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Applications of Work Physiology Science to Capacity Test Prediction of Full-Time Work - Eight Hour Work Day

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Introduction

The review of the published material for this investigation identified a number of component tests for capacity evaluation, however, these publications neglected to identify the definitive component of work physiology (Abdel-Moty, 1993; Blankenship, 1991; Hart, 1993-1994; King, 1998; Lechner, 1994; Saunders, 1997; Tramposh, 1999). Functional capacity testing requires the provider to have a thorough knowledge of the sciences comprising the protocols that are most appropriate for the given client as there is no single FCE that is universal to all cases (King, 1998). King et al (1998) completed a critical review of ten well-known Functional Capacity Evaluation (FCE) systems. That renew concluded that there were no scientific applications identified regarding a prediction to an 8-hour work tolerance, revealing that the tests were not standardized, and lacked comprehensiveness as well as objectivity in data collection. Additionally, Lechner et al (Piela 1996), reviewed 10 FCE methods, none of which published research for reliability in a refereed journal.

At best, subjective observations regarding client effort have replaced scientific formulas for predicting full-time work tolerance. Understandably, some degree of subjective observation is necessary by the therapists (Linn, 2001) such as perception of effort and proper lifting techniques; researchers have even claimed that direct observation by the trained therapist and personal communication between client and tester provides reliability for the study results. Subjective reactions are difficult to universally define and measure (Gamberale, 1990) and little or no data or formulas have been documented to support the contention that subjective measurements are superior to physiological indicators of fatigue (Reneman, 2002; Saunders, 1997).

The main criteria for choosing the activities to be included within the FCE have been historically guided by 'intuitive consensus" by the therapists, as stated by Jette (1980). The subjective measurements prove little or no inter and intrarater reliability (McDaniel & Tilton, 2004), thus leaving clinicians without any basis for evaluating improvements over time. Additionally, developers of functional capacity evaluations have claimed that scientists making "endurance projections" to predict full-time 8 hour work have done so without documenting prediction formulas (Lechner, 1994). It is essential that valid, reliable, safe, and scientifically determined measures be developed for practicing clinicians to accurately predict return to work. (Innes & Straker, 1988, 1999a, 1999b; Pransky, 2004).

Subjectivity of FCE Testing

One of the FCE methods reviewed by King et al (1998) and Brouwer et al (2003), is the FCE method developed by Isernhagen, Isernhagen work systems. The criteria used in the Isernhagen system includes changes in body mechanics, accessory muscle use, and heart rate increase to indicate whether the effort expended to lift a load is light, moderate, heavy, or maximum. Isernhagen instructs the evaluator to estimate the effort extended by the client according to changes in physiological indictors such as heart rate, yet does not utilize heart rate as a predictor for 8-hour time tolerance of work. Saunders also states "some FCE methods use proxy measures to determine the weight lifted occasionally by having a client lift repetitively over a 4 hour FCE (Glenda Key, Functional Assessments Inc; personal communication) or by judging the amount of effort expended to perform a lift (Susan J. Isernhagen, Isernhagen Work Systems; personal communication)" (Saunders, 1997). As a result of these, and other information sources, practitioners of FCE called for a new classification system in FCE testing to facilitate a further definition of possible variables to be evaluated. Most importantly, these practitioners called for a definitive method for using data to project an 8 hour work day which utilized a reliable and accurate scientific formula because none were currently available (Hale, 2004; King, 1998; Matheson, 2002a; Simmons, 2006).

Davies (1966) pointed out the main barriers to progress in work physiology were a lack of understanding of the significant differences between exercise and work physiological testing and a failure to appreciate the underlying physiological principles upon which work was based. Attempts within the profession to consider fitness in all forms of human function lead to an inadequate generalization that ultimately violated the foundation of work tolerance physiology. Lastly, Davies research concluded a need for specific procedures to predict prolonged work related physical exertion, completely independent of exercise fitness testing. Saunders et al (1997) confirmed significant errors within the estimates of work tolerance, thus questioning the use of formulas in predicting weight that could be lifted for frequency. Additionally, Asfour et al (1984) believes that a combination of psychophysical and physiological approaches should be utilized for establishing lifting standards during FCE testing, particularly for higher lifting frequencies.

A direct method for analyzing physiological status based upon measurements is a holter monitor. This data can show variations in the response of the worker due to varying stress levels, work versus rest days, and day versus night. This is a method for predicting full-time work by providing data outside the physiological testing environment (Collins, 2001). Acquiring this knowledge of the client directly allows the tester to include accurate return to work information (Gross 2004). It is particularly important to thoroughly assess a client with a musculoskeletal injury who has been out of work and not maintained a level of activity equal to previous work demands. The lack of cardiovascular fitness could mask the ability of the recovering musculature to perform a normal 8-hour workday leading to a false diagnosis by the tester (Matheson, 1996). Functional capacity practitioners must also understand that unless the client is maximally trained, FCE's do not measure current capacity, but reflect rather a tolerance for symptoms (AMA, 2005).

Lack of Standardization

Research by Abdel-Moty et al (1993) found major conceptual errors in trying to translate FCE data from a 1-2 hour test battery into an 8-hour work prediction tolerance. The authors went on to point out that evidence within the scientific literature, primarily in the psychophysical methods, indicated that an individual's ability to handle loads over time would require evaluation methods that included assessment of heart rate. Clearly lacking in the process of standardization is a definitive piece regarding work physiology and most importantly, a method upon which to judge a full time work tolerance prediction (Hart, Isernhagen & Matheson, 1993; Harwood, 2004; Matheson, Kane and Rodbard, 2001). Lechner (1994) and Tramposh (1992) both conclude in their publications that FCE's suffer from their lack of data to effectively support their ability to predict a worker's success within actual job related functions, including a projection of full-time work. As demonstrated by Ratzon (2004), many FCE protocols lack any physiological measurements that can be used to support work tolerance. The Saunders FCE method instructs the tester to use direct observation method for a determination of work tolerance, stating "we do not believe in using formulas or small work samples for extrapolation of a worker's ability to perform repetitiously over an 8-hour work day." Furthermore, he states that endurance capabilities are not critical when a return to work is not eminent (Saunders, 1998).

Prediction of work tolerance in the FCE has relied more on subjective estimates rather than objective data. The subjective determination of a safe and dependable performance level is placed upon the clinician to use their professional judgment, and the examinees potential for sustained work is "estimated" rather than directly measured or accurately predicted (Hart, 1993; Isernhagen, 1992; Matheson, 2001). Other authors, including Smith (1986), found that additional research is also necessary to document the end point reliability of the FCE work stamina testing. Authors have said that maximal effort testing should include standardized lifting protocols while measuring heart rate responses and observing biomechanical competitive test behavior (Lemstra, 2004).

The application of general fitness testing draws attention to the level of poor work physiology competency by many FCE providers. Physical therapists within the industrial physiology setting should be expected to acquire the knowledge of clinical exercise specialists who apply exercise as an assessment and diagnostic tool in treatment (Noonan, 2000). A comprehensive understanding of work physiology is necessary to select appropriate procedures that would be far more predictive for the desired 8-hour time tolerance estimate as advocated by King et a1(1998). Several authors and institutions (ACSM, 2004; Jiang, 1984) note that expertise is the primary prerequisite to perform exercise testing and Functional Capacity Evaluations (Dakos, 2004), interpret results and provide safeguards, as well as provide valid and reliable testing (Johnson & Miller, 2001).

Exercise Versus Work Physiology Testing

The exercise testing procedure is defined as a diagnostic and prognostic tool used as a therapeutic interpretative application for exercise prescription (Adams, 1998). The characteristics of the individual being tested should determine the protocol selected, the purpose of the test, and the outcomes that are desired (ACSM, 2004). The ACSM (2004) has identified relative contraindications to Graded Exercise Testing (GXT), such treadmill testing with staged elevations, which includes cardiovascular, neummuscular, musculoskeletal, or rheumatoid disorders that are exacerbated by exercise. The term 'physical fitness' can be defined as a quantitative (objective) expression of the overall fitness of an individual (Consolazio, 1963), but it is not work physiology. An exercise test protocol is conducted until the subject reaches a pre-determined physiological level, which is typically 80-85% V02 max, or voluntarily stops due to fatigue or reports of alarming symptoms. Herein lies the significant difference between exercise and work physiology testing. Using the exercise testing protocol endpoint of 80-85% VO2 max in an FCE procedure would be considered undesirable within the protocol of work physiology testing where many of the examinees have a history of the aforementioned relative contraindicated symptoms established by the ACSM. The work physiology test is designed to impose strain upon the individual that is correlated with the demands of their work environment and the worker's ability. Lastly, the relative intensity of exposure within an exercise test (80-85% maximal effort) far exceeds the highest work physiological expectations required for eight hours of work. Unfortunately, many developers of FCE protocols improperly utilize the exercise test endpoint of 85% (Matheson, 1995; Saunders, 1997; Mayer, 1988; Reneman, 2004; Lemstra, 2004; Lygren, 2005) or fail to correlate a HR to the "pre-determined physiological limits" (Matheson, 2002b).

Heart rate methods, such as the "Direct Method", the "HR Reserve Method (HRR)", also known as the Karvonen/Indirect Method, and "Percent Heart Rate Max Method (% HRmax) are all used for clinical evaluation, prognostication, and preparation for an exercise regime. The direct method requires constant monitoring and recording of the heart rate at each stage of a graded exercise test. The HKR or Karvonen Method, takes into account resting HR, age and age-predicted maximal HR (APMHR) (see below for calculations). The last method, 'Percent HR max method'is a fixed percentage of the maximal HR that was either directly measured or predicted by age. The most recent investigation (Gellish, 2007) into a predicted maximum heart rate for GXT reflects more sensitivity for the populations mean for people 30-75 years of age. This equation for prescription of exercise intensity in a GXT (HRmax = 192 - 0.007 x (age)2 is noted by the authors to be less desirable from a usability standpoint, but yields a confidence bound of +/- 2-5 bpm.

Equations: (Howley, 2003)

1) Direct Method: accurate measurement at each stage of the exercise test
2) HRR or Karvonen:
    a. APMHR: 220-age
    b. HRR: Max HR – Resting HR
    c. HRR value: HRR* % (60, 70, 80%)
    d. Goal HR: HRR value + Resting HR
3) % HR Max:
    a. APMHR: 220-age
    b. APMHR * % (60, 70, 80%)

Replacing the APMHR for a maximal HR that was measured directly from a Maximal Oxygen Uptake Test (VO2 max) ensures accuracy of the exercise prescription regarding HR ranges. Maximal exercise tests are utilized to either directly measure or predict maximal oxygen consumption (Max VO2) and are universally accepted for determining fitness levels as part of exercise prescription (Noonan, 2000). These protocols, or variations thereof, have been incorrectly utilized by the FCE providers, and are clearly not indicated for work physiology prediction tolerance.

Work Physiology Tutorial

The most important factors to consider when administering industrial physiological measurements are that they must be relatively uncomplicated to acquire and must supply accurate, valid and usable data. Energy expenditure (oxygen consumption) and heart rate are the two most common measurements; however, a number of researchers endorse heart rate as the primary measurement due to its linear relationship with energy expenditure (Berkow, 1982; McArdle, Katch & Katch, 2005; Payne, 1971). Heart rate, therefore, can be easily measured without interfering with the assessment in progress by having to use spirometry (VO) equipment (Booyens, 1960). Measuring the individuals' physiological response to the required work tasks can assess the heaviness of a task and the sustainable capacity for task completion; heart rate, as previously established, is one of the best indexes for this assessment (Bradbury, 2004; Ciriello, 1993; Davies, 1969; DHHS, 1996; Drury, 1989; Gamberale, 1990; Garg, 1988). Even in the presentation of moderate to strenuous work, alterations in posture and workspace (Morrissey, 1986), the physiological monitoring of heart rate is the best index of the stress imposed by the task (Demeter, 2002; Jiang, 1984; Kahlil, 1985; Kaudewitz, 2004; NIOSH, 1981).

The linear and steady state concept of work (oxygen consumption) with corresponding linear and steady state heart rate response is the foundational concept for the determination of full time work tolerance (deVries, 1972; Davis, Faulkner & Miller, 1969; Kaudewitz, 2004; Malhotra, 1962; Payne, 1971;). All individuals, regardless of fitness level or health status, demonstrate a linear relationship between oxygen consumption and heart rate (Ehrman, Gordon, Visich, & Keteyian, 2003). Additionally, the mean value for heart rate at any given submaximal task is the same for individuals of the same sex and state of training, regardless of age (Astrand, 2003; Davies, 1966; Giovoni & Goldman, 1971; NIOSH, 1981; Perry, 1982). Work that is not considered to be "heavy" (to be defined later) will result in a steady state heart rate response (+/- 5 bpm) for all apparently health individuals.

Researchers define the efficiency of physiological work as the percentage of energy that is transformed into useful sustainable work. The limit of continuous work, or LCW, is the sustainable work level that is linear and can be maintained without excessive fatigue. The expected ranges of this sustainable work have been reported by numerous authors (Astrand, 1961-2003; Davies, 1966; Fernandez, 1986; Fraser, 1992; Henschel, 1970; Hettinger, 1960; Kodak Ergonomics Group, 1986; Kroemer, 2001; Legg, 1985; Perry, 1992; Rodahl, 1989; Wilson, 1995). Under sedentary conditions, an individual on average will have an oxygen consumption of 3-5 ml/kg/min (ACSM, 2005; Kroemer, 2001). The basic premise of performance is that workloads of 3040% oxygen consumption are typical in industrial full-time work settings (Sharp, 1994). The typical workload heart rate in linear sustainedfunction was found to be in the range of 90-115 bpm (Jorgensen, 1999; Legg, 1985; NIOSH, 1981; Snook, 1965). Lower intensities (21-25% V02 expenditure), corresponded to heart rates between 90-92 bpm (Astrand, 2003; Jiang, 1984; Legg, 1985). Seated work requires 3-5% oxygen consumption and standing work requires 8-10% oxygen consumption (Kroemer, 2001). Work levels exceeding 50% maximal oxygen consumption capabilities, corresponding to an approximate heart rate of 130 bpm, have shown to cause limited work tolerance (Blankenship, 1991). Workloads between 30-50% can be achieved without undue fatigue (Henschel, 1970) and workloads of 25% were not sufficient to cause adverse signs or symptoms or general physiological fatigue. Authors have reported that 45-50%, or 125-130 bpm, have been identified as criteria of work tolerance ranging from 1-2 hours (Fernandez, 1986; Jiang, 1984; Kamon, 1982). These same authors note that workloads exceeding 50% or 140-150 bpm were the most limiting, with a tolerance of less than one hour. Typical continuous work performance was found to be 30-35 bpm above rest with a mean oxygen utilization of 33%. Jobs requiring intensities greater than 33% were found to be structured such that lighter work functions were intermittently introduced to an oxygen consumptionof less than 30%. Averaging the entire work performance over a full 8 hour workday revealed a 33% oxygen consumption or approximately 100-112 bpm. A work shift of 10 hours averaged 30.5% oxygen consumption and a 12 hour work shift averaged 28% oxygen consumption (Charya, 1996; Kamon, 1992; Krawczyk, 1993; Mital, 1994). If the burden placed upon the individual exceeds their capacity for sustained physical work, fatigue will invariably develop. Perry (1992) noted that any disease process of the cardiovascular, muscular or metabolic system would result in decreased oxygen consumption capabilities at any level of required work. Bassey, MacDonald and Patrick (1982) reported that the individual's physical tolerance to work as reflected by heart rate was directly proportional to their physical need for oxygen consumption. When the worker's condition was tolerant to standard intensity of work, there was a sustainable physiological response, which is measurable by heart rate. However, when the requirement of the work exceeds the tolerance of the individual, the heart rate elevated over time while the work function decreased symbolizing a decrease in oxygen delivery and the onset of fatigue. The contributors to the Disability Evaluation (Demeter, Andersson, and Smith, 1996) also noted that there is an inverse relationship between ability to sustain a task and the percent of strength requirement. In summary, the total sustainable work performed would decrease significantly as the work requirement exceeds the physiological tolerances. Thus, the endurance of the work requirement could be monitored as identified by the linear heart rate response, or the aberration thereof. The closer the task is to the workers maximum capacity, the shorter the bout of work that can be performed.

Numerous authors have demonstrated that once work has been commenced in a range of toleration, the motor speed reaches the steady state function in a range of 30 seconds to 3 minutes with heart rate response reaching steady state within 4-5 minutes. The heart rate documented within 5-6 minutes after initiation of work is designated as the working pulse rate (Astrand, 1961; Davies, 1966; deFries, 1972; Fraser, 1992). The linear association between oxygen consumption and heart rate from the 1st to the 5th minute of work would indicate that the stimulus and resultant are closely related and the degree of demand will depend on the rapidity of the work requirement and the output.

Relationship of Work Classification Severity and Heart Rate

Astrand et al (2003)

Workload	Heart rate, (beats/min)
Light	up to 90
Moderate	90-110
Heavy	110-130
Very heavy	130-150
Extremely heavy	150-170

Williams (1964)

Workload	Heart rate, (beats/min)
Very low	5
Low	75-100
Moderate	100-125
High	125-150
Very high	150-175
Extremely high	175

Kroemer & Grandjean (2001)

Workload	Heart rate, (beats/min)
Very low	60-70
Low	75-100
Moderate	100-125
High	125-150
Very high	150-175
Extremely high	175+

Wilson and Cortlett (1995)

Workload	Heart rate, (beats/min)
Light	up to 90
Moderate	90-100
Heavy	110-130
Very heavy	130-150
Extremely heavy	150-170

Jiang (1984)

Workload	Percent Work*	Work Duration	Heart Rate
Moderate	< 33%	8 hours	90-110
Heavy	33-50	8>1 hours	110-130
Very heavy	50-75%	1 hr> 20 min	130-150
Extremely heavy	>75%	<20 min	>150

* Percent work = % maximal oxygen consumption (ml/kg/min)

Kodak (1986)

Duration	Percent Maximum Aerobic Capacity	Heart Rate Elevation (bpm) above rest
8 hours	33	+35
1 hour	50	+55
20 min	70	+75
5 min	85	+90

Calculation of Heart Rate Response for Percentage Aerobic Capacity

Heart rate monitoring has been established as an effective and reliable method for determining the energy demands of work. According to Kodak (1986) and Rodahl (1989), the percentage of maximum heart rate is closely related to the percent maximum aerobic capacity, or maximum oxygen consumption. Therefore, a clear linear relationship between oxygen uptake and heart rate allows scientists to estimate intensity of required work (oxygen uptake) by directly measuring heart rate response during a bout of the particular job activity. An individual's age predicted maximum heart rate (APMHR) is calculated (estimated) as 220-age. On average, an individual's maximum HR declines by one beat per minute each year. To estimate the percent of maximum heart rate range required by a job or job activity, the following formula can be applied:

(AHRJ-RHR)/(PHRM-RHR) = % Max VO required

(Average HR on Job–Resting HR)/(Predicted HR Max-Resting HR)

The numerator represents (average) elevation in HR on the job, while the denominator represents the individual's heart rate range. The quotient in the equation is the percentage of maximum aerobic consumption required on the job.

Example:

Work requirement = 33% (% MaxVO)

Age = 50

Resting HR = 70 bprn (RHR)

Calculate average HR on the job AHRJ = (X)

(AHRJ-RHR)/(PHRM-RHR) = % Max VO required

(X-70)/([220-age]) – 70) = .33

(X-70)/(170-70) = .33

(X-70)/100 = .33

X-70 = (.33)*100

X-70 = 33

X = 33 + 70

X = 103 bprn

Conclusion: An average HR of 103 bpm is expected for this individual to participate in 8 hours of continuous work.

Alternative Formula for % oxygen consumption related to predicted work hours

[[(220-age) – (RHR)]* (% MaxVO2)] + RHR = Work HR

[(220-50) – 70]*.33 = 33 bpm

33+70 = 103 bprn

These formulas can be accurately applied to work prediction for the process of capacity evaluation testing thus providing a definitive approach to examiner analysis of calculating full-time work.

Select review of calculations used in FCE evaluations:

Blankenship (1991) cardiovascular endurance data calculation for age adjusted predicted heart rate:

Final working HR/APMHR = % MaxVO

Example:

115 /(220-age) = %

115/(220-40) = 64%

Blankenship (1991) Occasional Material Handling, Limiting Factor-Aerobic

220-age = (Final Working HR)* (.85)

220-40 = (Final Working HR) * (.85)

180 (.85) = 153 bpm

The values represented by 153 bpm for "Occasional Material Handling" are not consistent with values identified in the review of the Work Classification Severity and Heart Rate. By definition, the term "occasional" for time tolerance according to the Dictionary of Occupational Titles (1986), physical characteristics of work is up to 33% of the work time application. This severity index shows that a heart rate of 153 bpm; which according to Jiang (1984), would place this calculation in the range of very heavy work for which the duration would be less than 20 minutes. The occasional time application heart rate according to Jiang shows a heart rate range of 110-130 bpm. Additionally, the calculation of 64% by the Blankenship formula for endurance predicted heart rate is not consistent with the Work Classification Severity and Heart Rate data. A value of 64% oxygen consumption would place the worker in extreme expenditure resulting in a very limited time for work tolerance. If the typical work oxygen consumption percentage of 25-33% were applied to the formula calculated value of 180 bpm, the resultant heart rate would be 45 - 59 bpm. Obviously, this calculated heart rate value for comparison to work would be totally unrealistic since it would fall below most typical resting heart rate values. Therefore, the above calculations by the Blankenship formula do not comply with the standardizations identified by the work physiology profile (Jiang) nor are they consistent with the Severity and Heart Rate predictions for sustained full-time work.

In another example of current calculations regarding determination of work physiology HR (Valley Medical Center, 2003), a 49 year old male with a resting heart rate of 92 bpm was found to have a target heart rate of 103 bpm for 60% oxygen consumption. In comparison to the Work Classification and Severity Heart Rate Data, a heart rate of 103 bprn according to Jiang (1984) correlates to a work tolerance within the low to moderate categories, less than 33% oxygen consumption, which would not correlate to the 60% oxygen consumption as noted above.

A correct application of the alternate formula to predict work tolerance (as noted above), while using the data from the Valley Medical Center example (i.e. 49 y.o. male with resting HR of 92 bpm) would be as follows:

220-49 = 171

171 – RHR = 171 – 92 = 79

79 * .33 = 26

26 + RHR = 26 + 92 = 118 bprn

This calculation based upon 33% oxygen consumption is clearly not the same as the 60% oxygen consumption reported by the Valley Medical Center.

If the work level were decreased to anticipate 25% aerobic capacity, the tolerance prediction for HR would be as follows:

220-49 = 171
171 – 92 = 79
79 * .25 = 20
20 + 92 = 112 bpm

Therefore, the Valley Medical Center prediction of a target heart rate of 103 bpm as 60% of oxygen consumption is an incorrect prediction.

Conclusion

The general state of capacity evaluations for predicting full-time work has historically relied on exercise testing procedures and prediction formulas. Clearly, this method of applying exercise testing to work physiology testing is inappropriate and misinterpreted. Reviews by authors such as King, Tuckwell and Barrett (1998)concluded that there were no peer reviewed publications and a considerable lack of test control. Terms such as "uncontrolled test protocol" to explain FCE methodology, indicates that some examiners were self-taught or guided by other's who were likewise ill instructed. The glaring error of those FCE providers who have conducted or taught their protocol without incorporating scientifically correct methodology, have obviously done so without possessing qualifications or credentials from an accredited source such as the American College of Sports Medicine. Due to the relatively short period of time that FCE testing has been an identified discipline, it is obvious that there a clear lack of specific guidelines and/or practices related to work physiology which are to be performed by the licensed or credentialed provider. King, Tuckwell and Barrett (1998) in their review of the commercially available capacity evaluation protocols, found nothing to support the contention that providers were equipped with a credential enabling them to conduct work or exercise physiology testing. Few physical or occupational therapists providing capacity testing have made the commitment to upgrade their skills to a professional qualification level regarding physiological testing procedures.

When combining the lack of training and credentialing with the pitfalls of the commercial capacity evaluation products, the failure to correctly and accurately predict full-time work tolerance is understandable. The consumer, institutional organization, judicial system, or academic entity endorsing or utilizing commercial protocols reviewed by the aforementioned authors, should be advised that the continuity of testing for work prediction tolerance is significantly flawed. The foundational research for work physiology prediction in many cases predates the inception and introduction of the commercial FCE products, thus implicating the creators of the products as having done little to incorporate established work physiological principles. Secondly, the academic institutions preparing students for a career within the allied health professions must ensure their curriculums adequately incorporate the science of work physiology into the training regime regarding the disciple of FCE testing. The governing bodies of the allied health field such as APTA (American Physical Therapy Association), and ASHT (American Society of Hand Therapists) who have published guidelines for capacity evaluations must utilize the full range of scientific research and expertise available for the work physiology component concerning full time work prediction.

Basic exercise and work physiology principles can be applied in both the areas of industrial health as well as human performance, thus fulfilling many aspects of the objective quantification and evidence based procedures for capacity evaluation testing. It is the opinion of this authorship. that all professionals utilizing and conducting FCE testing must understand a variety of established principles. These principles are:

1. The linear relationship between oxygen consumption and heart rate allow for the heart rate response to be used as a non-invasive interpretive tool for examiners to predict full-time work tolerance. Work tolerance can therefore be performed in an efficient, short duration time period.
2. Deviations from the linear response of oxygen consumption and HR during work activity allow the examiner to effectively determine if there is a physical intolerance for sustainable work.
3. Prediction of work tolerance by HR prior to the execution of testing procedures is a distinct advantage in the decision making process regarding the examinee assignment to a full-time work tolerance. When appropriate protocols are introduced to the individual, the motor response can be accurately measured.
4. Physiological prediction can also be utilized to assess the participation of the examinee. Minimal elevation of HR above resting indicates below average recruitment of the muscular system that would be necessary to perform the required tasks. Considerable elevation of heart rate above resting is diagnostically interpretive of barriers to full-time work and/or the effects of systemic or disease processes.

It is incumbent upon professionals conducting capacity evaluations to hold themselves, as well as fellow professionals, accountable for the applications of the sciences that are the foundation of the procedures they are incorporating in the examination process.

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