functional capacity evaluation services will become widespread, supported by several of the major universities, and demanded by underwriters.

- Development of expert triage systems to guide the selection of functional assessment constructs that should be measured, accompanied by catalogs of tests that are appropriate for each construct will become available.

- The functional capacity evaluation process will be supported by expert administrative systems that are available online with built-in monitoring so that professionals with lower levels of skill who have received appropriate training will be able to work as evaluators and test technicians.

- New functional capacity evaluation administrative systems will identify patterns of performance that indicate less than full effort through dynamic monitoring of test performance, and will trigger follow-up testing to confirm or deny less than full effort. This will increase the reliability and, thereby, the validity and utility of FCE results.

- Functional capacity evaluation will be used much more often as practicality improves. The advent of focused tests systems will assist evaluators to select only those constructs that are necessary to evaluate, and not include those that are unnecessary.

Through these improvements, the value of functional capacity evaluation to industrialized societies throughout the world will continue to improve, so that FCE will become indispensable to the process of disability determination.

SUMMARY

This has been a review of functional capacity evaluation as it is used in rehabilitation, with a focus on its use in the determination of work disability. A new model of work disability has been presented and a taxonomic structure of functional assessment constructs has been introduced and briefly described. The taxonomy was used to organize several hundred functional assessment measures into a database that was tapped to provide representative instruments that are used to measure constructs in two areas, hand use, and manual material handling. The chapter concludes with predictions of likely improvements in FCE that will be developed through the application of the new taxonomic method.

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