Are commonly used manual handling assessment tools effective in the prevention of work-related musculoskeletal symptoms?

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Contents:

- MHO and MS disorders
- Risk Factors for LBD
- MHO assessment methods
- Worker based evaluation
- Cumulative effects of spinal loading

MHO and Musculoskeletal Disorders

- Local Statistics
  - 18.9% (8,375/44,267 in 2005)
- LBD is the commonest and frequently associated with physical demanding tasks such as manual lifting
- Tremendous research in this area
  - e.g. A four-folds increase in studies from 1971-80 vs 1981-90

REVIEW OF PREVALENCE OF LBD

Point prevalence	Mean = 34.8%	CI: 26.9-42.7%
1-year prevalence	Mean = 48.9%	CI: 43.6-54.1%
Life time prevalence	Mean = 62.9%	CI: 55.1-70.6%

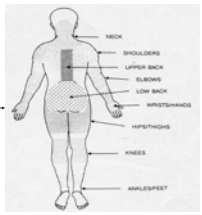
Based on medline search from 1960-2002
Summary of 65 studies

Does MHO only affect the lower back region?

- 217 male workers with varied levels of manual lifting experience from Hong Kong
- Nine companies from three major industries: warehouse operations, delivery services, and electric part manufacturing

Yeung SS et al. 2002a

MS outcome Nordic musculoskeletal Symptoms survey

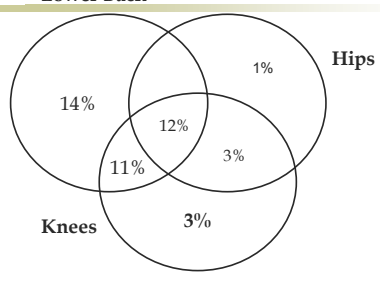


Body region	12 month Prevalence (%)
Upper back	32.87
Lower back	58.33
Hips/Upper legs	32.41
Knees/Lower legs	21.30
Ankles/Feet	26.85
Neck	31.02
Shoulders	38.89
Elbows/Forearms	21.30
Hands/wrists	20.83
Fingers	12.04

Body region	Prevalence (%)
Lower back + shoulders	52.38
Lower back + upper back	44.44
Lower back + upper legs	44.44
Lower back + lower legs	44.44
Lower back + Neck	43.65

Nursing Professionals

Boy region	12 months prevalence	1 month prevalence
Neck	96%	38%
Upper back	91%	36%
Lower Back	**98%**	**59%**
Hips/Upper legs	89%	30%
Knees/Lower legs	91%	39%
Feet and ankle	86%	29%
Shoulder	93%	38%
Arm	90%	14%
Hand-wrist	90%	20%
Fingers	77%	10%



Yeung SS et al. 2004

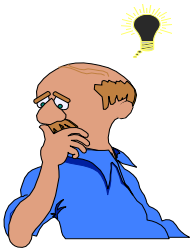
Personal Care Assistant in Nursing home

Body region	12 months Prevalence
Neck	65.8%
Upper back	89.5%
Lower Back	**94.7%**
Hips/Upper legs	81.6%
Knees/Lower legs	71.1%
Foot and ankle	76.3%
Shoulder	92.1%
Arm	73.7%
Hand-wrist	63.2%
Fingers	44.7%

Personal Care Assistant in Nursing Home

Low back pain	
12 month prevalence	94.7%
Symptoms duration with past 12 month:	
- 1-7 days	15.8%
- 8-30 days	18.4 %
- >30 days	23.7 % ⇦
- Everyday	36.8%
Affecting work	26.3% ⇦
Pain in the past 7 days	50.0%

MHO and Musculoskeletal Disorders



- We should not only focus on lower back
- Kinematics changes with multiple jts involvement
- Definition of LBP

RISK FACTORS ASSOCIATED WITH LBD

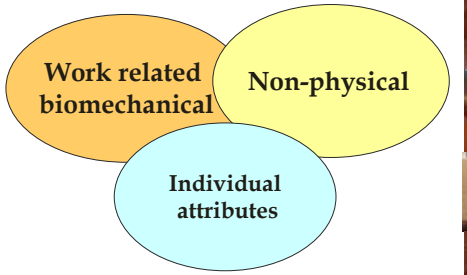
REVIEW OF RISK FACTORS

- Medline database from 1960-2002
- 94 studies extracted

Study design	**CS**	**N=60**
	Prospective	**N=31**
	CC	**N=3**
Risk factors assessed	**Physical**	**N=45**
	Non-physical	**N=16**
	Both	**N=32**
Evaluation methods	**Questionnaire**	**N=79**
	Interview	**N=16**
	Observation	**N=8**
	Direct measure	**N=15**
Outcome measures	**Self-reported**	**N=78**
	Medical Exam	**N=9**
	Work injuries	**N=12**

Physical			Non-physical		
	+ve	no		+ve	no
Lifting	34	4	Monotonous	4	
Push/pull	3		Stress/anxiety	7	
Carrying	2		Education	6	
Twist/bend	22	2	Job dissatisfaction	8	
Vibration	13		High work demand	14	1

RISK FACTORS ASSOCIATED WITH LBD



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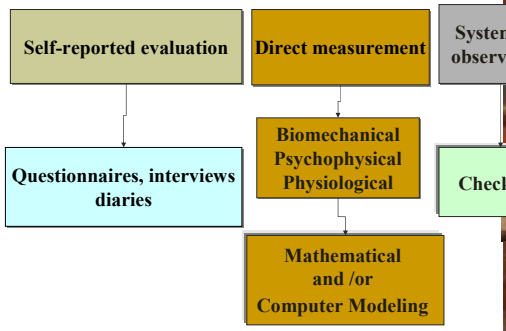
METHOD OF ASSESSMENT



Checklist Approach

- Code of Practices & Guidelines
  - MHO Guidelines (Labour Dept, HK, 1998)
  - MHO Guidelines (HSE, UK 1992)
  - MMH Code of Practices (Victoria, Australia 1988)
- lack sufficient practical guidance (Industry Commission, 1995)

Mathematical and /or computer modeling approach

- NLE (Revised NIOSH lifting equation, Waters et al., 1993)
- LMM and OSU Model (Marras et al., 1992, 1993)
- Psychophysical Approach – Snook et al., 1978
- The University 3D Static Strength Prediction Program (3DSSPP)
- Physiological model (University of Michigan EEPP)

NIOSH lifting equation

- A mathematical equation for the calculation of recommended weight limit (RWL) and lifting index (LI)
- Only for two-handed manual lifting activities
- Input data: 7 lifting variables
  - Weight of load
  - Horizontal distance
  - Twisting angle
  - Origin of lift
  - Height of lift
  - Frequency and duration
- LI = L/RWL

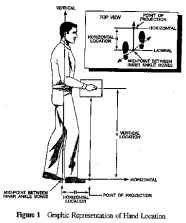


Figure 1 Graphic Representation of Hand Location

NIOSH lifting equation (1991)

- Originally, Work Practices Guide for Manual Lifting in 1981 (NIOSH 1981 lifting equation)
- Limitation
- In 1985, NIOSH convened an ad hoc committee of experts to update information on physiological, biomechanical, psychophysical, and epidemiological aspects manual lifting

Criteria used to develop the equation

Discipline	Design criterion	Cut-off value
Biomechanical	Max disc compression force	3.4 kN
Physiological	Max energy expenditure	2.2-4.7 kcal/min
Psychophysical	Max acceptable weight	75% of female and about 99% of male workers

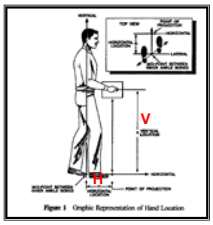
Rationale

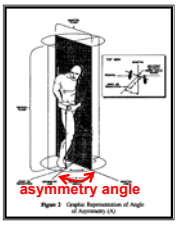
- Principal product: Recommended Weight Limit (RWL)
- For a specific set of tasks conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (up to 8 hrs) without an increased an increased risk of developing lifting related LBP
- "Healthy workers" are those who are free of adverse health conditions that would increase their risk of musculoskeletal injury
- Load constant: 23 kg

RWL

- Calculation of RWL

RWL= LC x HM x VM x DM x AM x FM x CM





LIFTING INDEX (LI)

LI = L / RWL

- RWL is compared with the ***actual*** weight W of the object being lifted
- Comparison is made at the ***origin*** and ***destination*** of a lift
- Larger of the two values is considered the ***"stress level"*** of a lift
- LI < 1.0 …. protective of most workers
- LI > 3.0 …. poses significant risk to most workers
- 1.0 < LI < 3.0 …. many jobs fall in this region
- Jobs need to be either redesigned to minimize LI, otherwise need increased job screening, more careful training, and medical monitoring

Evaluation of the Revised NIOSH Lifting Equation

- Waters et al, 1999 conducted a cross-sectional epidemiologic study to determine the correlation between the prevalence of low back pain and exposure to manual lifting stressors using the LI
- Evaluated 55 jobs from 4 industrial sites with the NIOSH lifting equation

LI ↑ from 1.0 to 3.0, odds of low back pain ↑
Peak odds ratio
in the 2< LI ≦ 3 category (OR =2.45)
However, OR (=1.45) was lower for jobs with LI > 3

OSU Regression Model

- Developed in 1993 by Marras and co-workers
- Literature review suggests trunk motions experienced by workers may be an over-looked causal factor
- Data reported by Bigos et al (1991) suggested risk of LBD is associated with dynamic lifting, but it has never been shown in in vivo studies

OSU Dynamic Trunk Motion Analysis

- Trunk motion variables were measured by a tri-axial electrogoniometer called Lumbar Motion Monitor (LMM)
- Allow capture of trunk angle position, velocity, and acceleration characteristics in each of the cardinal planes)
- Together with other task variables:
- Logistic regression models were developed

Evaluation of OSU Regression Model

- Cross-sectional study of 403 industrial jobs from 48 manufacturing companies
- Jobs were divided into three groups, *high*, *medium* and *low* risk of LBD, based on examination of the injury and medical records (independent variables)
- Dependent variables consisted of workplace, individual and trunk motion characteristics

- Logistic regression analysis was used to determine the association of the low risk jobs to high risk jobs with workplace, individual and trunk motion characteristics
- Maximum moment (OR 5.17 between high and low risk; OR 4.04 between low and medium risk) and velocity (OR 3.33 between high and low risk) are the two most powerful variables for discriminating between risk groups

PSYCHOPHYSICAL APPROACH

- Snook and Ciriello database
- Provide weight limits for lifting
- Base on workers' perception (integration of stress and strain)
- Maximum acceptable weight of lift for specified combinations of lifting variables (frequency, height of lift….etc.,)

Evaluation of NIOSH Guide/Equation & Psychophysical Measures

- Marras et al, 1999 assessed the NIOSH Guide (1981), Revised NIOSH Lifting Equation (1991) and psychophysical measures for their ability to correctly identify high, medium and low risk of LBD jobs (Independent variables)
- Defined workplace characteristics (Dependent variables) in 353 industrial jobs representing over 21 million person-hours exposure

Evaluation of NIOSH Guide/Equation & Psychophysical Measures

- Only factors of average weight of object lifted and average horizontal distance produced a statistically significant OR
- Both 1981 and 1991 NIOSH measures had odds ratios for high risk versus low risk of LBD
  - OR 3.1 and 3.5 (average moment arm)
  - OR 4.3 and 4.6 (maximum horizontal moments)

Evaluation of NIOSH Guide/Equation & Psychophysical Measures

- The NIOSH Guide 1981
  - Good specificity (91%) but low sensitivity (10%)

Table 4. 1981 NIOSH *guide* lifting index risk versus historical risk.

Historical risk	NIOSH lifting index: Lifting index < 1	1< lifting index < 3	lifting index > 3
Low risk (124)	**91% (113)** **LI= 0.19** **Risk= 0**	9% (11) LI= 1.85 Risk= 0	0% (0) LI= *** Risk= 0
Medium risk (118)	52% (61) LI= 0.41 Risk= 3.9	**43% (51)** **LI= 1.79** **Risk= 6.4**	5% (6) LI= 4.8 Risk= 4.9
High risk (111)	57% (63) LI= 0.41 Risk= 26.7	33% (37) LI= 1.67 Risk= 25.3	**10% (11)** **LI= 7.1** **Risk= 27.2**

***LI not calculated due to sample size.
Bold type indicates correct identification.

Evaluation of NIOSH Guide/Equation & Psychophysical Measures

- The NIOSH Guide 1991
  - Better sensitivity (73%) but did not

NIOSH guide (1981) **underestimating the risk**
Revised NIOSH lifting equation (1991)
Overestimating risk

		Risk= 0	Risk= 0
Medium risk (118)	11% (13) LI= 0.38 Risk= 4.2	31% (25) **LI= 1.90** **Risk= 3.3**	68% (80) LI= 10.9 Risk= 5.6
High risk (111)	8% (9) LI= 0.69 Risk= 34.2	19% (21) LI= 1.72 Risk= 24.9	73% (80) **LI= 11.3** **Risk= 25.9**

Bold type indicates correct identification.

Evaluation of NIOSH Guide/Equation & Psychophysical Measures

Table 6. Percentage of population finding jobs acceptable in high-, medium- and low-risk groups based upon psychophysical criteria.

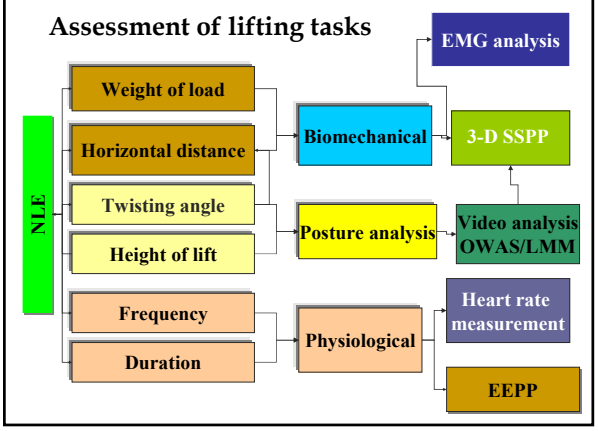
Percentage of population that can perform job	Number of jobs	Cumulative distribution
High risk		
90	57 (51%)	57 (51%)
75	10 (9%)	67 (60%)
50	13 (12%)	80 (72%)
25	8 (7%)	88 (79%)
10	23 (21%)	111 (100%)
75	5 (4%)	113 (91%)
50	5 (4%)	118 (95%)
25	0 (0%)	118 (95%)
10	6 (5%)	124 (100%)

Similar trend to the NIOSH measures, higher the risk fewer the workers would consider the jobs to be acceptable

3 D static strength prediction program (3DSSPP)

- A user-friendly biomechanical analysis software
- Required input of joint angles to define body posture
- Anthropometric measures for body characteristics
- Magnitude and direction of externally applied forces
- Software for the analysis of:
  - Moments
  - Anterio-posterior and lateral shearing force; and
  - Compressive force at L5/S1
  - Estimation of muscle strength requirements

Assessment of lifting tasks



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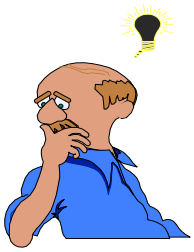
CURRENT PROBLEM OF LBD

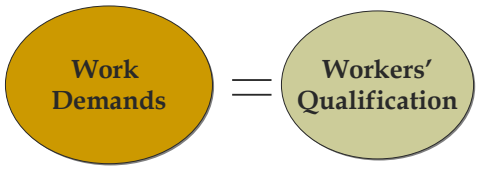
- LBD statistics had not declined to a satisfactory level
- Point prevalence 31.5 vs 39.3% in nursing profession between 1975-1990 and 1990-2000
- Similar statistics in UK, 12 month prevalence 36.4 vs 49.1% between 1987-8 and 1997-8.

MHO and LBD

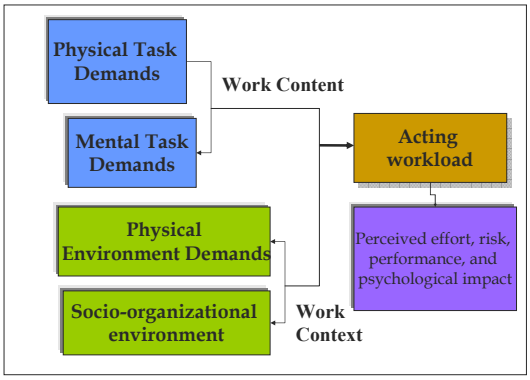


- LBD-multi-factorial
- Evaluation: self-reported, checklist, and direct measurement
- Outcome measure: self reported
- LBD statistics had not declined to a satisfactory level

MHO Evaluation



WORK DEMANDS

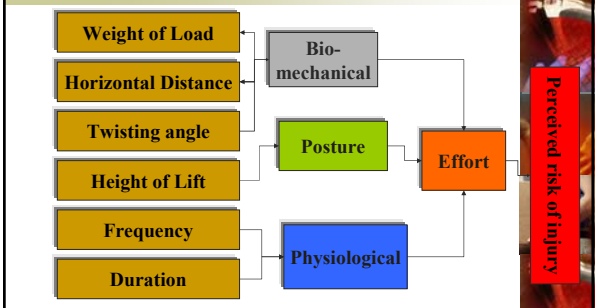


WORKER-BASED EVALUATION

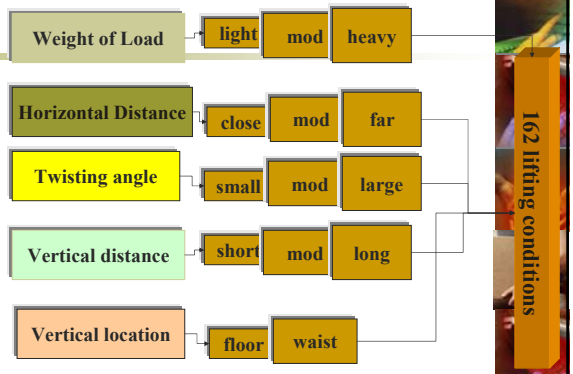
Yeung SS et al. 2002, 2003a, 2003b, 2003c

- Existing worker-based evaluation is predominately checklist-based model
- Worker-based evaluation capitalised workers knowledge and expertise in the evaluation of their own workplace
- Workers commit more easily to the work environment that they help create

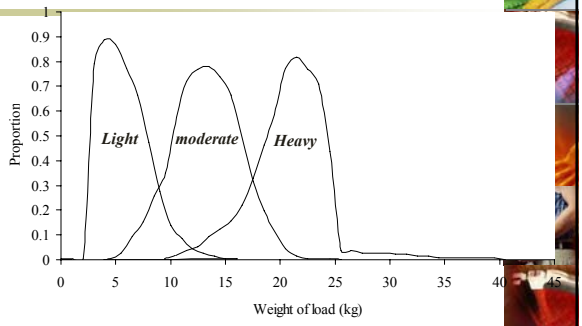
LIFTING



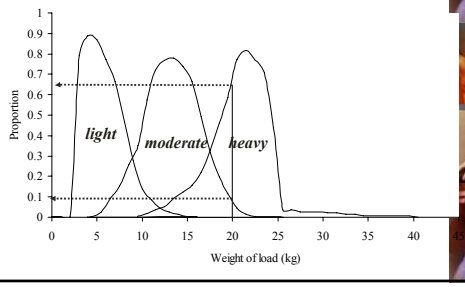
Evaluation Procedures

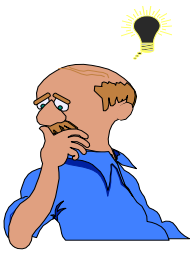


Linguistic-numerical mapping for weight of load



A given numerical value for a lifting task parameters translates to different linguistic interpretation with a given certainty factor



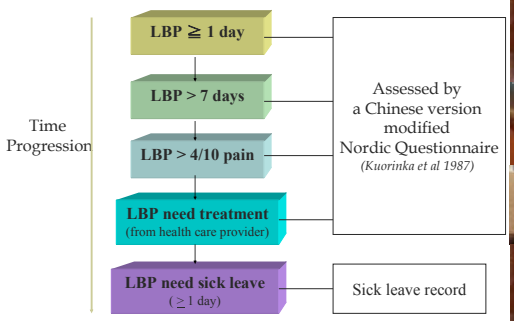


- Effort significantly associated with lifting variables; objective indices reported in the published literature for evaluating lifting stresses, and MS symptoms;
- Weight of load is the most important variable influencing effort;
- Relative importance of other variables were not in total agreement with NIOSH LE

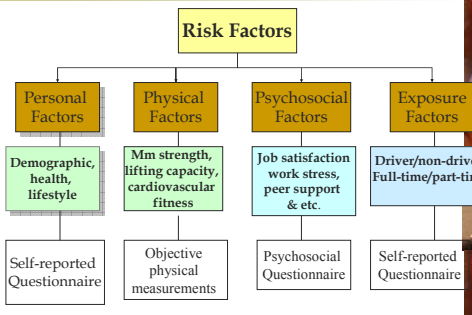
A Field Study

- Cross-sectional study (Tam & Yeung 2006)
  - on 38 staff of NEATS Dept.
- Four categories of risk factors
  - personal, physical, psychosocial & exposure factors
- Five LBP definitions with progressing severity

LBP definitions



Measurements of risk factors



LBP cases that required treatment from health care providers

		95% CI	
Variables	OR	Lower	Upper
Age**	0.05	0.75	0.99
RPE**	2.45	1.07	5.58
Job satisfaction*	1.45	1.07	5.58
Fatigue after work*	2.00	0.93	4.32
Self-perceived work load*	2.57	0.98	6.77
Flexor peak torque at 60°/s*	1.04	0.99	1.08
Flexor peak torque at 120°/s*	1.05	0.99	1.10

*p <0.1
**p <0.05

			95% CI	
Variables	β	OR	Lower	Upper
RPE	2.07	7.95*	1.46	43.27
Job satisfaction	1.431	4.18**	1.42	12.33
Age	-.287	0.75*	.56	1.00
Flexor peak torque at 120°/s	.086	1.09#	.99	1.19
constant	-14.169	0.00		

*p <0.05
**p <0.01
#p=0.06

Risk and protective characteristics of work-related factors and the prevalence of MS symptoms

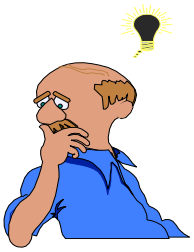
- 97 female registered nurses
- Two surveys were used to document the workload exposure of the nurses.
- One survey consisted of 148 items aimed to measure the acting workload variables from the environment; the other survey included 33 items which were aimed to measure the nurses' experienced workload.
- MS outcomes were documented with a modified version of the Nordic MS Symptom Survey.

- Factor analyses revealed three factors that accounted for 56% of the total variance.
- Factor 1 represented the psychological effects of work characteristics, effort, perceived risk and performance.
- Factor 2 consisted of non-physical variables of the work characteristics
- Factor 3 loaded on the both acting and experienced workload.

Variable	Factor1	Factor 2	Factor 3
Physical task requirements	-0.10	0.08	***0.68***
Mental task requirements	0.25	***0.59***	0.42
Sensory task requirements	-0.07	0.31	***0.57***
Physical environment requirements	-0.01	-0.09	***0.69***
Socio-organization environment requirements	-0.23	0.36	***0.56***
Effort requirements	0.04	0.24	***0.67***
Perceived risk requirements	-0.12	0.32	***0.66***
Social-communication conditions	0.29	***0.85***	0.07
Organization conditions	0.17	***0.75***	0.17
Economic growth conditions	0.01	***0.79***	0.21
Individual growth conditions	0.13	***0.82***	0.20
Satisfaction with task requirements	***0.74***	-0.03	0.13
Satisfaction with physical environment requirements	***0.63***	0.16	-0.22
Satisfaction with socio-organization environment requirements	***0.73***	0.00	-0.08
Satisfaction with organization conditions	***0.79***	0.21	-0.15
Satisfaction with social-communication conditions	***0.71***	0.14	-0.14
Satisfaction with growth conditions	***0.67***	0.08	0.02
Satisfaction with performance	***0.71***	0.13	-0.02

- Logistic regression analyses indicated that Factor 3 was significantly associated with the musculoskeletal symptoms of lower and upper back, hands/wrists, and knees/lower legs (odds ratios > 1.0)
- Factor 2 was significantly associated with the musculoskeletal symptoms of the upper back and knees/lower legs (odds ratios < 1.0).

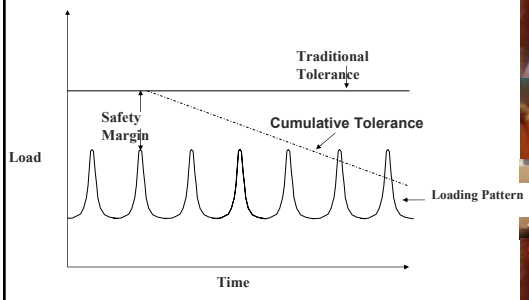
Yeung SS et al. 2005



- Comprehensive understanding of the relationship between the risk and protective elements of acting and experienced workload at the workplace

How about effects of cumulative spinal loading?

Time-varying load-tolerance model (Marras 1998)

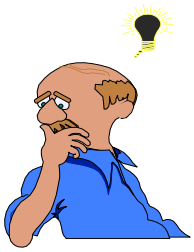


Meta-analysis

- Association between cumulative spinal loading and lower back disorders (LBD)
- 13 articles were identified as relevant
- Six of these studies evaluated the association of cumulative spinal loading with lower back disorders

- Quality of the studies are in general poo
- The meta-odds ratio for the fixed effect model was 1.66 (95% CI=1.46-1.89)

Waters T, et al., 2006a, 2006b



- Implication of cumulative loading in an aging workforce?

Summary

- MHO and MS disorders
- Multiple factorial risks for LBD
- MHO assessment methods
- Worker based evaluation
- Cumulative effects of spinal loading

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- Dr Thomas Waters (NIOSH)
- Prof PC Leung (CUHK)

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