REPLICATION OF MAXIMAL WORK OUTPUT LEVELS IN ABLE-BODIED WORKERS AND CANDIDATES FOR DISABILITY ASSESSMENTS: BENCHMARK DATA AND GUIDELINES.

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INTRODUCTION

Injured-at-work employees, when the impairments are musculo-skeletal, and the injury beyond dispute, may be faced with formal rehabilitation or informal recuperation, sometimes preceded by surgical intervention, or they may be exposed to a process of application for compensation, part of which may involve medico-legal assessments.

Questions that need to be addressed somewhere in this process will determine whether the impairment is of short duration, chronic or irreparable, and will involve determination also of the severity of the impairment and the issue of the workers' capacity to return to the former occupation versus the need to find a new employment niche commensurate with the disabled workers' capabilities. Inevitably in this process, if it is formal, someone will need to assess the musculo-skeletal strength of the injured employee and make pronouncements as to physical capacity and work-readiness. In the absence of clinical ergonomists in South Africa this task falls to a variety of professionals, some well and others poorly trained to make these determinations. Most often the assessments of work-readiness are crude, amounting to little more than unsubstantiable value judgements of supervisors or health professionals not well versed in human performance capabilities. Increasingly however, better qualified professionals are making themselves available to meet the growing demands of a more employee-centred working ethos in this country. This paper is targeted at those medical, paramedical and ergonomics professionals who already have the facilities and the expertise to make use of the technique outlined herein, to further enhance their already sound means of job-related disability assessment.

It is never an easy task to assess the physical strength of previously injured subjects, who may have residual pain, and who, quite naturally, will be psychologically predisposed not to exert themselves in ways likely to bring on a recurrence of pain or perceived to raise the risk of re-injury. Yet, when such exertions are pronounced to be medically safe, they must be made if we are to determine present capability and work-readiness. Workers, in short, are likely to inhibit their exertions for fear of re-injury; assessors on the other hand, can do little to assess disability levels if fluctuating submaximal efforts are made. Isoinertial strength tests, (those involving pre-set external weights to be moved), are laborious because successful accomplishment means only that the pre-set load *can* be moved; it does not imply that this was indeed the maximum which *could* be safely handled: a new, higher load must be attempted and the maximal load established by trial and error. Precautions must be taken to ensure that subjects are not fatigued in this process - further complicating the question whether capacity limits have been properly gauged. Isometric strength tests, on the other hand, may measure maximal effort levels, but only at the one fixed point in the range of motion of the musculo-skeletal lever system under consideration: the procedure is made laborious by the need to conduct properly standardised tests in an array of positions through the normal range of the joint in question.

Both the above drawbacks are removed by dynamic, full-range exertions as measured in isokinetic dynamometry. From a disability assessment perspective isokinetics has the additional advantage of being passive: the subjects control their own levels of exertion which is the best assurance that they will not, in the process, exceed pain tolerance levels or re-injure themselves. This advantage, however, is not without cost. The assessor must now determine whether the effort expended was, wilfully or not, inhibited. Wilful inhibition (malingering) might be the response of a compensation-seeking worker who is physically capable but chooses to appear more disabled than is in fact the case. Unconscious inhibition is a typical response from a previously injured subject, exacerbated by personality factors predisposed to symptom exaggeration or by physically-mediated low pain tolerance.

Our present concern, however, is not with employees suffering crippling real or imagined pain, but rather with people for whom there exists no medical reason why they should not be asked to produce a limited number of maximal muscular tension efforts, against resistance, as a means of assessing their capability limits and return-to-work prospects.
In such cases, if a worker exerts, say four times, to the limits of pain-free capacity, the assumption can be made that the four exertions will be closely similar. Conversely, if a worker, for whatever reason, is not working maximally, this will show up as inconsistency of effort-level. Only holistic analyses by interdisciplinary teams of experts hold promise for detection of wilful malingering. But the statistical likelihood of a subject producing consistent efforts yet not exerting maximally is so low that it can be discounted.

Several attempts have been made in recent years to quantify consistency of effort (reduced inter-curve variability); some of them subjectively involving expert opinion, as proposed by Hazard *et al*. (1988); and Reid *et al*. (1991), others of them objectively employing mathematical manipulations, as proposed by Lin *et al*. (1996), but all of them laboriously time - consuming. Presented here is a simple, easily administered, yet effective alternative.

Benchmark data

This paper offers a simple, yet effective method for detection of effort-level consistency, and provides guidelines for analyses of isokinetic strength tests used to assess disability level or work-readiness. In occupational, recreational or daily living situations in which musculo-skeletal exertions are required to be made it is the subjects' ability to generate forces through large arcs of motion about joints that is crucial rather than the subjects' strength at any particular point in the range of motion. When we lift objects it is often through an appreciable distance: our success depends upon our strength in the positions where we are least, not most, capable. Thus it is not so much the tension one can develop at the strongest point in the range of motion, but the tension one develops through the entire range that counts. For this reason we set more store by analysis of a subjects' work (full-range tension) output than by peak torque (point tension). Our criterion measure for inter-repetition effort-level consistency, therefore, is:(mean work per repetition/best work repetition) x100. Presented in Tables I and II are the results of detailed testing of 42 healthy adult males aged from 23 to 40 years, all engaged in non-clerical, manual materials handling-type physical work. It is beyond the purpose of the present paper to report on the actual raw strength measures of this group. Of relevance here is the degree of consistency of their efforts, across a wide variety of tests and a wide spectrum of test speeds. What these tables show is that, overall, we can expect a presumably reasonably well-motivated healthy adult to be able to produce a 4-repetition maximal isokinetic response whose mean work output is at least 90% of the maximum work produced in the best of the four efforts. This, then, offers a benchmark indicator of effort-level consistency: mean-over-max. work in a four-repetition set is inconsistent if it falls apparently below 90%.

Table I: Percentage-based level of consistency of effort across a 4-repetition bout in diverse clinical tests.

Test	**Motion**	**Consistency of Effort-Level (Mean Work/Max Work).100**				
		30°.s^{-1}	**120°.s^{-1}**	**210°.s^{-1}**	**Mean (SD)**	**C.V. (%)**
Knee	**Extension**	92.90	92.90	88.09	91.30(2.78)	3.04
	Flexion	90.05	90.84	88.42	89.77 (1.23)	1.37
Trunk	**Extension**	92.80	92.36	83.02	89.39 (5.52)	6.18
	Flexion	95.32	93.32	84.41	91.02 (5.81)	6.38
Shoulder	**Internal Rotation**	94.02	95.78	95.01	94.94 (0.88)	0.93
	External Rotation	94.50	96.20	94.95	95.22 (0.88)	0.93
Ankle	**Plantarflexion**	90.16	92.86	93.37	92.13 (1.73)	1.87
	Dorsiflexion	91.99	93.74	100.00	95.24 (4.21)	4.42
Hand	**Fist-clenching**	99.00	98.50	98.00	98.50 (1.03)	(1.05)
Hip	**Extension**	90.72	91.88	91.78	91.46 (0.64)	0.70
	Flexion	91.79	91.18	92.12	91.70 (0.48)	0.52
Elbow	**Extension**	94.68	93.67	95.71	94.69 (1.02)	1.08
	Flexion	94.20	94.57	95.61	94.79 (0.73)	0.77

Table II: Percentage-based level of consistency of effort across a 4-repetition bout in diverse occupation-simulating tests.

Test	Motion	Consistency of Effort-Level (Mean Work/Max Work).100				
		30°.s^{-1}	**120°.s^{-1}**	**210°.s^{-1}**	**Mean (SD)**	**C.V. (%)**
Valve-Turning	**Clockwise**	91.61	94.68	92.76	93.02 (1.55)	1.67
	Counter-Clockwise	93.56	94.60	95.62	94.59 (1.03)	1.09
Trolley-maneuvering	**Pull**	90.93	90.51	87.19	89.54 (2.05)	2.29
	Push	92.43	89.47	85.90	89.27 (3.27)	3.66
Screw-turning	**Internal Rotation**	94.77	96.38	96.78	95.98 (1.06)	1.11
	External Rotation	96.72	95.18	95.78	95.89 (0.78)	0.81

Guidelines for assessment of effort-level consistency

We suggest the following guidelines for the diverse assessment-categories listed below:

1. In strength screening for "able-bodied" personnel in military, police, firefighting and other emergency services, use as the criterion of effort-level consistency a minimum mean/max. work ratio of 90%.
2. In assessing return-to-work readiness for manual materials handling jobs, following job-related musculo-skeletal injury, use as the criterion of effort-level consistency a maximum mean/max. work ratio of 85%.
3. In disability assessments and medico-legal contexts, assume that a mean/max. work ratio below 80% indicates that, for reasons physical and/or psychological, the subject is failing to produce a normal effort-level consistency. In these contexts, if the assessments are being properly conducted, clinical ergonomists should be working in concert with orthopaedic and/or neurological specialists, occupational and/or physiotherapists and of course, psychiatrists. Informed decisions as to whether objectively-measured fluctuating effort levels are consistent with pain-amplification, disability magnification, "illness behaviour" low pain tolerance, manifest and clinically-relatable pain, impaired kinesthesis, physical range-of-motion limitation *etc*. can be made, by consensus, in a collaborative interdisciplinary way by the disability assessment consortium. The objective measure of detected submaximal effort levels forms a powerful adjunct to consensual disability assessment.

REFERENCES

Hazard RG, Reid S, Fenwick I and Reeves V (1988). Isokinetic trunk and lifting strength measurements; variability as an indicator of effort. **Spine**, 13: 54-57.

Lin P, Robinson ME, Carlos J and O'Connor P (1996). Detection of submaximal effort in isometric and isokinetic knee extension tests. **Journal of Orthopaedic and Sports Physical Therapy**, 24 (1): 19-24.

Reid S, Hazard RG and Penwick JW (1991). Isokinetic trunk-strength deficits in people with and without low-back pain: a comparative study with consideration of effort. **Journal of Spinal Disorders**, 4 (1): 68-72.