WEBINAR MAGISTRALI 2023

Società Italiana di Medicina del Lavoro

ATTUALITÀ IN TEMA DI VALORI LIMITE TRA BASI SCIENTIFICHE RICADUTE NORMATIVE ED APPLICATIVE

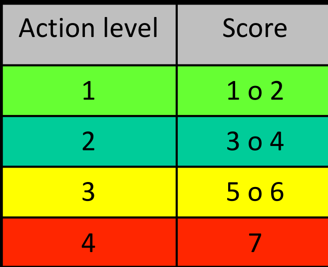
Numeri, aree, colori nella definizione dei valori limite: qualche lezione dalla valutazione del rischio muscoloscheletrico?

Venerdì 23 giugno 2023 h. 15.00/17.00

Relatore: *Roberta Bonfiglioli, Università di Bologna*

Conduce: *Stefano Mattioli, Università di Ferrara*

Webinar Magistrali 2023



Action level	Score
1	1 o 2
2	3 o 4
3	5 o 6
4	7

Numeri, aree, colori ....

Table 2
Interpretation of Lifting Index and derivates (*LI,*

Lifting Index Value (Exposure level)	Risk Implica
LI ≤ 1,0	Very low
1,0 < LI ≤ 1,5	Low
1,5 < LI ≤ 2,0	Moderate
2,0 < LI ≤ 3,0	High
LI > 3,0	Very high

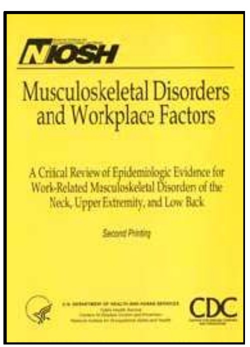
Green zone	**Acceptable risk**	No action is required
Yellow zone	**Conditionally acceptable risk**	Redesign of work Where redesign is not possible, other measures to control the risk shall be taken
Red zone	**Not acceptable**	Immediate action to reduce the risk is necessary (e.g. redesign, work organization, worker instruction and training).

- Musculoskeletal disorders MSDs are **one of the most common work-related ailments**.
- Throughout Europe they affect **millions of workers** and cost employers billions of euros. Tackling MSDs helps improve the lives of workers, but it also makes good business sense.
- Work-related MSDs **affect the back, neck, shoulders and upper limbs as well as the lower limbs**. They cover **any damage or disorder of the joints or other tissues.** Health problems range from minor aches and pains to more serious medical conditions requiring time off or medical treatment. In more chronic cases, they can even lead to **disability and the need to give up work.**

Evidenza epidemiologica

- **Identificare “hazard”** (fattori biomeccanici, fattori fisici (es. vibrazioni, fattori psicosociali, …)
- Studiare e comprendere la **relazione con le malattie muscoloscheletriche**

Epidemiology



NIOSH (Bernard, 1997)

- The term musculoskeletal disorders (MSDs) refers to conditions that involve the nerves, tendons, muscles, and supporting structures of the body
- Risk factors: **Repetition, Force, Posture, Vibration, Combination**
- *Lifting forceful* ***movements,*** *Awkward* ***posture, Heavy physical work, WBV, Static work***

Table 1. Evidence for causal relationship between physical work factors and MSDs

Body part *Risk factor*	**Strong evidence (+++)**	**Evidence (++)**	**Insufficient evidence (+/0)**	**Evidence of no effect (-)**
Neck and Neck/shoulder				
Repetition		•		
Force		•		
Posture	•			
Vibration			•	
Shoulder				
Posture		•		
Force			•	
Repetition		•		
Vibration			•	
Elbow				
Repetition			•	
Force		•		
Posture			•	
Combination	•			
Hand/wrist				
Carpal tunnel syndrome				
Repetition		•		
Force		•		
Posture			•	
Vibration		•		
Combination	•			
Tendinitis				
Repetition		•		
Force		•		
Posture		•		
Combination	•			
Hand-arm vibration syndrome				
Vibration	•			
Back				
Lifting/forceful movement	•			
Awkward posture		•		
Heavy physical work		•		
Whole body vibration	•			
Static work posture			•	

Physical / biomechanical risk factors and MSDs (Hazard identification)

Repetitive movements
Hand force

Carpal tunnel syndrome
[*Kozak et al. 2015]*

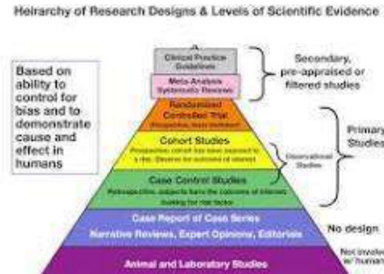
Elbow tendonitis
[van Rijn et al., 2009; Descatha et al., 2016; Curti et al., 2021]

Manual material handling – Pushing and pulling activities - Lifting heavy loads – Awkward postures high frequency and duration

Low back pain and lumbar disc diseases
[da Costa et al., 2010; Griffith et al., 2012; Coenen et al., 2014 – Zang et al, 2009; Seidler et al., 2009; Sørensen et al., 2011]

Lumbosacral radiculopathy [*Kuijer et al. 2018]*

Shoulder disorders (shoulder pain, rotator cuff tendonitis, long head biceps tendonitis) *[Van Rijn et al., 2010; Seidler et al., 2011; Mayer et al., 2012; Van der Molen et 2017]*



Valutazione dell’esposizione a fattori biomeccanici Rischio di disturbi/patologie muscolo-scheletriche

Attività

“safe ” job

- I lavoratori esposti non hanno un rischio maggiore di manifestare disturbi o patologie muscolo scheletriche
- Non è sinonimo di rischio zero

Attività pericolosa

“hazardous ” job

- L’intensità dell’esposizione è sufficiente da aumentare la probabilità per i lavoratori di manifestare disturbi o patologie muscolo scheletriche

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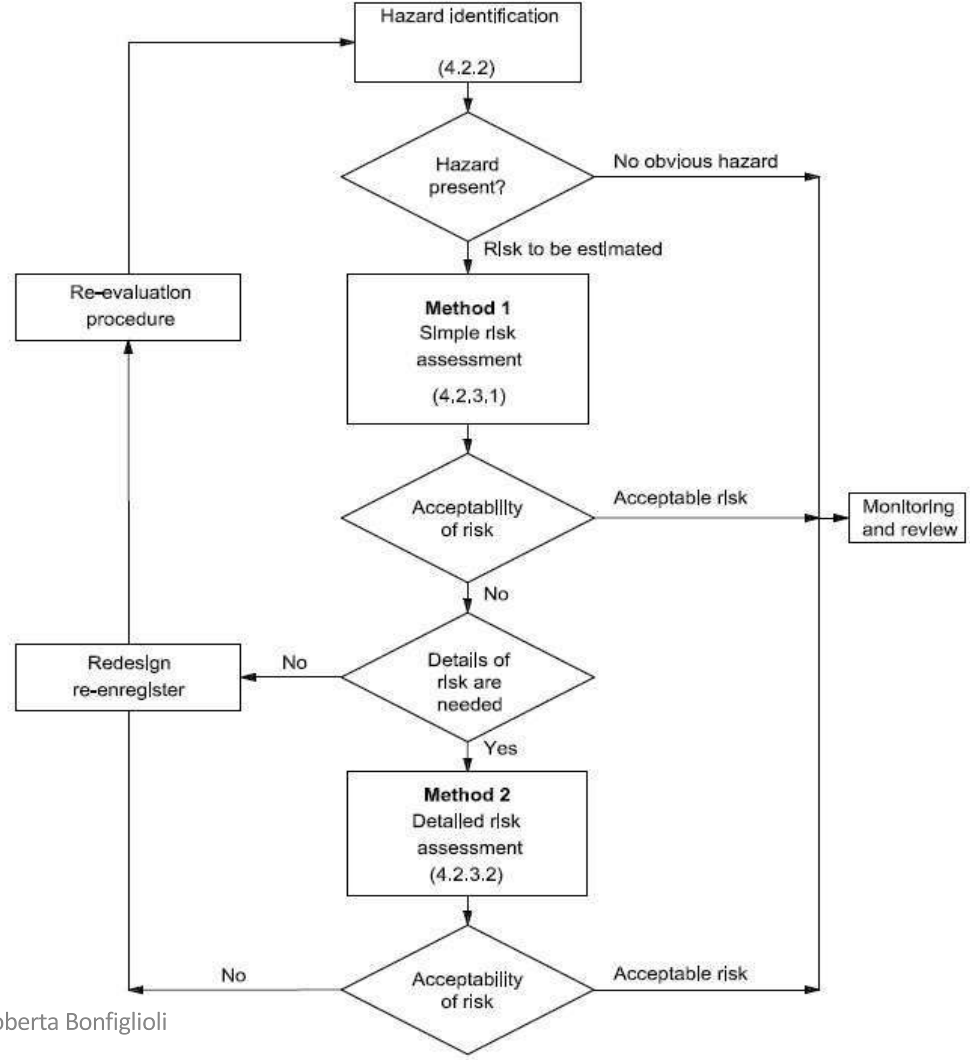
Red zone	Not acceptable	Immediate action to reduce the risk is necessary (e.g. redesign, work organization, worker instruction and training).



ISO 11228-3: 2007 Risk assessment procedure

Definizione dell'«*Hazard*»
Criteri e strumenti per la misura dell'esposizione

Valori guida

- dati antropometrici e funzionali
- dati sperimentali

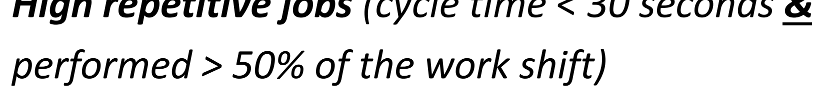
Meccanismo patogenetico (plausibilità biologica)

Movimenti ripetitivi

- Movimenti identici o molto simili eseguiti ad elevata frequenza a carico di un distretto corporeo, durante il compito lavorativo o buona parte di esso

Misura della Ripetitività

Silverstein 1986
Alta ripetitività: cycle time <30 sec; fundamental cycle > 50%
Bassa ripetitività: cycle time >30 sec; fundamental cycle < 50%



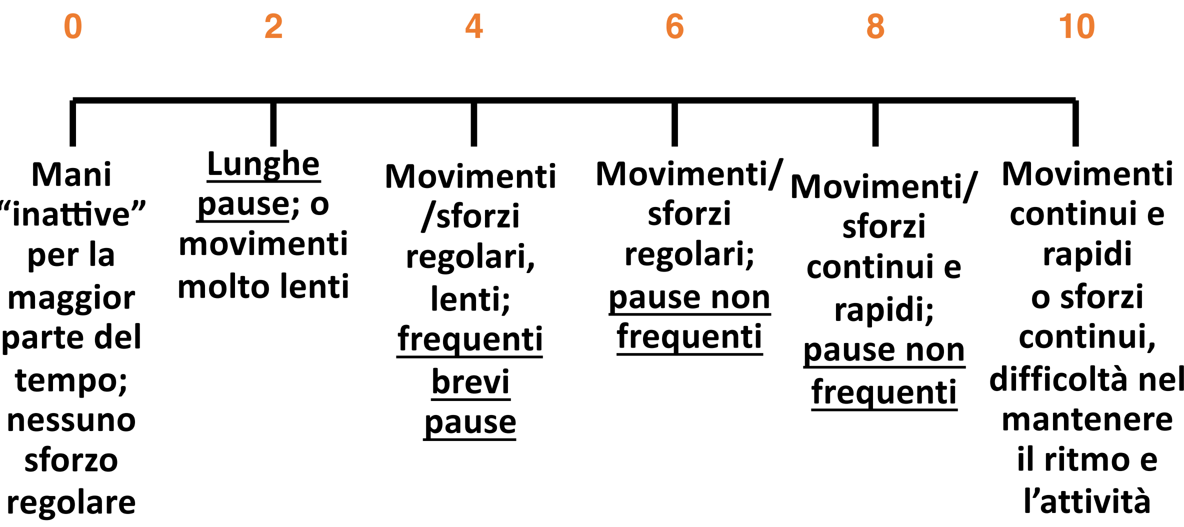
High repetitive jobs *(cycle time < 30 seconds* ***&*** *performed > 50% of the work shift)*
Low repetitive jobs *(cycle time > 30 seconds* ***or*** *performed < 50% of the work shift)*

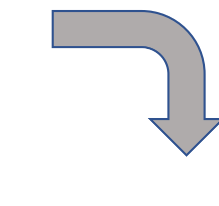
Armstrong e Ulin 1995
Valutazione della ripetitività in rapporto alla **capacità del lavoratore di svolgere il lavoro**

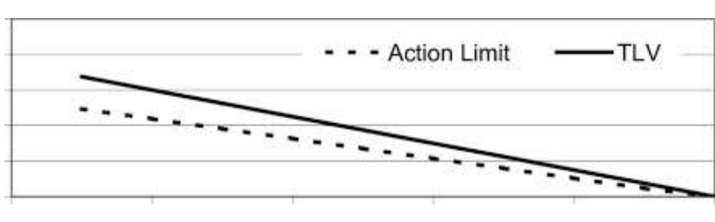
- ***Molto alta****: movimenti rapidi e regolari,* ***il lavoratore fa fatica a mantenere il ritmo di lavoro***
- ***Alta****: movimenti regolari, qualsiasi imprevisto implica un ritardo rispetto al ritmo di lavoro*
- ***Media:*** *movimenti regolari; il lavoratore mantiene comodamente il ritmo e può permettersi brevi pause*
- ***Bassa****: il lavoratore non ha nessuna difficoltà a mantenere il ritmo, le pause sono frequenti per attendere il lavoro successivo*
- ***Molto bassa****:* ***il lavoratore è fermo per la maggior parte del tempo****, occasionalmente usa le mani*

Misura della Ripetitività

Latko e Armstrong 1997





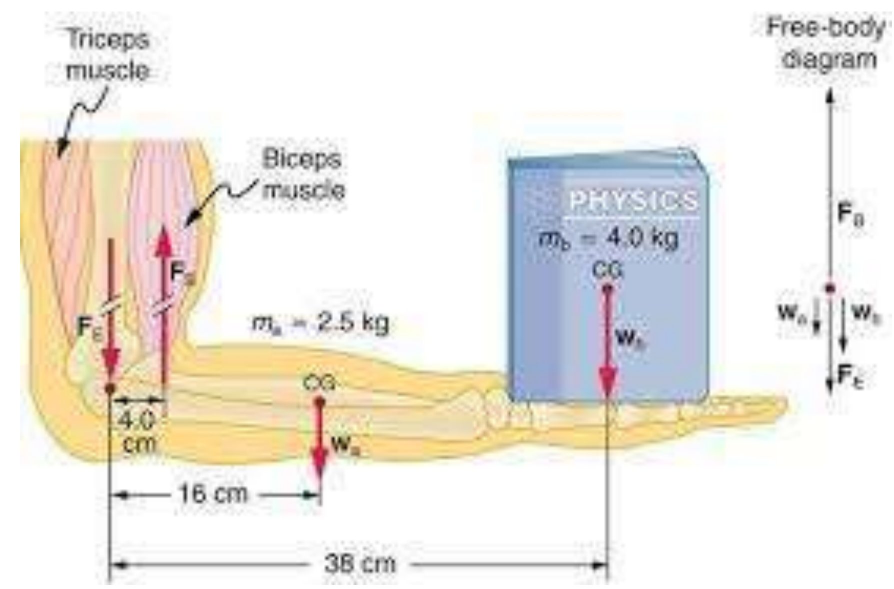


ACGIH Hand Activity TLV
(adapted from ACGIH, 2000)

Forza

- Azione meccanica necessaria per compiere uno specifico movimento, mantenere una postura, movimentare un carico

- **Forze esterne** (es. carico/massa da movimentare, forza di gravità)
- **Forze interne** (prodotte dal sistema muscolare, modulate dalla postura)



Come si valuta la forza - soggetto

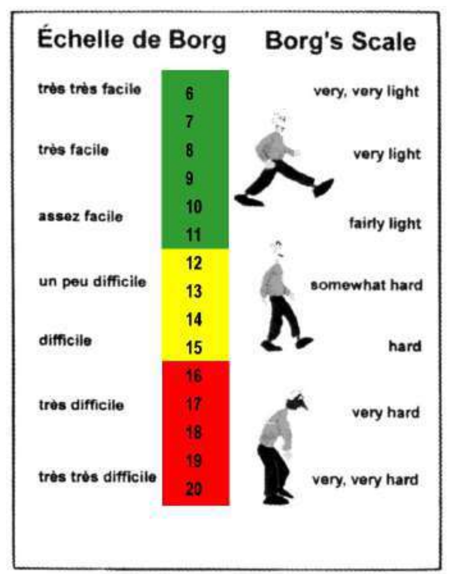
- Metodi psicofisici
  ⇒ percezione dello sforzo
  ⇒ sforzo accettabile
- Scala di Borg

MEDICINE AND SCIENCE IN SPORTS AND EXERCISE
Vol. 14, No. 5, pp. 377-381, 1982

Psychophysical bases of perceived exertion

GUNNAR A.V. BORG

Department of Psychology
University of Stockholm
Box 5602
S-114 86 Stockholm, Sweden



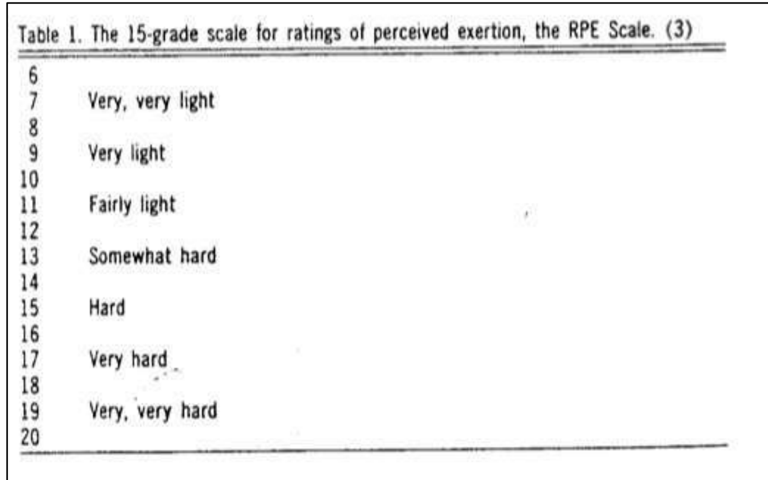


Table 1. The 15-grade scale for ratings of perceived exertion, the RPE Scale. (3)

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	

Table 2. The new rating scale constructed as a category scale with ratio properties. (5)

0	Nothing at all	
0.5	Very, very weak	(just noticeable)
1	Very weak	
2	Weak	(light)
3	Moderate	
4	Somewhat strong	
5	Strong	(heavy)
6		
7	Very strong	
8		
9		
10	Very, very strong	(almost max)
•	Maximal	

Come si valuta la forza - osservatore

«Normalizzazione»

- Per un determinato compito (sforzo) il grado di fatica che si manifesta e la velocità di insorgenza dipendono dall'intensità e dalla durata dello sforzo in rapporto alla massima capacità di produrre forza del soggetto (MCV)

- **MCV** (Massima Contrazione Volontaria)

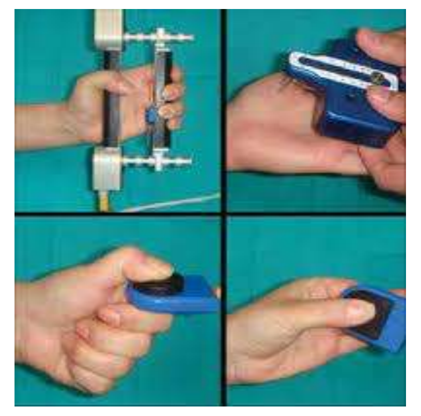
% di **MCV** =

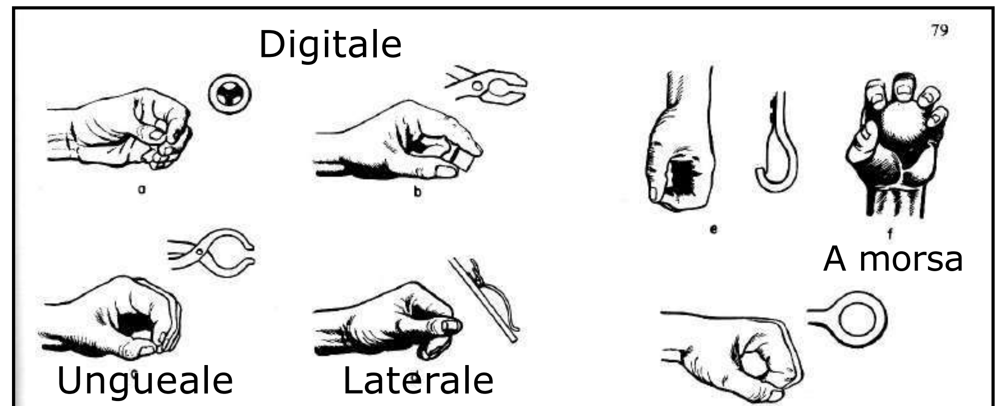
100 * **(**Forza richiesta / **MCV** soggetto)

Picco di forza normalizzato

0 2 4 6 8 10

Bassa	Media	Alta
Sforzo **rilassato**, movimenti fluidi, apparentemente senza resistenza: (1-3) ■ tenere o sollevare un oggetto leggero (come piccoli oggetti o utensili) (1-2) ■ scrivere a computer (1-3)	Sforzo **medio**: ■ avvitare con avvitatori pneumatici (3-5) ■ cucire tessuti spessi o pellame (4-5)	Sforzo **importante**: uso del peso del corpo, tensione dei muscoli, mimica facciale: ■ dare colpi (8-10) ■ tenere o sollevare oggetti pesanti (6-8) ■ "lanciare oggetti"

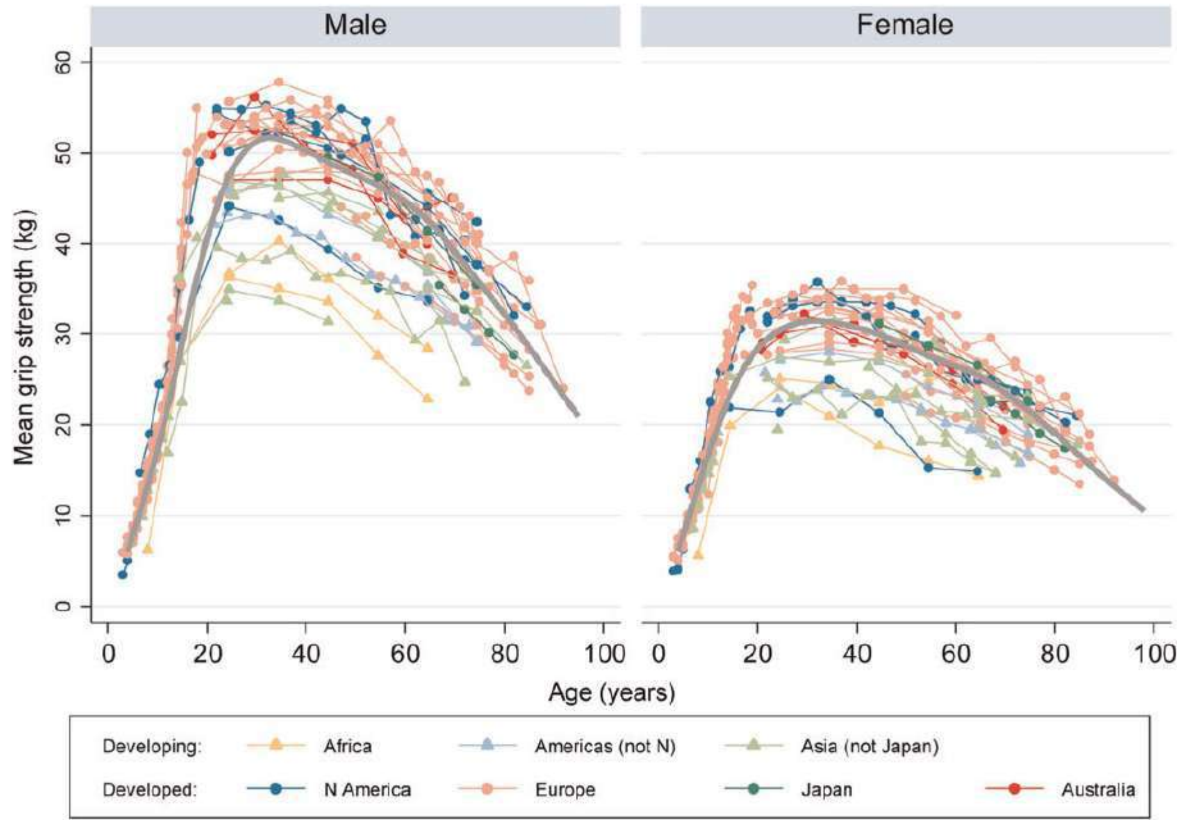




Valori «di riferimento»
Forza massimale di prensione

Tipo presa	**Ungueale** c	**Laterale** d	**Digitale** a,b	***A morsa*** *g*
Media (kg)	9.5	9.8	10.5	*40.9*
DS (kg)	2.2	2.4	2.2	*7.3*
Ambito di variazione (kg)	5.7-12.7	6.9-14.3	7.3-13.6	*29.1-54.5*

Gender/Age differences in hand strength



Dodds et al, 2016. Global variation in grip strength: a systematic review and meta-analysis of normative data

Fattori in grado di influenzare la capacità di esprimere forza

- Tipo presa e Postura

  Pinch strength = 15-20% Grip strength

- Differenze tra i due sessi

  F strength = 0.55 M strenght

- Dominante v. Non-dominante

  Mano Non-dominante = 0.90 Mano Dominante

Condizioni legate all'età

- Forza manuale si riduce progressivamente dopo I 35 anni, influenzata dall'allenamento (popolazioni lavorative addette a lavoro manuale industriale)

Fatica

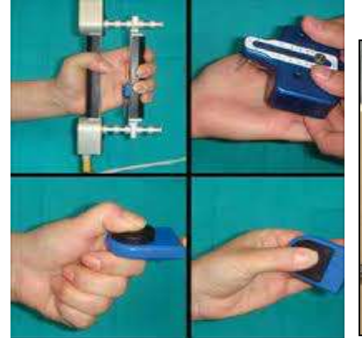
- Forza (Strength) si riduce in caso di attività ripetitive (repetitive exertions) quando la forza media > 15-20% MVC

Uso guanti

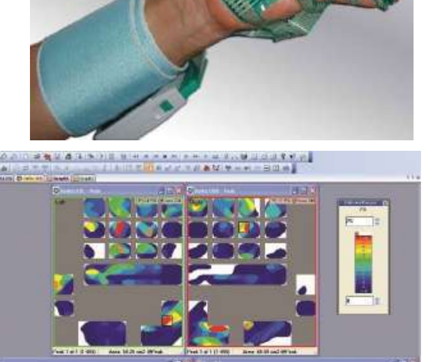
Sistemi per la stima/misura della Forza

Misure dirette
⇒ dinamometro
⇒ sensori di pressione (es. nella sede di contatto tra la mano e l'oggetto)

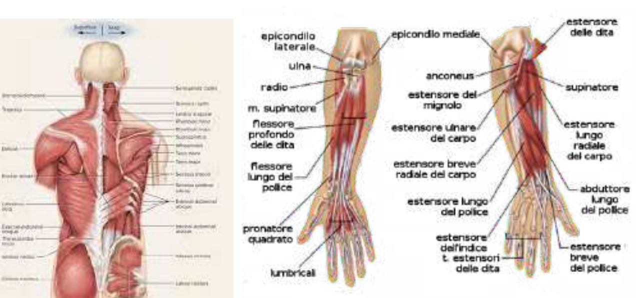
Elettromiografia di superficie

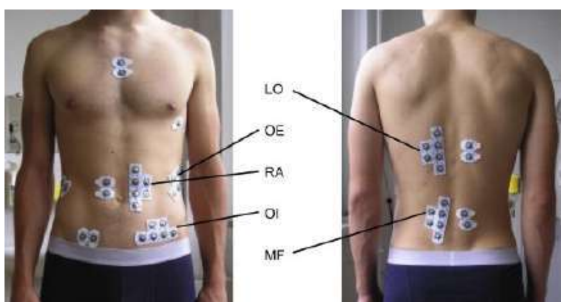


Presure sensors
Grip-system



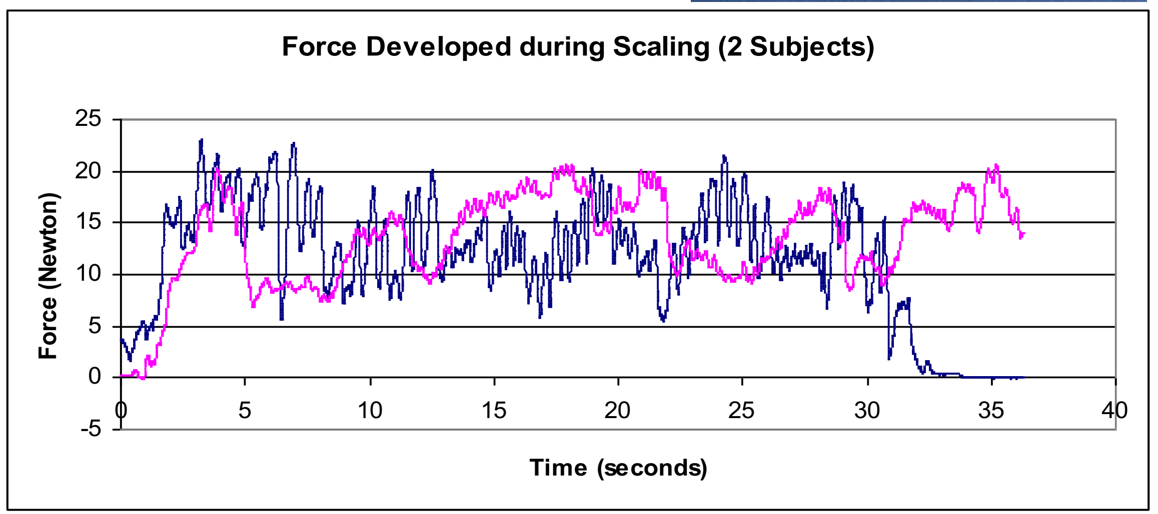
(wireless) sensor for Surface Electromyography (sEMG)





Direct force measurement
(Pinch and Tip force during Dental Hygiene work)

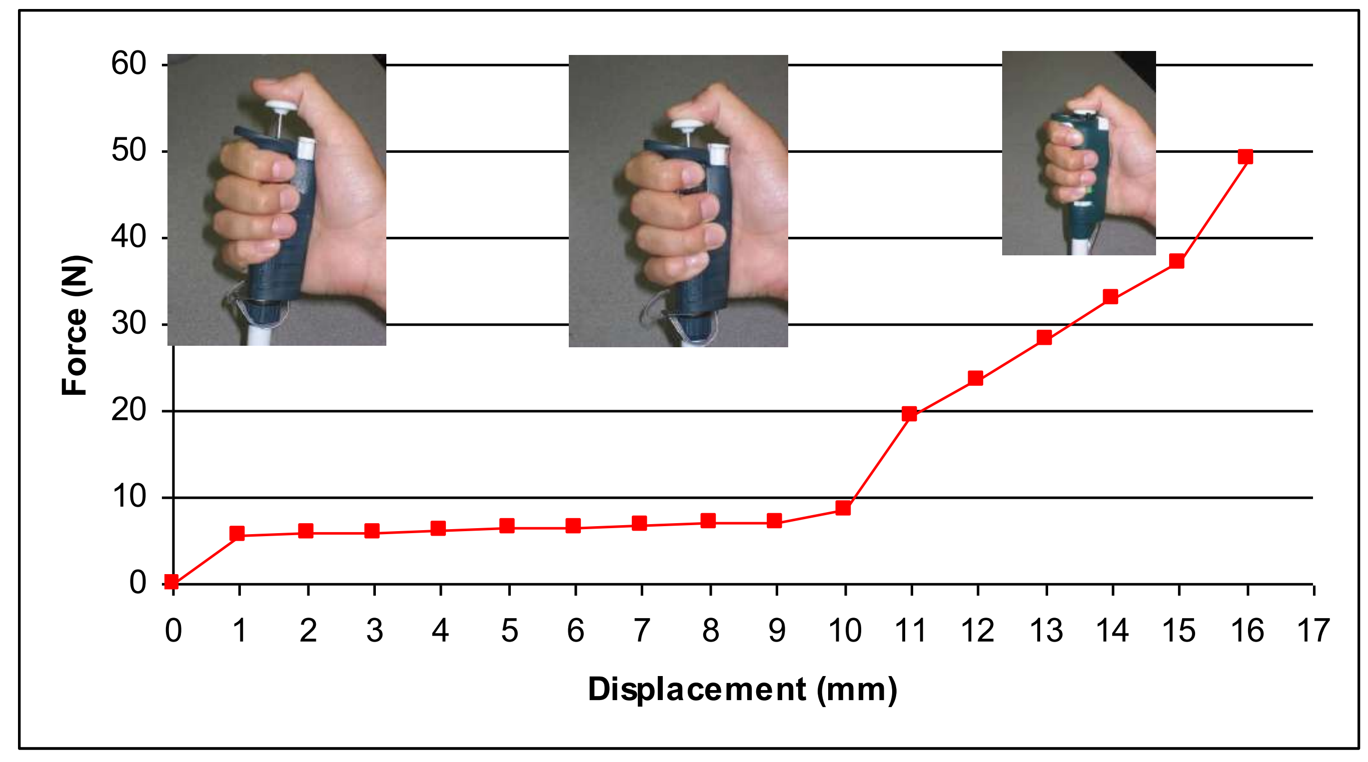
- Tool handle instrumented with **Pressure Profiles force sensor**, tip instrumented with 6-axis micro **load cell**



Villanueva A, Dong H, Rempel D. A biomechanical analysis of applied pinch force during periodontal scaling. J Biomech. 2007;40(9):1910-5..

Direct force measurement

(Pipette Instrumented with Load Cell to Measure Thumb Force)



Forza manuale negli studi epidemiologici (USA)

- Force classification (intensity)
  - *no load (fingers or palm in no contact with any objects)*
  - *light **pinch** (≤1 kg force, 9 N)**
  - *heavy **pinch** (>1 kg force, 9 N)*
  - *light **power** grip (≤4 kg force, 45 N)**
  - *heavy **power** grip (>4 kg force, 45 N)*

Characteristics

- **Pinch**: a load that is primarily applied to the fingers
- **Power grip:** a load that is evenly distributed between the palm and the fingers or primarily located on the palm

**10% mean MCV - 20% 5° p.le MCV*

Bao S, Silverstein B. Estimation of hand force in ergonomic job evaluations. Ergonomics. 2005 Feb 22;48(3):288-301.

Forza negli studi epidemiologici (USA)

- "**Significant" forceful exertion** (important enough to be estimated) Newton (N)
  - Lifting force of 8.9 N
  - Pushing/pulling force of 44.5 N
  - Pinch griping force of 8.9 N
  - Power griping force of 44.5 N.

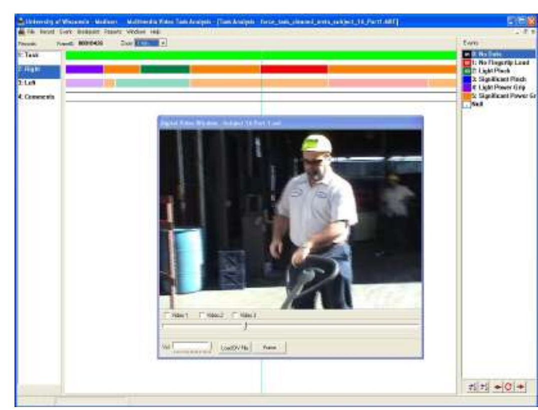
Force values consistent with *Stetson et al. (1991) and hand force limits used in the repealed Washington State Ergonomics Rule (Washington State Department of Labor and Industries, 2000)*

Bao, S., Spielholz, P., Howard, N., Silverstein, B. Force measurement in field ergonomics research and application. International Journal of Industrial Ergonomics. International Journal of Industrial Ergonomics. 2009 39(2), pp. 333-340.

Force and repetition estimates (USA)

- Repetition rates per task should be calculated for each of the five different hand postures
- Exertion: a readily observed movement of the wrist or fingers, (wrist/finger extension/flexion) or a change in the load to the hand (eg, change from light to heavy)
- Total repetitions per minute is the repetition rate across all five hand postures: no load, light pinch, heavy pinch, light power grip, and heavy power grip.
- Heavy pinch or power grip repetition rate is the repetition rate while in **heavy pinch or heavy power grip.** Both hands are evaluated separately

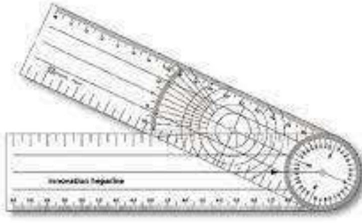
Force estimates using video analysis

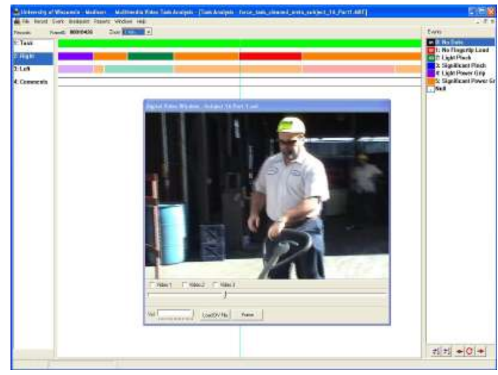


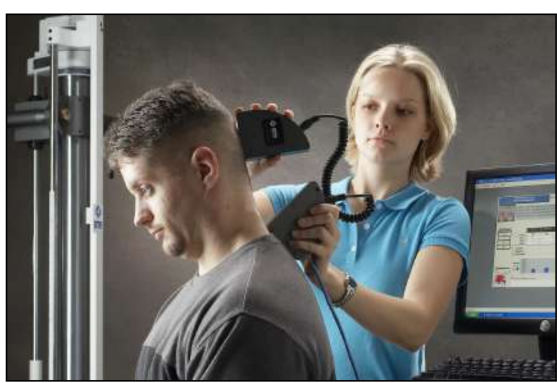
- % time that the hand was in **each grip** is calculated by summing its number of frames and dividing it by the total number of frames observed for that task
- % time spent in **all pinch and power grip** is the sum of the % time spent in light pinch, heavy pinch, light power grip, and heavy power grip
- % time spent in **any pinch** (heavy and light pinch), **any power** grip (heavy and light power grip), and **heavy pinch** or **power grip**

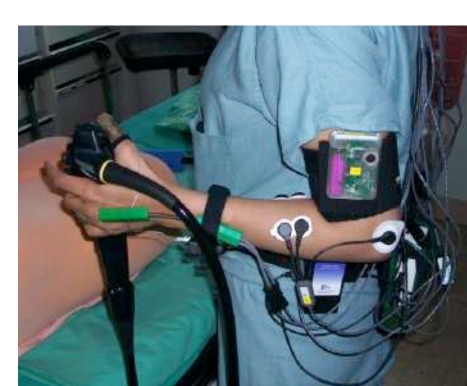
Valutazione della Postura

- Metodi osservazionali diretti
- Videoripresa, *video analysis*
- Applicazione di sensori di posizione, acquisizione ed elaborazione dei rispettivi segnali



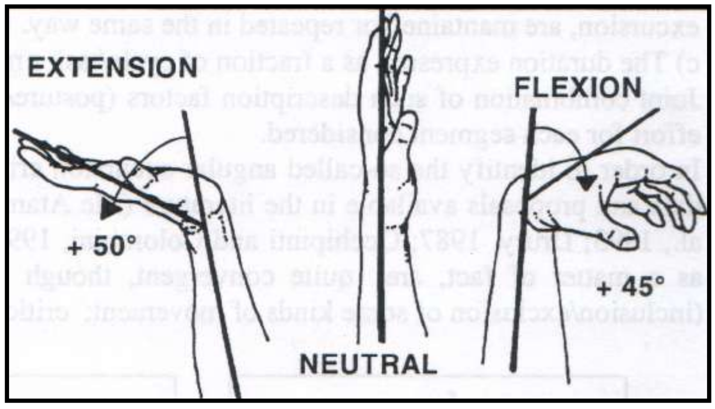






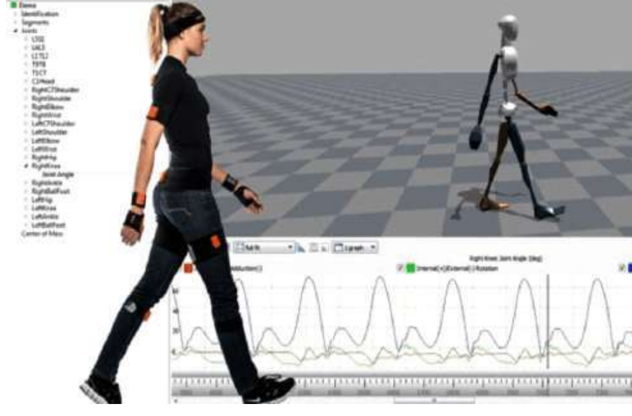
Effetto della postura sulla capacità di sviluppare forza

Postura del polso	**Presa di Forza** (%)
Neutra	100
45° Flessione	60
65° Flessione	45
45° Estensione	75
60° Estensione	63
45° Deviazione ulnare	75
25° Deviazione radiale	80



Sistemi di misura: posture
(sistema Xsens MVN Awinda, Enschede, The Netherlands)

17 sensori inerziali
Fasce con velcro

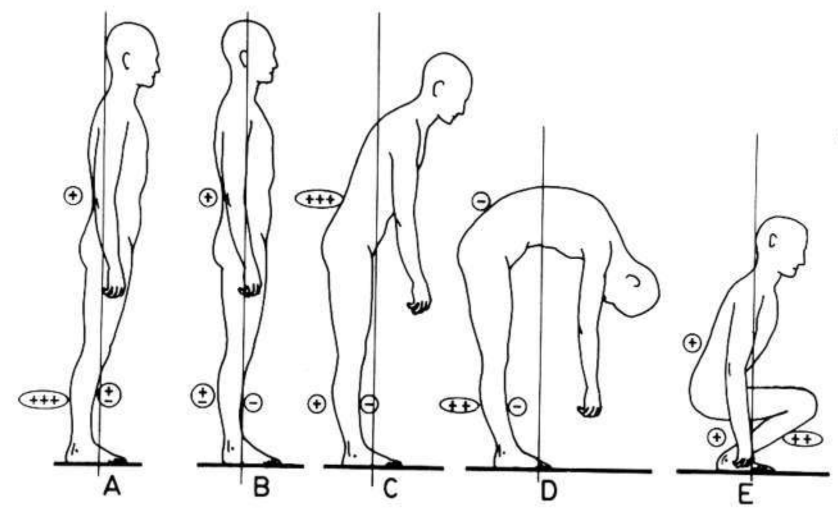


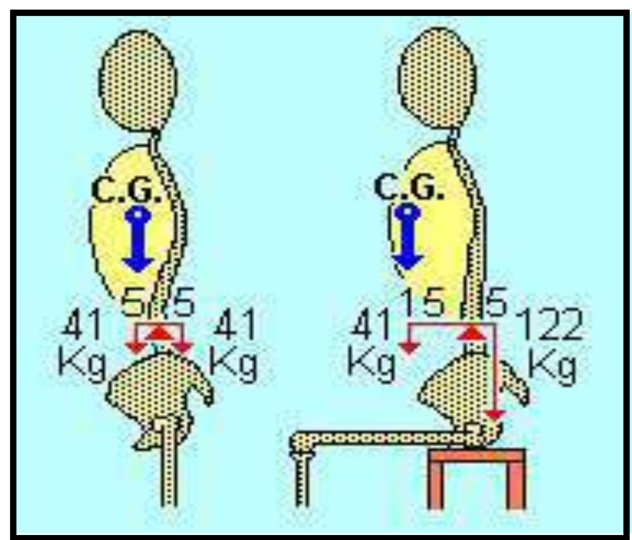
Accelerometro, giroscopio, magnetometro e sensore di pressione (barometer)

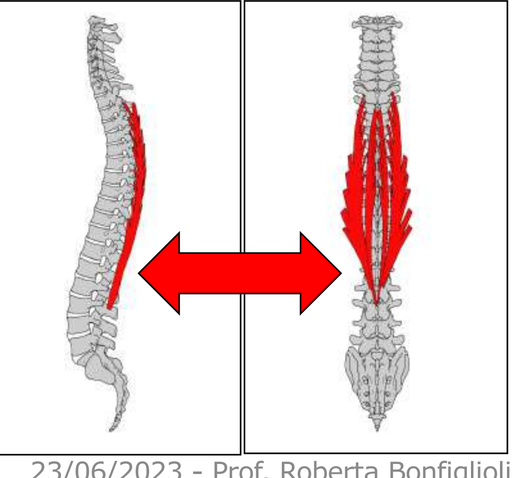
- 16g
- dimensioni 47x30x13 mm

Physical factors
Muscular load

- Attivazione muscolare al variare della postura
- La contrazione dei muscoli paravertebrali influenza la P intradiscale

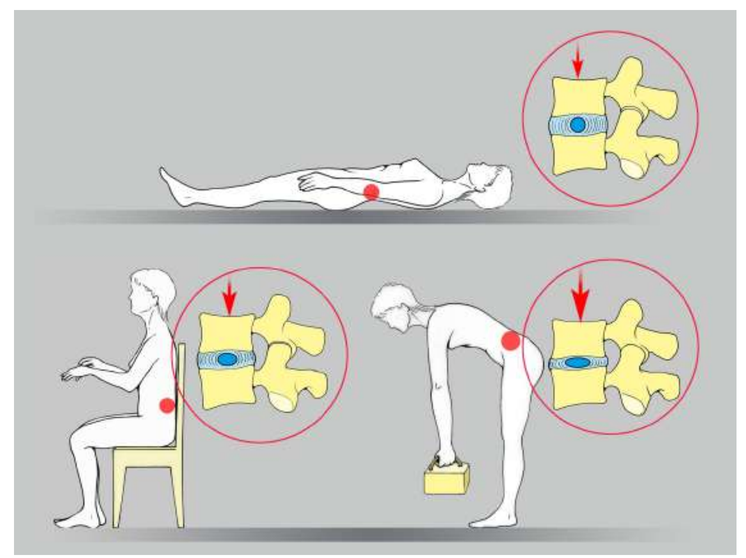


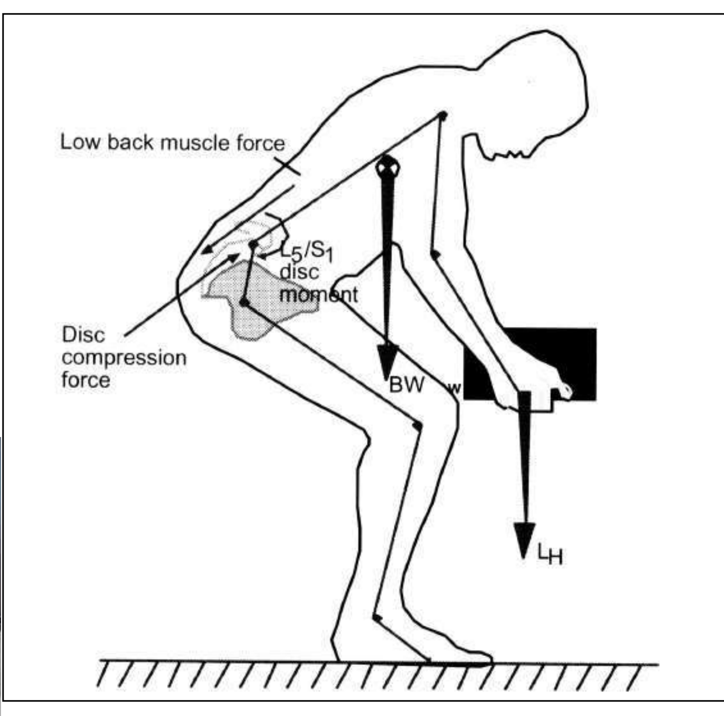




- Articolazione L5 S1 è la zona soggetta alla maggiore sollecitazione (modelli biomeccanici, misura P intradiscali)
- Fulcro della leva

Physical factors –
Lumbar disc compressive forces

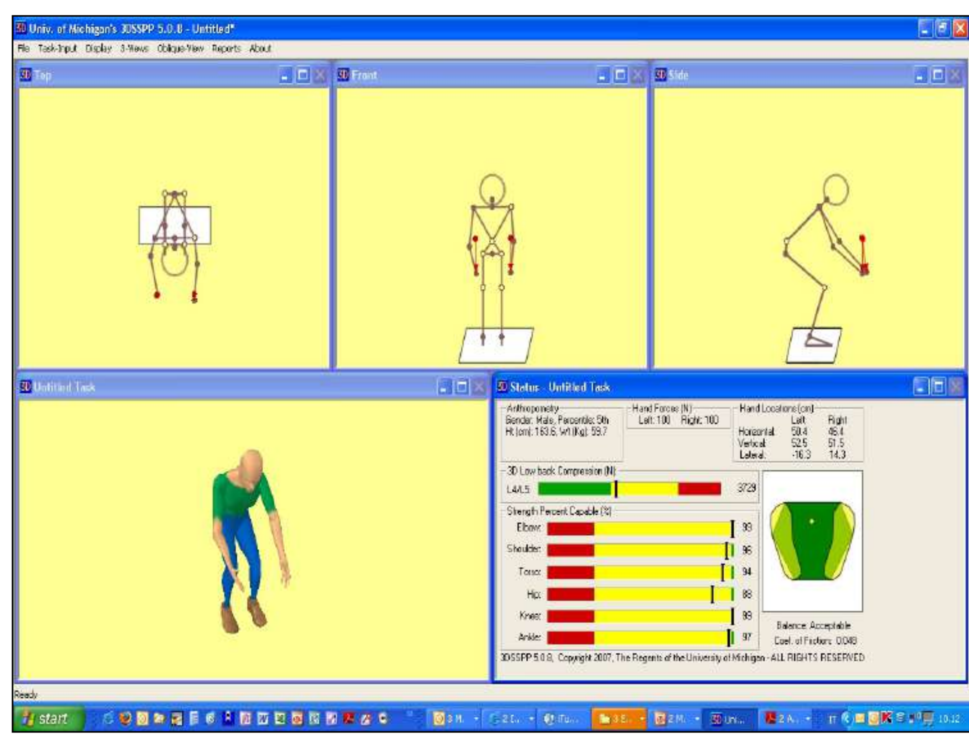




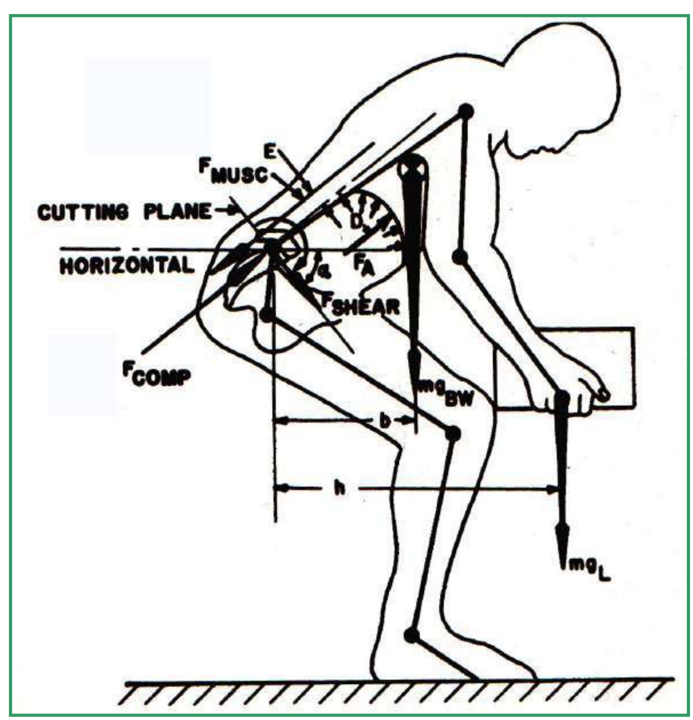
(Chaffin, Static model)

3DSSPP

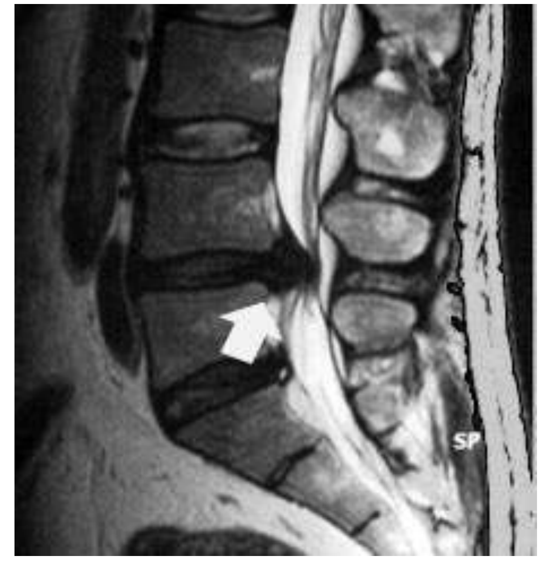
- Static models or software to calculate load moment
- Strenght % capable

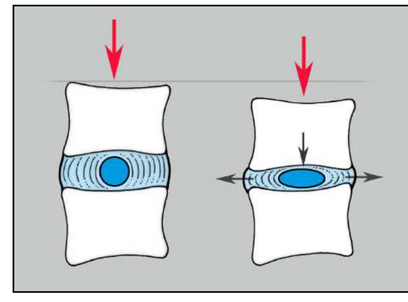


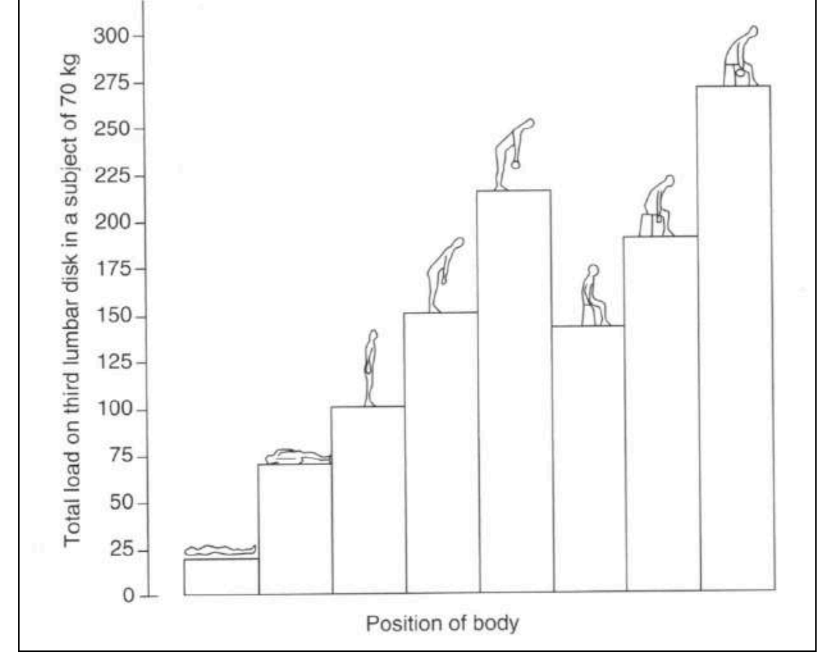
https://c4e.engin.umich.edu/tools-services/3dsspp-software/

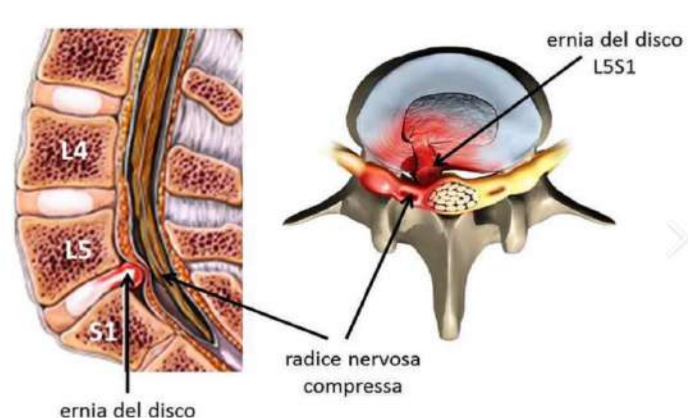


Physical factors – Lumbar compressive forces





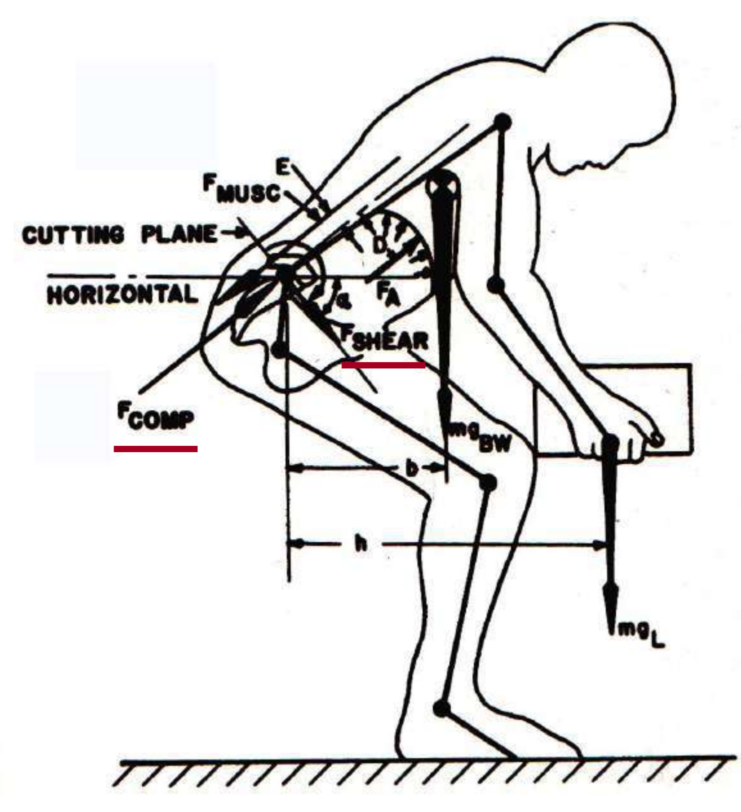




Valori limite - Spinal loading

- Forze che agiscono al passaggio lombosacrale (⇒ unità disco-vertebrale)
- **3400 N (3.4 kN) Fc F compressiva**
- **1000 N Ft F di taglio** (direzione anteroposteriore)

(Chaffin)

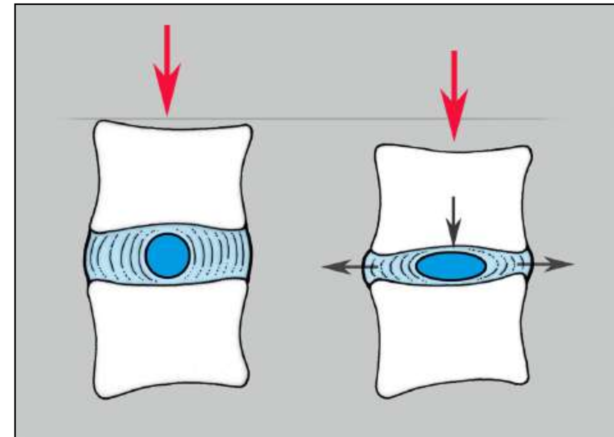


Valori limite - Spinal loading

Sono anche stati proposti limiti differenziati per età e genere

- Donne
- 20 anni 4400 N
- 40 anni 3200 N
- 60 anni 1800 N

(Luttmann 1997)



EXTENDED COMPILATION OF AUTOPSY-MATERIAL MEASUREMENTS ON
LUMBAR **ULTIMATE COMPRESSIVE STRENGTH** FOR DERIVING REFERENCE VALUES IN ERGONOMIC WORK DESIGN:
THE REVISED DORTMUND RECOMMENDATIONS
Matias Jäger - EXCLI Journal 2018;17:362-385

The Revised Dortmund Recommendations

age	female	male
20 years	4.1 kN	5.4 kN
30 years	3.8 kN	5.0 kN
40 years	3.1 kN	4.0 kN
50 years	2.4 kN	3.1 kN
≥ 60 years	1.8 kN	2.2 kN

Age-and- gender related limits for compressive forces at a lumbar disc or vertebra during manual materials handling to avoid biomechanical low-back overload

- Dati sperimentali
- ULTIMATE COMPRESSIVE STRENGTH VALUES

- 36 studi inclusi 1192 valori.
- Media e DS resistenza kN
- Noti età e genere del donatore, età minima 20 aa
- I **valori di riferimento** sono derivati da regressioni per età divise per genere
- Ogni punto individuato è una sorta di **valore medio per età e genere** cui viene **sottratta una deviazione standard**

Table 2: Investigations into and data on lumbar ultimate compressive strength of autopsy material as collated from the literature. With regard to the respective study: number of test results considered in the current compilation (n_{cons1}), strength's mean and standard deviation (S.D.) and (cf. right column) number of test results considered in the subsequent derivation of reference values (n_{cons2})

Ref. no.	author(s)	year	number	strength in kN		number
			n_{cons1}	mean	S.D.	n_{cons2}
1	Wyss & Ulrich	1954	6	5.56	1.75	6
2	Bartelink	1957	1	3.34	*–	1
3	Brown et al.	1957	10	4.02	1.73	0
4	Perey	1957	142	5.15	2.10	2
5	Decoulx & Rieunau	1958	9	4.41	1.14	0
6	Evans & Lissner	1959	11	3.51	1.22	11
7	Roaf	1960	3	4.83	**2.06	0
8	Bartley et al.	1966	4	5.35	**4.03	2
9	Eie	1966	19	5.18	**2.16	5
10	Farfan	1973	39	3.84	1.22	6
11	Lin et al.	1978	8	3.30	1.06	8
12	Hutton et al.	1979	58	6.47	3.35	51
13	Hansson et al.	1980	109	3.85	1.71	109
14	Adams & Hutton	1982	58	5.34	2.34	55
15	Hutton & Adams	1982	28	7.41	2.83	28
16	Brinckmann & Horst	1983	19	5.86	1.48	15
17	Brinckmann et al.	1986	1	2.50	*–	1
18	Brinckmann et al.	1988	5	6.00	**2.44	5
19	Brinckmann et al.	1989	86	5.31	1.73	86
20	Crone-Münzebrock et al.	1989	35	6.91	2.80	5
21	Eriksson et al.	1989	61	3.03	1.29	0
22	Granhed et al.	1989	52	5.43	2.34	48
23	Porter et al.	1989	18	9.18	1.97	12
24	Ranu	1990	2	3.71	**0.66	2
25	Shirado et al.	1992	9	4.18	1.68	0
26	Adams et al.	1994	18	7.31	2.55	18
27	Myers et al.	1994	61	5.56	2.26	0
28	Bjarnason et al.	1996	32	6.13	3.38	0
29	Werner	1996	17	2.33	0.99	17
30	Cheng et al.	1997	62	5.81	2.48	0
31	Hayes & Bouxsein	1997	11	2.62	1.44	0
32	Andresen et al.	1998	19	2.60	1.15	0
33	Lochmüller et al.	1998	48	3.37	1.37	0
34	Haidekker et al.	1999	12	3.53	0.95	12
35	Bürklein et al.	2001	114	3.03	1.51	0
36	Nagel et al.	2013	5	8.94	**1.84	5
total			**1,192**	**4.84**	**2.50**	**510**

*: S.D. not applicable, **: x.yz, n_{cons1}: considered in data compilation, n_{cons2}: considered in limit derivation

Studi psicofisici Dati sperimentali

Approccio psicofisico: studi sulla movimentazione manuale di carichi c/o *Liberty Mutual Research Center (MA, USA)*

- Primi dati nel 1978, integrati nel 1991 (Snook SH and Ciriello VM)
- Linee guida per la valutazione e la progettazione dei compiti di movimentazione manuale di carichi in rapporto alle capacità e ai limiti dei lavoratori (*"work as hard as you can without straining yourself, or without becoming unusually tired, weakened, overheated, or out of breath")*
- I risultati degli esperimenti hanno permesso la creazione di tabelle che contengono riferimenti per valutare i limiti di accettabilità per valori di forza o di peso e di riferirli a diverse percentuali della popolazione maschile o femminile (10, 25, 50, 75 e 90%)

Metodi psicofisici

- Utili per valutare i limiti di accettabilità

- Quale è l'entità del rischio insita in compiti giudicati accettabili con test psicofisici?
- Rischio 3:1 low back injury in lavori che espongono a carichi maggiori di quelli giudicati accettabili dal 75% degli uomini rispetto a lavori meno gravosi (Snook)

Aggiornamento delle Tabelle

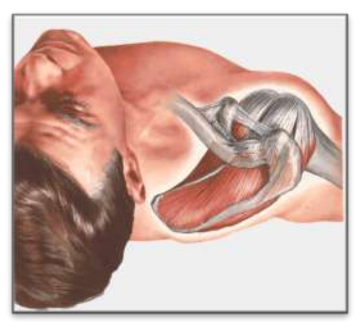
- https://libertymmhtables.libertymutual.com/CM_LMTablesWeb/taskSelection.do?action=initTaskSelection
- The new “Liberty Mutual Manual Materials Handling Tables” **provide both the male and female population percentages capable of performing manual material handling tasks without over exertion**, rather than maximum acceptable weights and forces.
- Can be used to perform ergonomic assessments of lifting, lowering, pushing, pulling, and carrying tasks with the primary goal of supporting ergonomic design interventions.

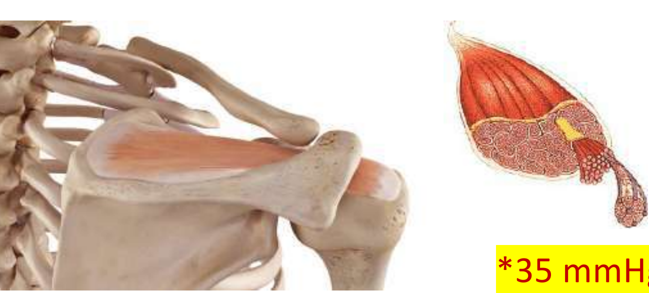
Physical factors
Shoulder posture

Flexion vs. Abduction – Static vs. Dinamic

Static load – Supraspinatus muscle

- ↑ **Intramuscular pressure**
- ↓ Blood flow (>35mmHg)
- **>20mmHg/2,7 kPa** Fatigue
- **>42 mmHg/5,6 kPa** inadequate blood flow (**muscle and tendon**) [Korner et al., 1984]





*35 mmHg

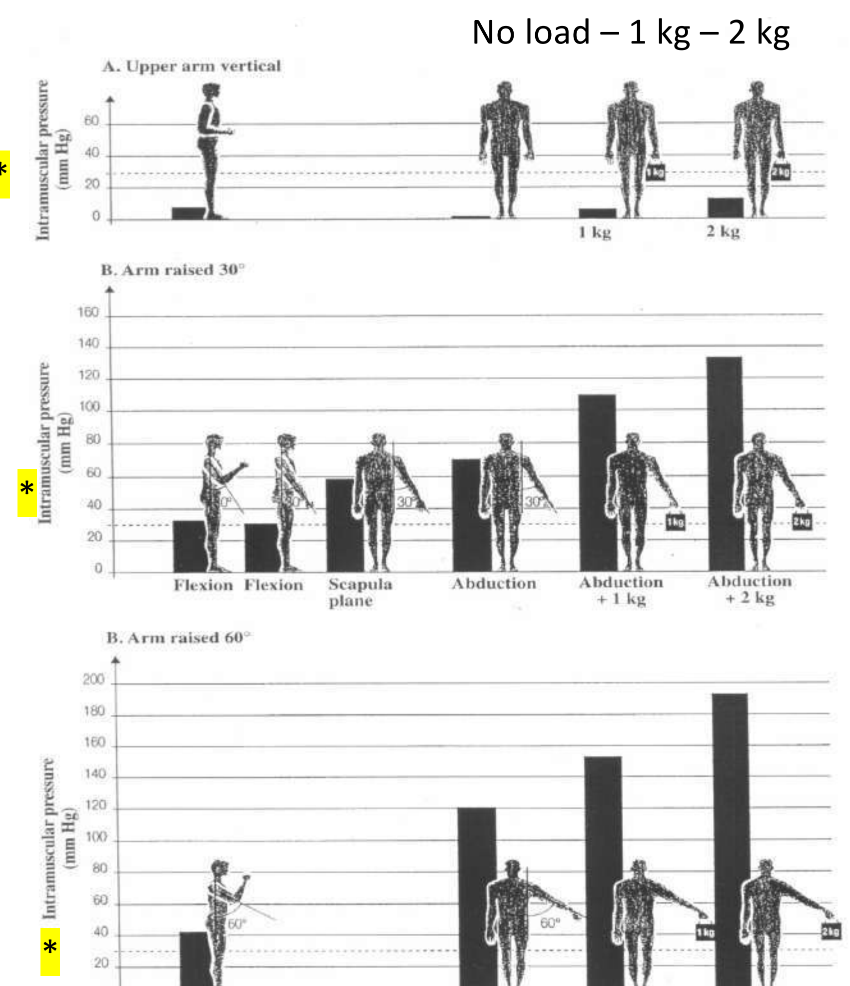
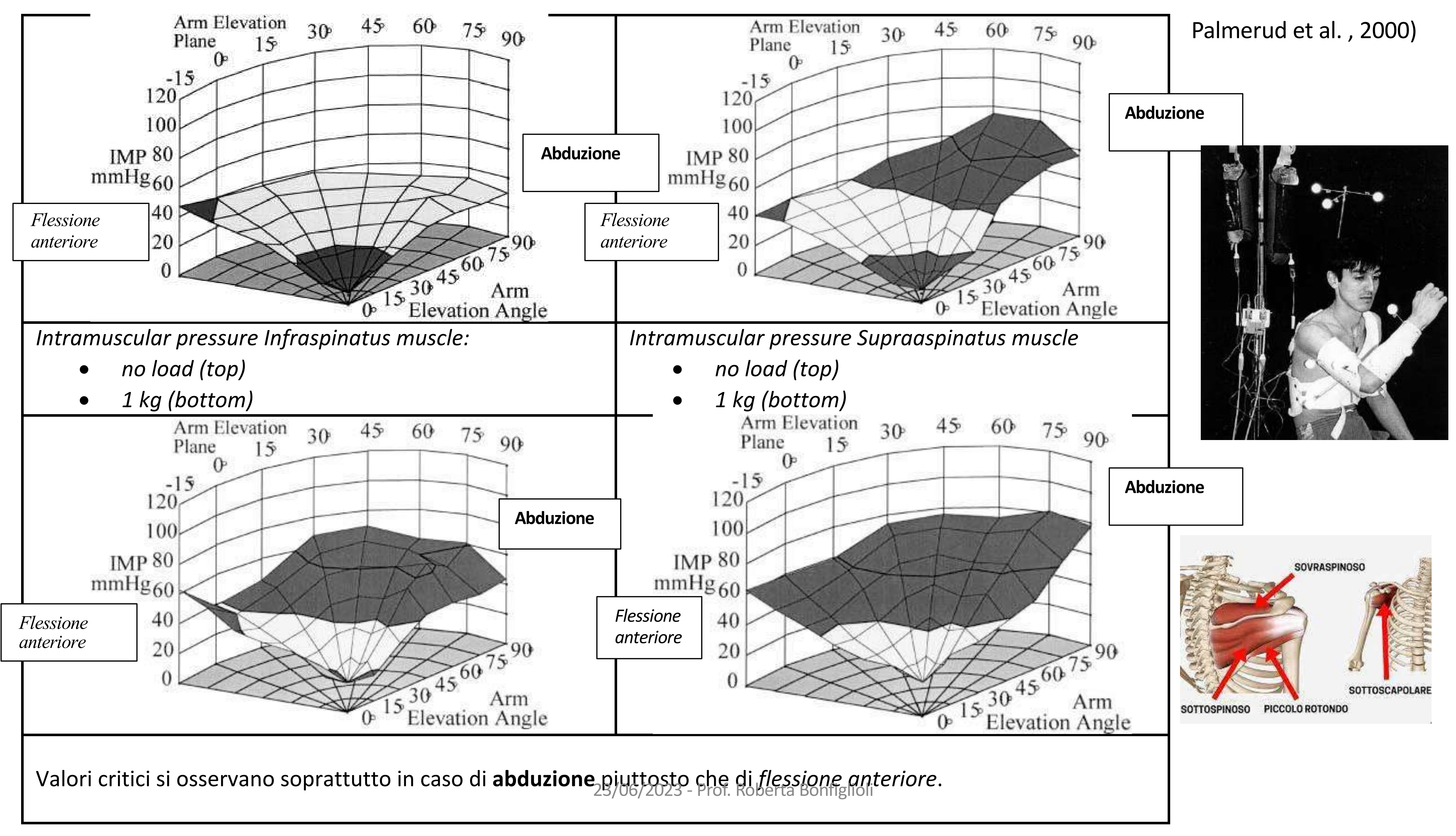


Figure 3–6. Intramuscular pressure measured in supraspinatus muscle at different arm positions. *A*, Upper arm vertical. *B*, Arm elevated 30 degrees, and arm elevated 60 degrees.

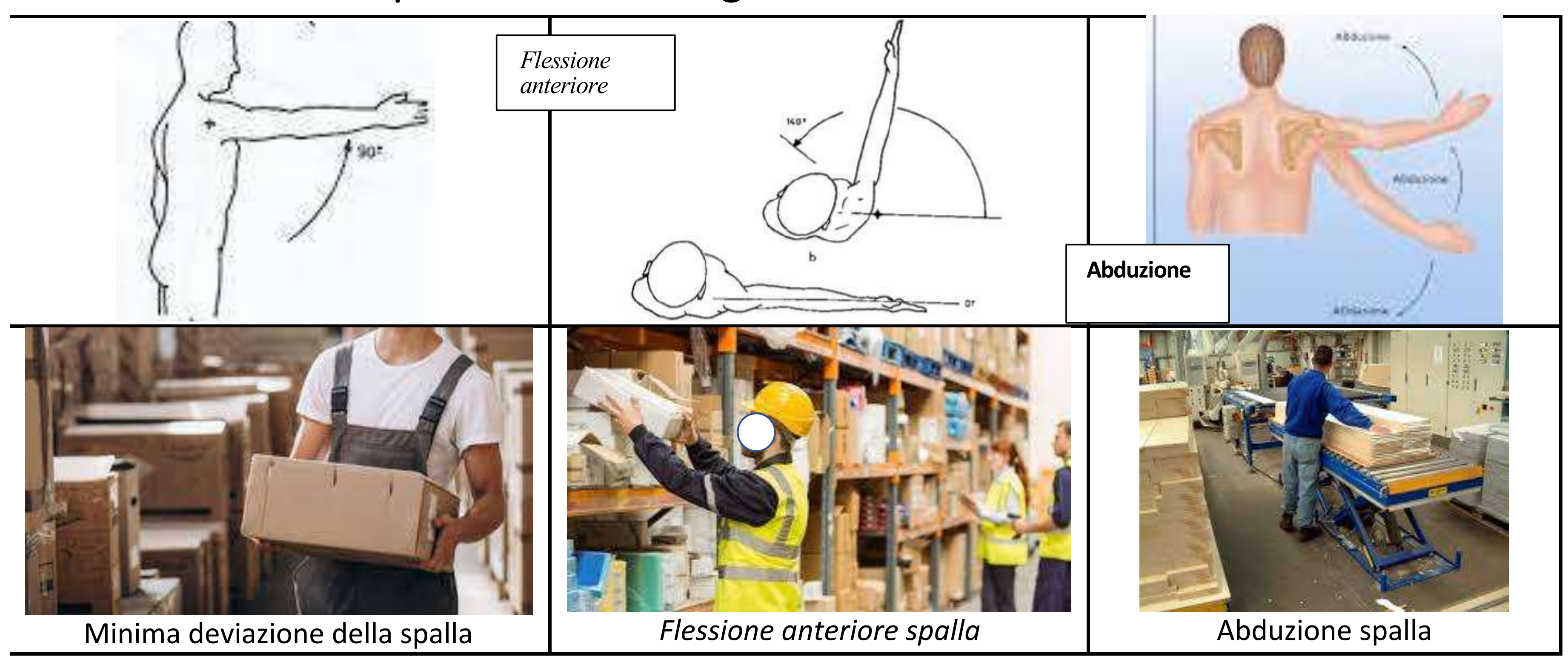

Palmerud et al. , 2000)
Abduzione
Flessione anteriore
Arm Elevation Plane
IMP mmHg
Arm Elevation Angle
Intramuscular pressure Infraspinatus muscle:
no load (top)
1 kg (bottom)
Intramuscular pressure Supraaspinatus muscle
no load (top)
1 kg (bottom)
SOVRASPINOSO
SOTTOSCAPOLARE
SOTTOSPINOSO
PICCOLO ROTONDO
Valori critici si osservano soprattutto in caso di abduzione piuttosto che di flessione anteriore.

Palmerud et al. Intramuscular pressure of the infra- and supraspinatus muscles in relation to hand load and arm posture. Eur J Appl Physiol. 2000 Oct;83(2-3):223-30

- ***Distinction between "safe" and "harmful" position of arm is, however, vague***. *IMP measurements can contribute to identification of harmful working postures.*
- *The IMP is influenced **by arm posture**, and primarily by elevation angle.*
- ***Hand load** influence greatly the development of IMP, and primarily the infraspinatus.*

- ***Special attention should be paid to working situation in which elevated arm are combined with use of heavy hand-powered tools.***

Physical factors
Shoulder awkward postures – Lifting loads



La movimentazione di carichi comporta movimenti di flessione anteriore delle spalle di ampiezza variabile, minima l'abduzione (salvo che il carico non abbia dimensioni largamente superiori alla larghezza delle spalle).

Physical factors – Hand-arm Vibrations
Shoulder and neck awkward postures - Arm-hand elevation

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2022, VOL. 65, NO. 10, 1338–1351
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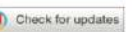
ARTICLE

OPEN ACCESS 

A design tool to estimate maximum acceptable manual arm forces for above-shoulder work

David Rempel[a] and Jim Potvin[b]

[a]Department of Bioengineering, University of California, Berkeley, CA, USA; [b]McMaster University, Hamilton, ON, Canada

ABSTRACT
There is a need for design criteria for above-shoulder work to prevent shoulder fatigue and supraspinatus injuries. A tool is developed to estimate maximum acceptable manual arm forces for above-shoulder work based on 25th % female strength with adjustments for supraspinatus tendon impingement and shoulder fatigue. The tool equations are presented along with tables of maximum acceptable manual arm forces in 77 locations in the 3 D space above the shoulder that accommodates a 50th % female reach. The largest acceptable anterior force, 140.3 N, occurs at shoulder height, 0.5 m anterior to the shoulder. The largest acceptable superior force, 84.4 N, occurs at shoulder height, 0.1 m anterior and 0.2 m medial to the shoulder. The new tool provides design criteria for arm exertions at a higher level of detail than prior ergonomic tools, making it useful for engineers. Based on sensitivity analyses, the tool is robust to parameter assumptions.

ARTICLE HISTORY
Received 30 June 2021
Accepted 19 November 2021

KEYWORDS
Overhead work; rotator cuff; musculoskeletal disorders; work design; supraspinatus tears

Practitioner summary: Above-shoulder work is associated with increased risk for shoulder fatigue and injuries. A new tool is developed that estimates maximum acceptable manual arm forces for work at or above shoulder height. The tool can be used to design acceptable above-shoulder work so that it can be accomplished by most workers.

Abbreviations: AFF: arm force field; AP: anterior/posterior; DC: duty cycle; GH: glenohumeral angle; HT: humerothoracic angle; LM: lateral/medial; MAE: maximum acceptable effort; MAF: maximum acceptable force; MAS: manual arm strength; MVC: maximum voluntary contraction; N: newton; OCRA: occupational repetitive action; R: reach distance; RMS: root means square; RULA: rapid upper limb assessment; SF: scale factor; SI: superior/inferior; ST: scapulothoracic angle; T: thoracic

KEY POINTS

- A new design tool is introduced that estimates maximum acceptable hand forces for specific locations above the shoulder.
- This above-shoulder tool is based on a 50th percentile female anthropometry and 25th percentile female manual arm strength.
- These base strengths are multiplied by scaling factors that adjust for subacromial impingement and fatigue.
- The tool was shown to be robust based on sensitivity analysis.

A new tool is proposed for designing above-shoulder work that is based on the strength capabilities of the 25th percentile female worker with scaling factors to prevent supraspinatus tendon impingement and shoulder muscle fatigue.
The tool estimates hand force limits based on the position of the hand relative to the shoulder, which is relatively easy to measure; therefore, the tool can readily be used by practitioners and other health and safety personnel.

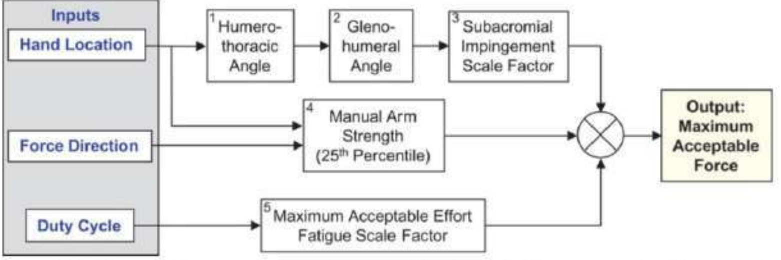


Figure 1. Flowchart of the five models incorporated into the above-shoulder tool. The inputs are hand location relative the shoulder, hand force direction, and duty cycle. In the current application, the hand location is combined with 50th percentile female arm segment lengths to estimate humerothoracic angle, glenohumeral angle and the subacromial impingement scale factor. The force direction and hand location are used to estimate the 25th percentile female manual arm strength. The duty cycle is used to estimate a scale factor for maximum acceptable effort to control for fatigue. The 25th percentile manual arm strength is multiplied by the subacromial impingement scale factor and the fatigue scale factor to calculate the maximum acceptable force for above-shoulder work.

GH: glenohumeral angle; HT: humerothoracic angle;
ST: scapulothoracic angle; T: thoracic

Ergonomics

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David Rempel & Jim Potvin

Scapular rhythm

1. Neutral posture
2. Impingement begins (90° ca.)
3. Full impingement (130°)

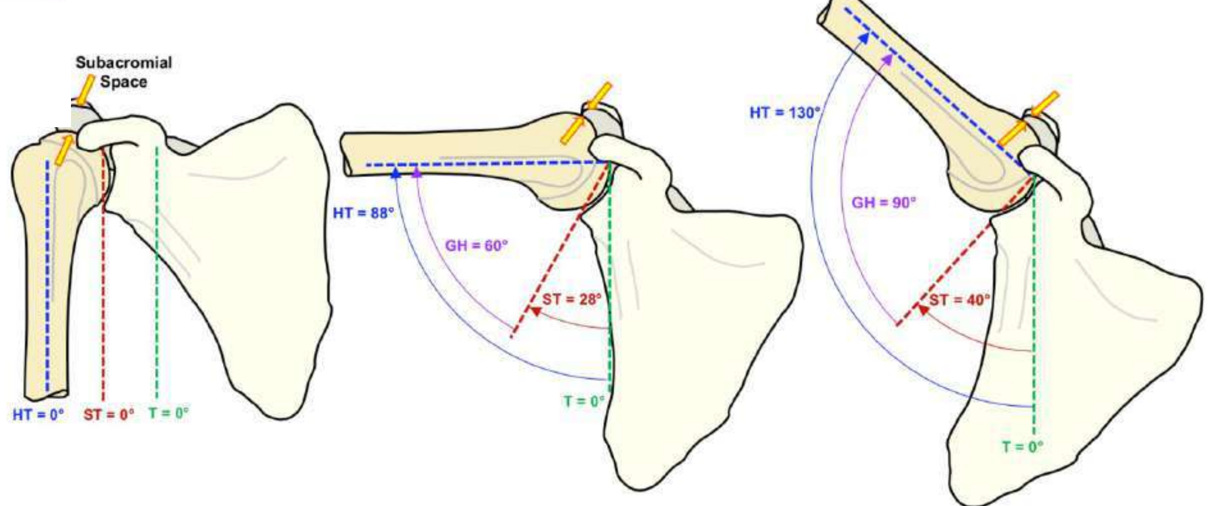


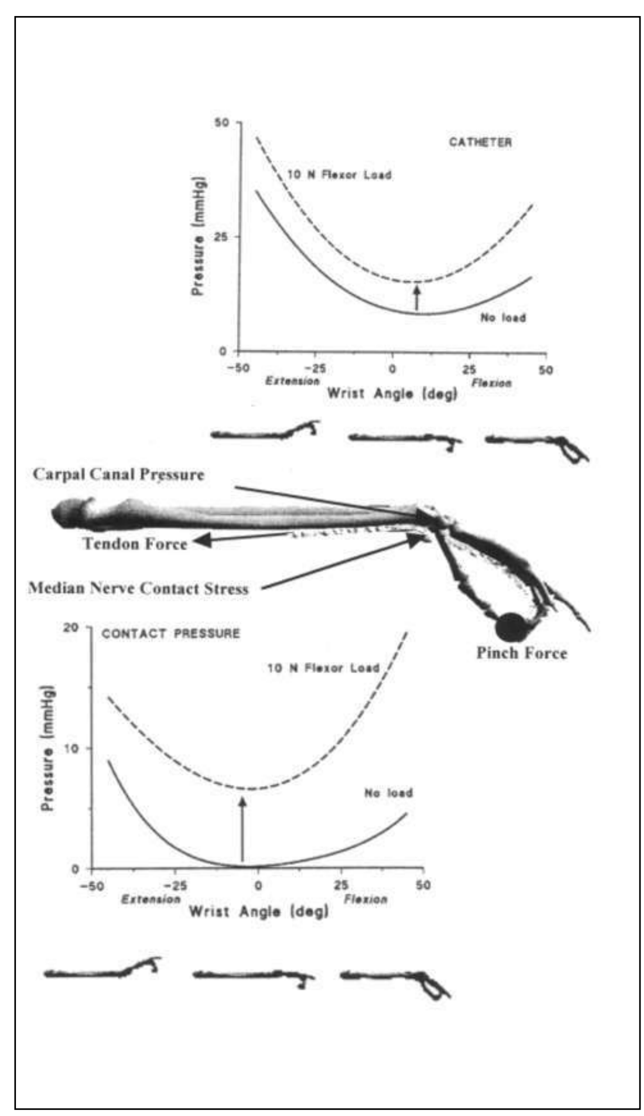
Figure 3. Illustration of scapular rhythm and the associated changes in subacromial space. Impingement begins at 60° GH rotation and full impingement occurs at 90° GH rotation. (Left) The shoulder in the neutral posture with humerothoracic (HT), scapulothoracic (ST) and thoracic (T) angles at 0°. (Middle) HT = 88° is accomplished through ST = 28° and a glenohumeral (GH) of 60°. (Right) HT = 130°, ST = 40° and GH = 90°. The subacromial space is shown between the yellow arrows.

Figure 3 – Alt text. Three sketches demonstrating how the humerus and scapula rotate together as the arm is elevated. In the left sketch the humerus is not rotated, in the middle, it is rotated to 88 degrees relative to the torso, and in the right it is rotated to 130 degrees. There is more narrowing of the subacromial space the more the humerus is rotated.

Rempel and Potvin 2022

Wrist posture

- Variazioni della **pressione** nel **canale carpale** al variare della postura e del carico (pinch force)



Effect of Wrist Posture on Carpal Tunnel Pressure while Typing (Rempel et al. 2007)

Carpal tunnel pressure

Soglia di danno nervoso **4kPa***

Dati sperimentali

4kPa: parestesie, ridotta ampiezza potenziale azione nervoso e velocità conduzione

Modelli animali: soglia riduzione flusso sanguigno nervo 2.7kPa

P>4kPa per 2h (edema, demielinizzazione)

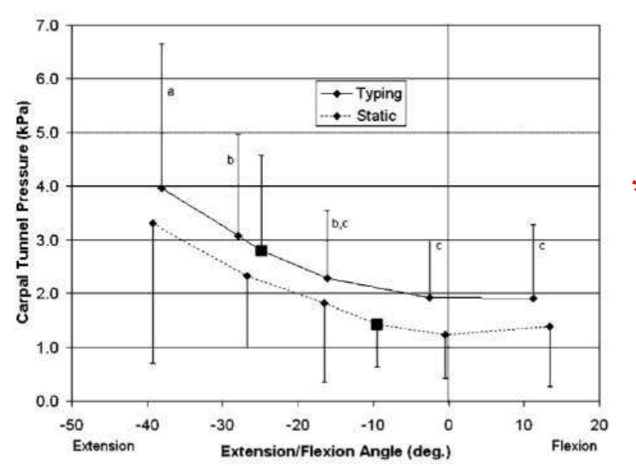


Figure 2. Mean carpal tunnel pressure versus mean right wrist flexion/extension angle ($N=20$). Values represent means ± SD. Typing pressure values with a common superscript letter were not significantly different from each other. Values for the conventional keyboard are labeled as -■- and were not included in the analysis.

*

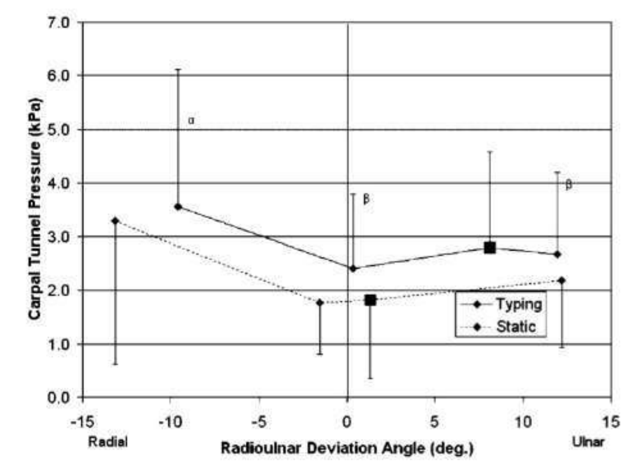


Figure 3. Mean carpal tunnel pressure versus mean right wrist radial/ulnar deviation angle ($N=20$). Values represent means ± SD. Typing pressure values with a common superscript letter were not significantly different from each other. Values for the conventional keyboard are labeled as -■- and were not included in the analysis.

CTP measure: a catheter was inserted at the distal wrist crease with a suture to minimize tip motion within the carpal tunnel.

Acute Effects on Carpal Tunnel

- Acute **median nerve conduction impairment** occurred experimentally when carpal canal pressure increased between has bee**40-50 mmHg**; nerve dysfunction caused by non-neutral hand postures, grip forces and external pressure,n demonstrated *(Keir and Rempel , 2005; Lundborg et al., 1982; Gelberman et al., 1983)*
- In response to manual exercise, an acute increase in the **cros-sectional area of the median nerve** at the pisiform level has been detected using ultrasonography before and after activity or keyboarding *(Massy-Westropp et al., 2001; Toosi et al., 2011)*

40-50 mmHg = 5.3-6.6 kPa

Guidelines for Wrist Posture Based on Carpal Tunnel Pressure Thresholds (Keir et al. 2007)

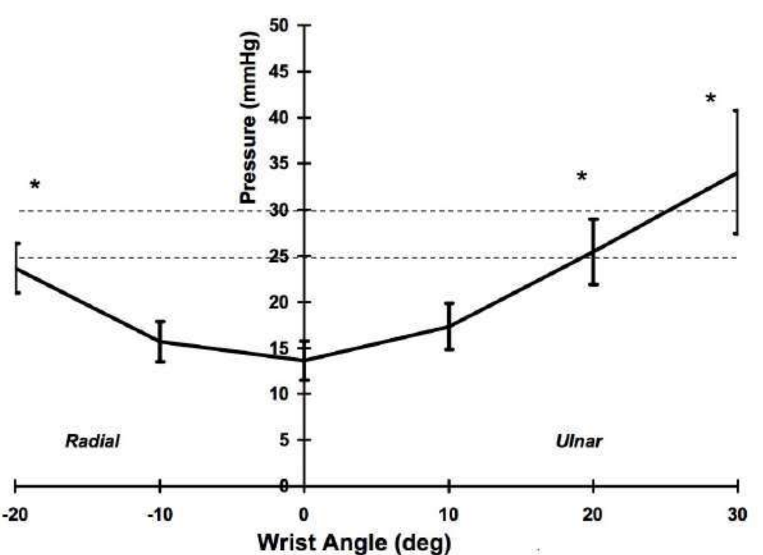
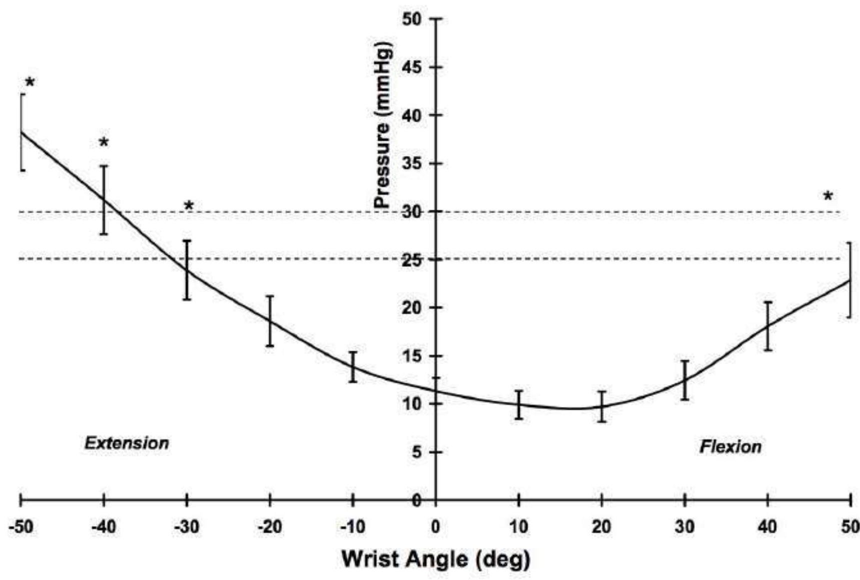


Figure 2. Carpal tunnel pressure (mmHg) versus wrist radioulnar angle (degrees). Asterisks indicate significant diffi ence from the neutral wrist. Horizontal dashed lines represent threshold levels. $N = 37$.



re 1. Carpal tunnel pressure (mmHg) versus wrist extension-flexion angle (degrees). Asterisks indicate significant rence from the neutral wrist. Horizontal dashed lines represent threshold levels. $N = 37$.

«**Metodi**» per la **stima di dati di esposizione a fattori biomeccanici**

- Dati raccolti sul campo (dati osservazionali, analisi video, misura)
- Classificazione dei risultati
- Indici composti

Takala EP et al. 2010

- Identify published (1965-2008) observational methods assessing biomechanical exposures at work

Methods classification:

- General methods (the main focus is to assess general workload) (n.15)
- Methods assessing workload of upper limb (n.9)
- Methods assessing mainly manual material handling (n.8)

Review

Scand J Work Environ Health 2010;36(1):3–24

Systematic evaluation of observational methods assessing biomechanical exposures at work

by Esa-Pekka Takala, PhD,[1] Irmeli Pehkonen, MSc,[1] Mikael Forsman, PhD,[2] Gert-Åke Hansson, PhD,[3] Svend Erik Mathiassen, PhD,[4] W Patrick Neumann, PhD,[5] Gisela Sjøgaard, PhD,[6] Kaj Bo Veiersted, PhD,[7] Rolf H Westgaard, PhD,[8] Jørgen Winkel, PhD [9]

Takala E-P, Pehkonen I, Forsman M, Hansson G-Å, Mathiassen SE, Neumann WP, Sjøgaard G, Veiersted KB, Westgaard RH, Winkel J. Systematic evaluation of observational methods assessing biomechanical exposures at work. *Scand J Work Environ Health.* 2010;36(1):3–24.

Objectives This systematic review aimed to identify published observational methods assessing biomechanical exposures in occupational settings and evaluate them with reference to the needs of different users.

Methods We searched scientific databases and the internet for material from 1965 to September 2008. Methods were included if they were primarily based on the systematic observation of work, the observation target was the human body, and the method was clearly described in the literature. A systematic evaluation procedure was developed to assess concurrent and predictive validity, repeatability, and aspects related to utility. At least two evaluators independently carried out this evaluation.

Results We identified 30 eligible observational methods. Of these, 19 had been compared with some other method(s), varying from expert evaluation to data obtained from video recordings or through the use of technical instruments. Generally, the observations showed moderate-to-good agreement with the corresponding assessments made from video recordings; agreement was the best for large-scale body postures and work actions. Postures of wrist and hand as well as trunk rotation seemed to be more difficult to observe correctly. Intra- and inter-observer repeatability were reported for 7 and 17 methods, respectively, and were judged mostly to be moderate or good.

Conclusions With training, observers can reach consistent results on clearly visible body postures and work activities. Many observational tools exist, but none evaluated in this study appeared to be generally superior. When selecting a method, users should define their needs and assess how results will influence decision-making.

Key terms posture; review; risk assessment; workload.

Takala EP et al. Systematic evaluation of observational methods assessing biomechanical exposures at work. *Scan J Work Environ Health 2010*

Table 1. Description of observational methods. Exposures included in the method: posture (P), force (F), duration (D), frequency of actions (Fr), movements (M), and vibration (Vib). (RPE=rating of perceived exertion; NIOSH=National Institute of Occupational Safety and Health; VAS=visual analog scale; TLV=threshold limit value; MMH=manual material handling)

Method and year of first publication	Target exposures and dimensions	Metrics	Observation strategy	Mode of recording
Methods assessing mainly manual material handling				
NIOSH lifting equation, 1981 (revised 1991)	P, F, D, Fr	Multiplied score; risk index	No detailed rules	Pen & paper, computerized
Arbouw, 1997	P, F, D, Fr	3 levels of risk tables	No detailed rules	Pen & paper
New Zealand code for material handling, 2001	P, F, D, Fr	Sum score of weighted items indicating risk	Flowchart; tasks including hazardous MMH	Pen & paper
Manual handling assessment charts (MAC), 2002	P, F, Fr	Item profile; sum score indicating risk	Selection by general knowledge of work	Pen & paper, (video)
Washington State ergonomic checklists, 2000	P, F, D, Fr	Lifting limit computed as multiplied score	Worst & most common lifts	Pen & paper
Manual tasks risk assessment (ManTRA), 2004	P, F, D, Fr, Vib	Sum score of risk	Rules stated in Queensland manual tasks advisory standard	Pen & paper
ACGIH lifting TLV, 2004	P, F, D, Fr	Hazardous lifting TLV	No detailed rules	Pen & paper
Back-Exposure Sampling Tool (BackEst), 2008	P, F, Vib	Frequency of items	Time sampling	Pen & paper

Takala EP et al. Systematic evaluation of observational methods assessing biomechanical exposures at work. *Scan J Work Environ Health 2010*

Table 1. Description of observational methods. Exposures included in the method: posture (P), force (F), duration (D), frequency of actions (Fr), movements (M), and vibration (Vib). (RPE=rating of perceived exertion; NIOSH=National Institute of Occupational Safety and Health; VAS=visual analog scale; TLV=threshold limit value; MMH=manual material handling)

Method and year of first publication	Target exposures and dimensions	Metrics	Observation strategy	Mode of recording
Methods assessing workload on upper limbs				
Health and Safety Executive (HSE) upper-limb risk assessment method, 1990	P, F, D, Fr, Vib	Yes/no answers	Tasks involving high repetition/low variety	Pen & paper
Stetson's checklist, 1991	P, F, D, Fr	Frequency of items by their duration	No detailed rules	Pen & paper
Rapid upper-limb assessment (RULA), 1993	P, F, static action	Sum score of weighted items	No detailed rules	Pen & paper, video
Keyserling's cumulative trauma checklist, 1993	P, F, D, Fr, Vib	Sum score of positive findings	Screening of job with questions put to the worker	Pen & paper
Strain index, 1995	P, F, D, Fr	Multiplied score; risk index	No detailed rules	Pen & paper
Occupational Repetitive Actions (OCRA), 1996	P, F, D, Fr, Vib	Sum score of weighted items; risk index	Assessment of repetitive action incl. in profile of work	Pen & paper
American Conference of Governmental Industrial Hygienists hand activity level (ACGIH HAL), 1997	M, F,	Hand activity & force requirement on VAS	"Typical activity"	Pen & paper, (video)
Washington State ergonomic checklists, 2000	P, F, D, Fr, Vib	Yes/no to questions combining risk factors	Items selected by caution zone checklist	Pen & paper
Ketola's upper-limb expert tool, 2001	P, F, D, Fr, Vib	Yes/no answers; profile of items	No detailed rules	Pen & paper

- La maggioranza dei metodi di valutazione dell’esposizione a fattori biomeccanici è di tipo osservazionale, gravata da una importante quota di soggettività

- Per questo è necessario considerare SEMPRE i dati disponibili sulla validazione dei metodi in uso e i relativi indici di esposizione

Validazione di un metodo di valutazione del rischio

- E' un percorso attraverso il quale si dimostra scientificamente che una procedura risponde effettivamente alle esigenze per cui si propone

- *Un metodo di «valutazione del rischio biomeccanico» misura effettivamente l'entità dell'esposizione a fattori biomeccanici, e i suoi risultati possono essere messi in relazione con un aumento della probabilità (rischio) di ammalarsi di una patologia plausibilmente correlata all'esposizione stessa?*

Validazione di un metodo di valutazione del rischio

- E’ un processo complesso e che presenta più passaggi
- E’ un processo necessario per garantire la solidità del metodo stesso

Criterion validity*: compare results with a “gold standard” (as for posture measured with instruments) /* ***concurrent validity****: compare with other methods considered to be more valid*

Predictive validity*: ability of the method to predict risk (exposure/effect – MSD- relationship)*

Face validity*: does the method measures what it is intended to measure?*
Intra and inter observer ***repeatability***

Takala EP et al. Systematic evaluation of observational methods assessing biomechanical exposures at work. *Scan J Work Environ Health 2010*

Table 2. Validity and repeatability of observational methods [– =Insufficient information; NIOSH=National Institute of Occupational Safety and Health; MMH=manual material handling]

Method	Correspondence with 'valid' reference [a]	Association with musculoskeletal disorders (MSD) [b]	Intra-observer repeatability	Inter-observer repeatability
Methods to assess mainly manual material handling				
NIOSH lifting equation	·	X	–	–
Arbouw	Moderate (NIOSH lifting equation)	–	–	–
New Zealand code for material handling	–	–	–	–
Manual handling assessment charts (MAC)	–	–	Moderate–good	Moderate–good
Washington State ergonomic checklists	Moderate (NIOSH lifting equation)	X	–	Moderate
Manual tasks risk assessment (ManTRA)	–	–	–	–
ACGIH lifting threshold limit value	Moderate (NIOSH lifting equation)	–	–	–
Back-exposure sampling tool (BackEst)	Low–moderate (technical measures)	–	–	Moderate

[a] Correspondence with valid reference/repeatability: Good, Moderate, Low,

[b] Association with musculoskeletal disorders: X = association in cross-sectional studies; L = prediction in longitudinal studies,

Takala EP et al. Systematic evaluation of observational methods assessing biomechanical exposures at work. *Scan J Work Environ Health 2010*

Table 2. Validity and repeatability of observational methods [– =Insufficient information; NIOSH=National Institute of Occupational Safety and Health; MMH=manual material handling]

Method	Correspondence with 'valid' reference [a]	Association with musculoskeletal	Intra-observer repeatability	Inter-observer repeatability
Methods to assess workload on upper limbs				–
Health and Safety Executive (HSE) upper-limb risk assessment method	–	–	–	–
Stetson's checklist	–	–	–	Moderate
Rapid upper-limb assessment (RULA)	Low–moderate (technical measures, ACGIH HAL, OCRA, strain index)	X	–	Moderate–good
Keyserling's cumulative trauma checklist	Moderate (video, workplace data)	–	–	Low–moderate
Strain index (SI)	Moderate (RULA, ACGIH HAL)	L, X	Moderate–good	Moderate–good
Occupational Repetitive Actions (OCRA)	Moderate (SI, RULA, ACGIH HAL)	X	–	–
American Conference of Governmental Industrial Hygienists hand activity level (ACGIH HAL)	Moderate (video, SI)	L, X	Good	Moderate
Washington State ergonomic checklists	–	X	–	Moderate
Ketola's upper-limb expert tool	Low–moderate (technical measures)	–	–	Moderate

a Correspondence with valid reference/repeatability: Good, Moderate, Low,

b Association with musculoskeletal disorders: X = association in cross-sectional studies; L = prediction in longitudinal studies,

Kilbom A, *Assessment of physical exposure in relation to work-related musculoskeletal disorders--what information can be obtained from systematic observations? 1994*

- Indici composti
- *“Primarily intended as an instrument for priority setting in ergonomic work*
- *Need to be **validated***
- *Indices or composite measures must never be used in a way that obscures an analysis of the effects of single exposure variables”*

Takala EP et al. Systematic evaluation of observational methods assessing biomechanical exposures at work, 2010

- In order for observational data to provide a **sound basis for decision-making**, the assessment should be **valid** for the targeted purpose and the results should be **reproducible**

  Criterion validity/ concurrent validity

  Predictive validity

  Face validity

  Intra + inter observer repeatability

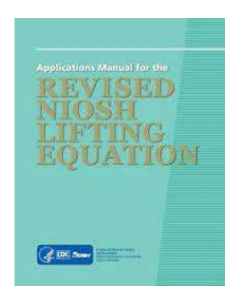
Revised NIOSH Lifting Equation RNLE
Equazione NIOSH - criteri

- Metodo di valutazione delle azioni di sollevamento sviluppato dal N*ational Institute for Occupational Safety and Health (NIOSH)*
- Individua un limite di peso (Recommended weight limit RWL) e identifica compiti lavorativi a rischio per lo sviluppo di lombalgia (*lifting-related low back pain)*

Revised NIOSH Lifting Equation RNLE
Equazione NIOSH – criteri, presupposti

Biomeccanico	Massima forza di compressione sul disco	3.4 kN	Limita gli effetti dello stress fisico sul rachide lombosacrale (importante in sollevamenti occasionali)
Fisiologico	Massimo dispendio energetico	2.2-4.7 kcal/min	Limita lo stress metabolico e la fatica associati a compiti ripetuti di sollevamento
Psicofisico	Massimo peso accettabile	Accettabile per il 75% delle lavoratrici femmine e per il 99% circa dei lavoratori maschi	Limita il carico di lavoro sulla base della percezione della capacità di sollevamento del lavoratore per quasi tutti i tipi di compiti (esclusi quelli ad elevata frequenza >6/min)

Revised NIOSH Lifting Equation RNLE
Updated version of the Applications Manual for the RNLE 2021



- NIOSH [1994]. Applications manual for the revised NIOSH lifting equation. By Waters TR, Ph.D., Putz–Anderson V, Ph.D., Garg A, Ph.D. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-110
- (Revised 9/2021),
- https://doi.org/10.26616/NIOSHPUB94110revised092021

https://www.cdc.gov/niosh/docs/94-110/pdfs/94-110revised082021.pdf?id=10.26616/NIOSHPUB94110

1.3 The Equation and Its Function

The revised lifting equation for calculating the Recommended Weight Limit (RWL) is based on a multiplicative model that provides a weighting for each of six task variables. The weightings are expressed as coefficients that serve to decrease the load weight to be lifted under ideal conditions.

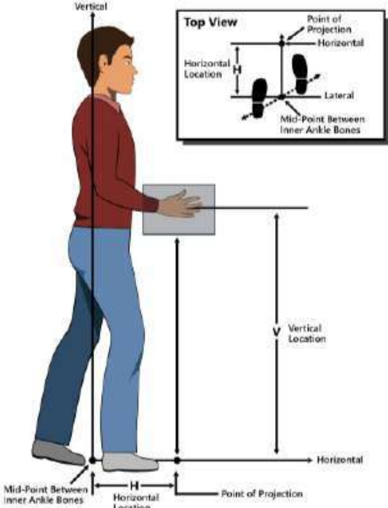
The RWL is defined by the following equation:

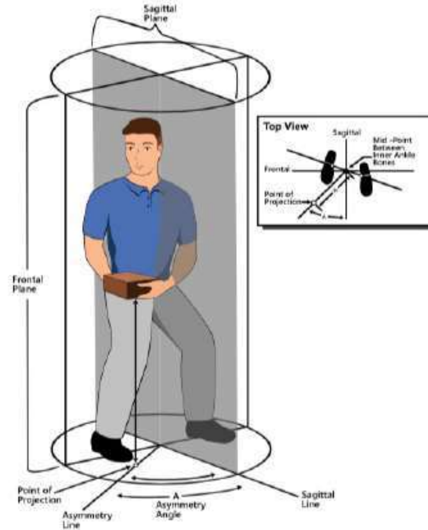
$$\mathbf{RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM}$$

Where:

		Metric	U.S. Customary
Load Constant	LC	23kg	51lb
Horizontal Multiplier	HM	(25/H)	(10/H)
Vertical Multiplier	VM	1– (.003|V-75|)	1– (.0075|V-30|)
Distance Multiplier	DM	.82 + (4.5/D)	.82 + (1.8/D)
Asymmetric Multiplier	AM	1– (.0032A)	1– (.0032A)
Frequency Multiplier	FM	From Table 5	From Table 5
Coupling Multiplier	CM	From Table 7	From Table 7

The term ***task variables*** refers to the measurable task descriptors (i.e., H, V, D, A, F, and C); whereas, the term ***multipliers*** refers to the reduction in the equation (i.e., HM, VM, DM, AM, FM, and CM).



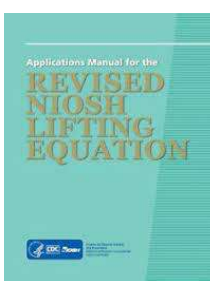


1.4 The Lifting Index (LI)

As defined earlier, the Lifting Index (LI) provides a relative estimate of the physical stress associated with a manual lifting job.

Where **Load Weight (L)** = weight of the object lifted (lbs or kg).

$$LI = \frac{\text{Load Weight}}{\text{Recommended Weight Limit}} = \frac{L}{RWL}$$



1.4.1 Using the RWL and LI to Guide Ergonomic Design

The recommended weight limit (RWL) and lifting index (LI) can be used to guide ergonomic design in several ways:

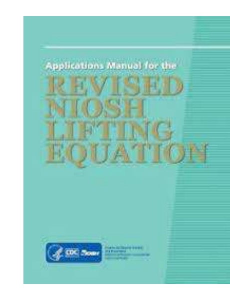
1. The individual multipliers can be used to identify specific job-related problems. The relative magnitude of each multiplier indicates the relative contribution of each task factor (e.g., horizontal, vertical, frequency, etc.)
2. The RWL can be used to guide the redesign of existing manual lifting jobs or to design new manual lifting jobs. For example, if the task variables are fixed, then the maximum weight of the load could be selected so as not to exceed the RWL; if the weight is fixed, then the task variables could be optimized so as not to exceed the RWL.
3. The LI can be used to estimate the relative magnitude of physical stress for a task or job. The greater the LI, the smaller the fraction of workers capable of safely sustaining the level of activity. Thus, two or more job designs could be compared.
4. The LI can be used to prioritize ergonomic redesign. For example, a series of suspected hazardous jobs could be rank ordered according to the LI and a control strategy could be developed according to the rank ordering (i.e. jobs with lifting indices above 1.0 or higher would benefit the most from redesign).

Revised NIOSH Lifting Equation RNLE
LI: Lifting related **Low back pain**

1.4.2 Rationale and Limitations for LI

The NIOSH Recommended Weight Limit (RWL) equation and lifting index are based on the concept that the risk of lifting-related low back pain increases as the demand of the lifting task increase. In other words, as the magnitude of the LI increases, (1) the level of the risk for a given worker would be increased, and (2) a greater percentage of the workforce is likely to be at risk for developing lifting–related low back pain. The shape of the risk function, however, is not known. Without additional data showing the relationship between low back pain and the LI, it is impossible to predict the magnitude of the risk for a given individual or the exact percent of the work population who would be at an elevated risk for low back pain.

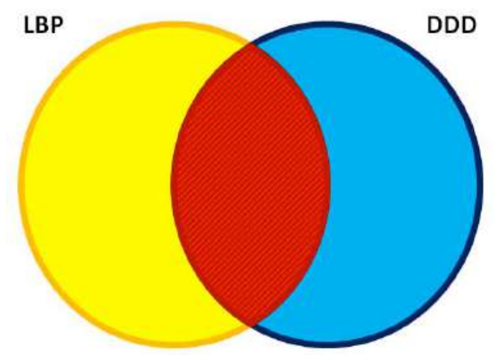
To gain a better understanding of the rationale for the development of the RWL and LI, consult the paper entitled *Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks* by Waters, Putz-Anderson, Garg, and Fine (1993). This article provides a discussion of the criteria underlying the lifting equation and of the individual multipliers. This article also identifies both the assumptions and uncertainties in the scientific studies that associate manual lifting and low back injuries.

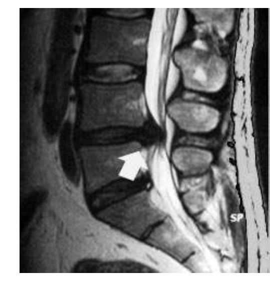


Significato dell'indice di sollevamento

- Nonostante il metodo proposto dal NIOSH e i suoi derivati siano punto di riferimento a livello internazionale va sottolineata **la necessaria prudenza interpretativa nei confronti dell'indice di sollevamento in relazione alla sua validità in termini predittivi nei confronti di possibili effetti sulla salute a carico del rachide lombo-sacrale.**

Low back pain (LBP) is a clinical entity, and degenerative disc disease (DDD) is a radiographic-anatomical finding





- There are many reasons why patients can present with LBP: lifetime prevalence 84%
- Conversely, DDD is frequently found in imaging studies of asymptomatic patients.
- **However, there is an overlap, and patients with LBP can present with imaging findings consistent with DDD. The challenge for the clinician then is to establish whether there is a causative relationship.**

Kirnaz e coll, ***Pathomechanism and Biomechanics of Degenerative Disc Disease: Features of Healthy and Degenerated Discs****. Int J Spine Surg.* ***2021*** *Apr;15(s1):10-25*

Fox RR, Lu ML, Occhipinti E, Jaeger M. Understanding outcome metrics of the revised NIOSH lifting equation. Appl Ergon. 2019 Nov;81

- Una **sintesi degli studi ad oggi disponibili relativi alla comprensione della relazione esistente tra l'esposizione misurata mediante l'equazione NIOSH** nelle diverse metriche proposte e possibili effetti sulla salute conclude riportando le indicazioni della seguente tabella

Table 2
Interpretation of Lifting Index and derivates (*LI, CLI, VLI, SLI*).

Lifting Index Value (Exposure level)	Risk Implication	Recommended Actions
LI ≤ 1,0	Very low	None in general for the healthy working population.
1,0 < LI ≤ 1,5	Low	In particular pay attention to low frequency/high load conditions and to extreme or static postures. Include all factors in redesigning tasks or workstations and consider efforts to lower the LI to values ≤ 1,0.
1,5 < LI ≤ 2,0	Moderate	Redesign tasks and workplaces according to priorities to reduce the LI, followed by analysis of results to confirm effectiveness.
2,0 < LI ≤ 3,0	High	Changes to the task to reduce the LI should be a high priority.
LI > 3,0	Very high	Changes to the task to reduce the LI should be made immediately.
For Any level of Risk/Exposure	Identify any workers who may have special needs or vulnerabilities in lifting tasks and assign or design the work accordingly. Training workers on recognizing and eliminating material handling hazards is regarded as beneficial. Limiting the weight to be lifted, to less than the Reference Mass may also be considered.	

Fox RR, Lu ML, Occhipinti E, Jaeger M. Understanding outcome metrics of the revised NIOSH lifting equation. Appl Ergon. 2019 Nov;81

Table 1
Epidemiological studies (in chronological order) investigating the relationship between various types of LI metrics and LBD outcomes.

No.	Authors	N	Study Design	LI Metric	Health Outcome	LI Value Threshold*	% of Met Criteria	Quality**
1	Schneider et al., (1997)	19	Retrospective	CLI	Company MSD records	Unclear	35.9	Poor
2	Wang et al., (1998)	97	Retrospective	LI	Low back discomfort rating	1.0	56.4	Fair
3	Waters et al. (1999)	308	Cross-sectional	LI	Self-reported LBP 7 days or more in the past year	2.0	64.1	Fair
4	Marras et al. (1999)	353***	Retrospective	LI	Company low back injury records in the past 6 years	3.0	61.1	Fair
5	Sesek et al., 2003	182***	Retrospective	LI	Company low back injury records related to medical visits in the past year	1.0	50	Fair
6	Xiao et al., 2004	69	Cross-sectional	LI	Self-reported LBP 7 days or more in the past year	Unclear	76.9	Good
7	Kucera et al., 2009	105	Prospective		LBP limiting normal work activity	3.0	78.2	Good
8	Waters et al. (2011)	677	Cross-sectional	LI	Self-reported LBP 7 days or more in the past year	1.0	79.9	Good
9	Lu et al. (2014)	78	Prospective	CLI	Self-reported LBP 7 days or more in the past year	2.0	83.3	Good
10	Kappellusch et al., 2014	258	Prospective	CLI/LI	Medical care due to LBP in past 90 days	3.0	81.0	Good
11	Garg et al. (2014b)	258	Prospective	CLI/LI	Sickness absence due to LBP in past 90 days	2.2	83.3	Good
12	Garg et al. (2014a)	258	Prospective	CLI/LI	LBP > 1 day in past 90 days	3.0	81.0	Good
13	Pandalai et al. (2016)	138	Prospective	CLI	Self-reported LBP 7 days or more in the past year	1.5	80.2	Good
14	Battevi et al. (2016)	3,402	Cross-sectional	VLI	Acute LBP in the past year	1.0	78.0	Good
15	Stucchi et al., 2017	3,402	Cross-sectional	VLI	Acute LBP in the past year	1.0	75.1	Good

* Value that is significantly associated with an increased risk of the LBP outcome.
** Quality assessment is based on the averaged percentage of the met criteria in the NIH quality assessment tool: Poor (< 50%); Fair (50–75%); Good (76–100%).
*** The number is for jobs instead of persons.

Fox RR, Lu ML, Occhipinti E, Jaeger M. Understanding outcome metrics of the revised NIOSH lifting equation. Appl Ergon. 2019 Nov;81

- Si evidenzia come gli effetti sulla salute studiati **riguardino esclusivamente la lombalgia** (*low back pain/disconfort*) riferita dai lavoratori di durata variabile nell'ultimo anno, o che abbia richiesto o meno cure mediche.
- Da rilevare che i due studi più recenti si basano su un disegno "trasversale" ("cross-sectional") che consiste di fatto in una osservazione puntuale e simultanea dei due parametri in studio: l'esposizione e l'effetto sulla salute. Tali studi sono in grado di fornire una stima dell'associazione tra i due parametri ma non permettono inferenza sul rapporto di causalità.

- Come si evince da quanto sopra riportato la ricerca condotta ad oggi con l’obiettivo di stimare il valore predittivo dei risultati dell’applicazione dell’equazione **NIOSH ha riguardato un solo “outcome” cioè la lombalgia.**
- Non sono ad oggi disponibili studi che permettano di conoscere la relazione che lega l’indice derivante dall’applicazione dell’equazione NIOSH e patologie discali quali ernia o malattia degenerativa discale del tratto lombare della colonna vertebrale.

Revised NIOSH Lifting Equation RNLE - 2022

Dehghan P, Arjmand N. The National Institute for Occupational Safety and Health (NIOSH) Recommended Weight Generates Different Spine Loads in Load-Handling Activity Performed Using Stoop, Semi-squat and Full-Squat Techniques; a Full-Body Musculoskeletal Model Study. Hum Factors. ***2022*** *Nov 26:*	A full-body subject-specific musculoskeletal model (Anybody Modeling System, AMS) driven by a 10-camera Vicon motion capture system was used to simulate different static stoop, semi-squat, and full-squat load-handling activities of ten normal-weight volunteers (mean of ~70 kg) **Spinal loads are expected to pass their recommended limits for heavier individuals especially during semi-squatting as the most frequently adapted technique by workers.**
Donisi et al. A Logistic Regression Model for Biomechanical Risk Classification in Lifting Tasks. Diagnostics (Basel). ***2022*** *Oct 29;12(11):2624.*	Aim of this work is to explore the **feasibility of a logistic regression model fed with time and frequency domains features extracted from signals acquired through one inertial measurement unit (IMU) to classify risk classes associated with lifting activities according to the RNLE.** The logistic regression model fed with significant features showed **good results to discriminate "risk" and "no risk" NIOSH classes with an accuracy, sensitivity and specificity equal to 82.8%, 84.8%** and **80.9%, respectively.** Therefore, could be a valid tool **to assess the biomechanical risk in an automatic way also in more complex conditions (e.g., real working scenarios).**
Ahmad S, Muzammil M. Predicting the load constant of the revised NIOSH lifting equation based on demographics. Int J Occup Saf Ergon. ***2022*** *Aug 4:1-9.*	**The equation is based on data primarily from the West.** To make the model universally applicable, the effect of worker characteristics like age, gender, weight and anthropometry on maximum acceptable weight limits (MAWLs) was studied. A psychophysical methodology was adopted to arrive at the MAWLs. In total, 58 industrial workers (30 men and 28 women) participated in the study. Based on the observations of the study, **an equation was developed that would allow the RNLE load constant to be modified for different populations based on simple anthropometric data.** The load constant for the Indian population was found to be comparable to the RNLE recommendations.

- Di seguito alcuni esempi di metodi di valutazione tra quelli citati nella norma ISO parte 3

- Nonostante la pluralità di metodologie, i fattori valutati sono sostanzialmente i medesimi
- Ciò che cambia sono i criteri di misura esposizione e di classificazione del rischio (che necessitano di validazione)

Applied Ergonomics 1993, 24(2), 91–99

RULA: a survey method for the investigation of work-related upper limb disorders

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Keywords: Working posture, assessment, upper limb disorders, RSI

Introduction

This paper describes the development of a posture, force and muscle use assessment tool. Called RULA (rapid upper limb assessment) this tool has undergone initial validation and reliability studies which are also reported upon here.

RULA was developed to investigate the exposure of individual workers to risk factors associated with work-related upper limb disorders. Part of the development took place in the garment-making industry, where assessment was made of operators who performed tasks including cutting while standing at a cutting block, machining using one of a variety of sewing machines, clipping, inspection operations, and packing. RULA was also developed through the evaluation of the postures adopted, forces required and muscle actions of both VDU operators and operators working in a variety of manufacturing tasks where risk factors associated with upper limb disorders may be present.

The method uses diagrams of body postures and three scoring tables to provide evaluation of exposure to risk factors. The risk factors under investigation are those described by McPhee[1] as *external load factors*. These included:

- numbers of movements;
- static muscle work;
- force;
- work postures determined by the equipments and furniture;
- time worked without a break.

In addition to these factors McPhee cited other important factors which influence the load, but which may *vary between individuals*. These were the work postures adopted, unnecessary use of static muscle work or force, speed and accuracy of movements, the frequency and the duration of pauses taken by the operator. Third, according to McPhee, are factors which altered the *individual's response* to a particular load, individual factors (such as age and experience), workplace environmental factors and psychosocial variables. Many other authors have also reported on risk factors associated with upper limb disorders[2–8].

In an effort to assess the first four external load factors described above (number of movements, static muscle work, force and postures), RULA was developed to:

1. provide a method of screening a working population quickly, for exposure to a likely risk of work-related upper limb disorders;

2. identify the muscular effort which is associated with working posture, exerting force and performing static or repetitive work, and which may contribute to muscle fatigue;

3. **give results which could be incorporated in a wider ergonomics assessment covering epidemiological, physical, mental, environmental and organizational factors, and particularly to assist in fulfilling the assessment requirements of the UK *Guidelines on the prevention of work-related upper limb disorders*.**

Applied Ergonomics 1993, 24(2), 91–99

RULA: a survey method for the investigation of work-related upper limb disorders

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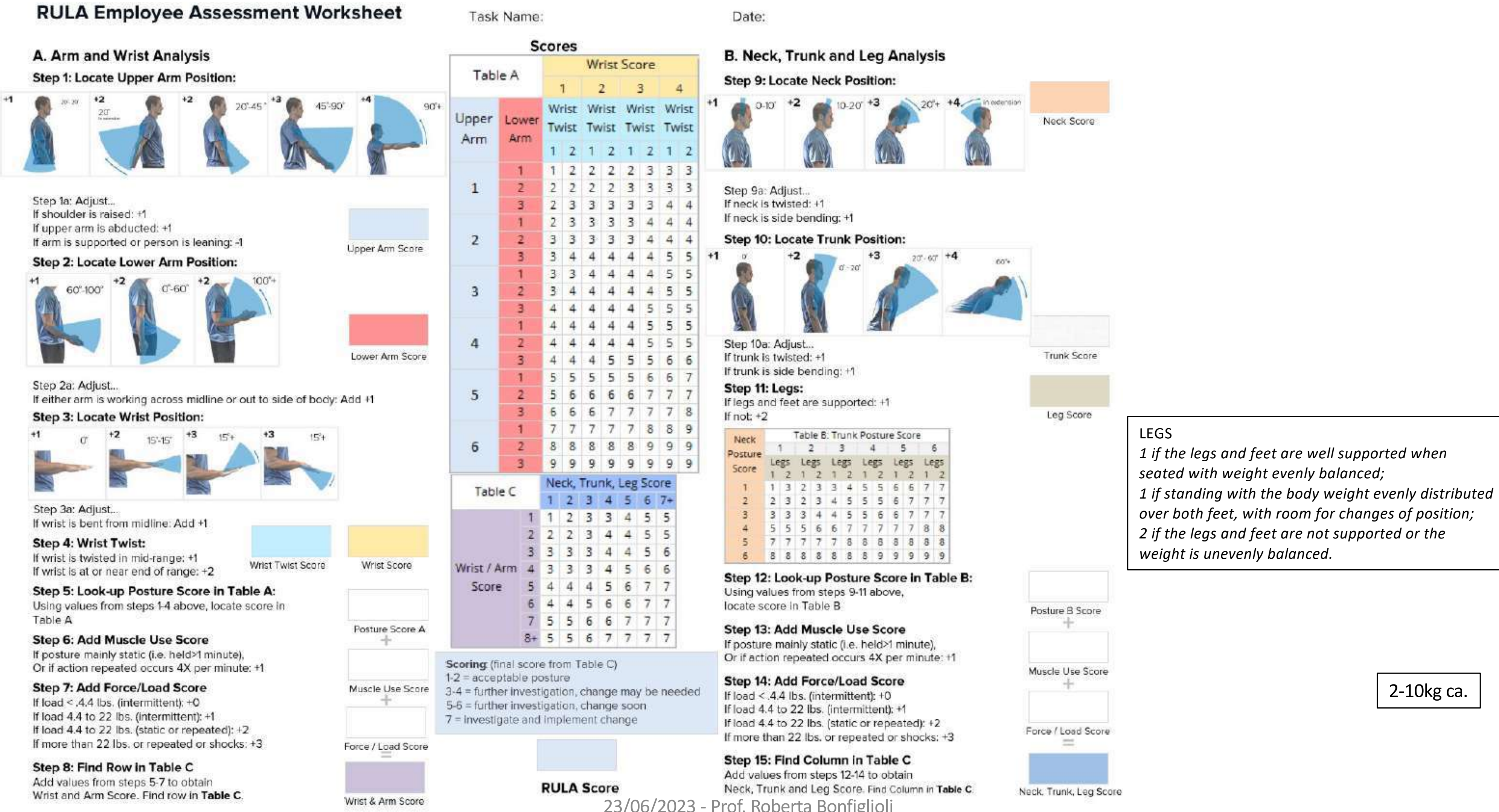
RULA (rapid upper limb assessment) is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported.

This tool requires no special equipment in providing a **quick assessment of the postures** of the **neck, trunk and upper limbs** along with **muscle function** and the **external loads** experienced by the body.

Recording the posture score The assessment commences by observing the operator during several work cycles in order to select the tasks and postures for assessment. Selection may be made of the posture held for the greatest amount of the work cycle or where highest loads occur. As RULA can be conducted quickly, an assessment can be made of each posture in the work cycle. When using RULA, only the right or left side is assessed at a time. After observing the operator it may be obvious that only one arm is under load; however, if undecided, the observer would assess both sides.



RULA Employee Assessment Worksheet

Task Name:

Date:

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

+1 20°-20° | +2 20° | +2 20°-45° | +3 45°-90° | +4 90°+

Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 2: Locate Lower Arm Position:

+1 60°-100° | +2 0°-60° | +2 100°+

Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:

+1 0° | +2 15°-15° | +3 15°+ | +3 15°+

Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score

Wrist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

Posture Score A
+

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>1 minute),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score
+

Step 7: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score
=

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain
Wrist and Arm Score. Find row in **Table C**.

Wrist & Arm Score

Scores

Table A		Wrist Score 1		Wrist Score 2		Wrist Score 3		Wrist Score 4	
Upper Arm	Lower Arm	Wrist Twist 1	Wrist Twist 2	Wrist Twist 1	Wrist Twist 2	Wrist Twist 1	Wrist Twist 2	Wrist Twist 1	Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C		Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
Wrist / Arm Score	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

RULA Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

+1 0-10° | +2 10-20° | +3 20°+ | +4 in extension

Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

+1 0° | +2 0°-20° | +3 20°-60° | +4 60°+

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Leg Score

Neck Posture Score	Table B: Trunk Posture Score 1		2		3		4		5		6	
	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2	Legs 1	Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above,
locate score in Table B

Posture B Score
+

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>1 minute),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score
+

Step 14: Add Force/Load Score
If load < 4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score
=

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain
Neck, Trunk and Leg Score. Find Column in **Table C**.

Neck, Trunk, Leg Score

LEGS
1 if the legs and feet are well supported when seated with weight evenly balanced;
1 if standing with the body weight evenly distributed over both feet, with room for changes of position;
2 if the legs and feet are not supported or the weight is unevenly balanced.

2-10kg ca.

based on RULA: a survey method for the investigation of work-related upper limb disorders, McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99

Applied Ergonomics 1993, 24(2), 91–99

RULA: a survey method for the investigation of work-related upper limb disorders

Lynn McAtamney and E Nigel Corlett

Institute for Occupational Ergonomics, University of Nottingham, University Park, Nottingham NG7 2RD, UK

Action level	Score	*A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator*
1	**1 o 2**	*A score of 1 or 2 indicates that posture is acceptable if it is not maintained or repeated for long periods.*
2	**3 o 4**	*A score of 3 or 4 indicates that further investigation is needed and changes may be required.*
3	**5 o 6**	*A score of 5 or 6 indicates that investigation and changes are required soon.*
4	**7**	*A score of 7 indicates that investigation and changes are required immediately.*

The higher action levels will not, however, lead to unequivocal actions to eliminate any risks to the operator. It must be strongly emphasized that, since the human body is a complex and adaptive system, simple methods cannot deal in simple ways with postural and loading effects on the body. What the RULA system provides is a guide, and it was developed to draw boundaries around the more extreme situations. However, the conbination of factors which influence the load but vary between operators, and factors which alter the individual's response to a particular load[1], may contribute to increasing the load from being within acceptable boundaries to being a serious problem for some people.

For these reasons the action list leads, in most cases, to proposals for a more detailed investigation. To draw the limits too tightly would lead to an undue expense in changing jobs without any guarantee that those still within the boundary would be safe. Hence the use of RULA will give a priority order for jobs which should be investigated, while the magnitude of the individual posture scores and the muscle use or exerted force scores indicate which aspects of the postures are likely to be those where trouble will be expected.

Applied Ergonomics 31 (2000) 201–205

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Technical note

Rapid Entire Body Assessment (REBA)

Sue Hignett[a,*], Lynn McAtamney[b]

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Received 20 July 1998; accepted 17 June 1999

Analisi posturale di tipo quantitativo predisposta per le situazioni in cui le posture di lavoro siano impredicibili (come è il caso dell'assistenza ai pazienti)

Data collection and individual coding of over 600 examples of postures from

- Healthcare
- Manufacturing
- Electricity industries

1. Introduction

Postural analysis can be a powerful technique for assessing work activities. The risk of musculoskeletal injury associated with the recorded posture(s), in the context of a full ergonomic workplace assessment, can be a major factor for implementing change, so the availability of task-sensitive field techniques is of great assistance for the ergonomics practitioner.

Most postural analysis techniques have two, usually contradictory, qualities of generality and sensitivity (Fransson-Hall et al., 1995). High generality in a postural analysis method may be compensated by low sensitivity, for example; the Ovako Working posture Analysis System (OWAS, Karhu et al., 1977) has a wide range of use but the results can be low in detail (Hignett, 1994). In contrast NIOSH (Waters et al., 1993) requires detailed information about specific parameters of the posture, to give high sensitivity with respect to the defined indices, but has a limited application in health care in particular with respect to animate load handling.

A need was perceived within the spectrum of postural analysis tools, specifically with sensitivity to the type of unpredictable working postures found in health care (e.g. animate load handling) and other service industries. This lead to the development of the following postural analysis tool: Rapid Entire Body Assessment, REBA (Hignett, 1998; McAtamney and Hignett, 1995).

2. Aims

The development of REBA aimed to:

- Develop a postural analysis system sensitive to musculoskeletal risks in a variety of tasks.
- Divide the body into segments to be coded individually, with reference to movement planes.
- Provide a scoring system for muscle activity caused by static, dynamic, rapid changing or unstable postures.
- Reflect that coupling is important in the handling of loads but may not always be via the hands.
- Give an action level with an indication of urgency.
- Require minimal equipment – pen and paper method.

REBA (Rapid Entire Body Assessment)

Hignett e McAttamney, Appl Ergon 31(2):201-5, **2000**

Metodo sviluppato nel Regno Unito per <u>valutare il carico posturale</u>

Applied Ergonomics 31 (2000) 201–205

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Technical note

Rapid Entire Body Assessment (REBA)

Sue Hignett[a,*], Lynn McAtamney[b]

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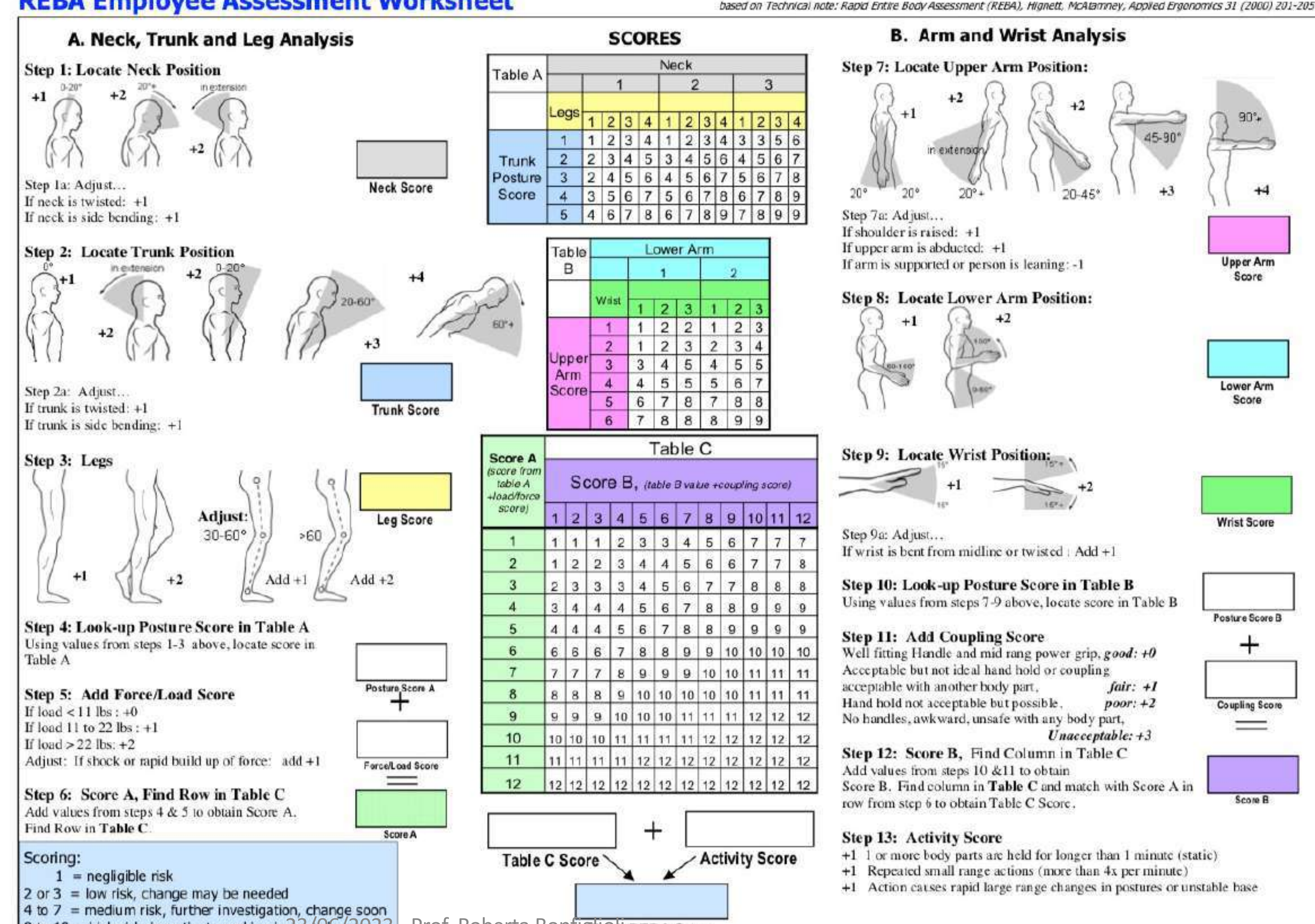
Received 20 July 1998; accepted 17 June 1999

- To define the initial body segment codes simple tasks were analysed with variations in the load, movement distance and height
- Data were collected using several techniques including NIOSH (Waters et al.,1993),Rated Perceived Exertion (Borg,1985), OWAS, Body Part Discomfort Survey (Corlett and Bishop,1976) and Rapid Upper Limb Assessment (McAtamney and Corlett,1993)

- The analyses were used to establish the body part ranges shown in the Group A and B diagrams based on the body part diagrams from RULA (McAtamney and Corlett,1993).and REBA score

Attribuisce un **punteggio** per le posture assunte dai diversi segmenti corporei, in riferimento ai piani di movimento

Attribuisce un **punteggio** anche per il livello di attività muscolare legata a posture statiche, dinamiche, instabili (Step 11) stimando il <u>peso del carico o la forza impiegata (Step 5)</u>



REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

Step 1a: Adjust…
If neck is twisted: +1
If neck is side bending: +1

Neck Score

Step 2: Locate Trunk Position

Step 2a: Adjust…
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 3: Legs

Leg Score

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above, locate score in Table A

Posture Score A

+

Step 5: Add Force/Load Score
If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

Force/Load Score

=

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in **Table C**.

Score A

Scoring:
1 = negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate and implement change
11+ = very high risk, implement change

SCORES

Table A	Neck	1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table B	Lower Arm	1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Table C

Score A (score from table A +load/force score)	Score B, (table B value +coupling score) 1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score + **Activity Score**

Final REBA Score

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:

Step 7a: Adjust…
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 8: Locate Lower Arm Position:

Lower Arm Score

Step 9: Locate Wrist Position:

Wrist Score

Step 9a: Adjust…
If wrist is bent from midline or twisted : Add +1

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

Posture Score B

+

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, ***good: +0***
Acceptable but not ideal hand hold or coupling acceptable with another body part, ***fair: +1***
Hand hold not acceptable but possible, ***poor: +2***
No handles, awkward, unsafe with any body part, ***Unacceptable: +3***

Coupling Score

=

Step 12: Score B, Find Column in Table C
Add values from steps 10 &11 to obtain Score B. Find column in **Table C** and match with Score A in row from step 6 to obtain Table C Score.

Score B

Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

REBA (Rapid Entire Body Assessment)
Hignett e McAttamney, Appl Ergon 31(2):201-5, **2000**
Metodo sviluppato nel Regno Unito per valutare il carico posturale

Table 4
REBA action levels

Action level	REBA score	Risk level	Action (including further assessment)
0	1	Negligible	None necessary
1	2–3	Low	May be necessary
2	4–7	Medium	Necessary
3	8–10	High	Necessary soon
4	11–15	Very high	Necessary NOW

4. Discussion

During the second workshop there was a change in one of the body part ranges, the Upper Arm category, to introduce the gravity assisted score (−1) for upper limb flexion with trunk flexion. The inter-observer reliability of the 14 participants for coding achieved between 62 and 85% agreement (omitting the Upper Arm category).

Although the initial development of REBA shows promise as a useful postural analysis tool, further validation needs to be carried out. Others may be better placed to carry out this validation, perhaps in cross reference with other tools (OWAS, NIOSH, Posture targeting, biomechanical models) or through empirical measurement in a laboratory setting.

Livello di azione	Punteggio REBA	Livello di rischio	Azione (compresa ulteriore valutazione)
0	1	Nullo	Nessuna
1	2-3	Basso	Talvolta necessaria
2	4-7	Medio	Necessaria
3	8-10	Alto	Necessaria al più presto
4	11-15	Molto alto	Necessaria ADESSO

OCRA (*OCcupational Repetitive Action*)

Risk assesment and managment of repetitive movements and exertions of upper limbs.
Colombini D, Occhipinti E, Grieco A. Elsevier Science, 2002
The occupational repetitive action (OCRA) methods: OCRA index and OCRA chek-list .
In Eds. Stantin N, et al: Handbook of human factors and ergonomics methods. Chapter 15, CRC Press, 2004
Metodo sviluppato in Italia fine anni 90'

- ❑ Metodo per la valutazione del rischio connesso ai movimenti ripetitivi degli arti superiori

- ❑ Si articola in due diversi strumenti (OCRA-index e ocra chek-list) aventi dettaglio analitico e finalità differenti

- ❑ (1990-1996) OCRA-Index: Indice sintetico di esposizione a rischi connessi con movimenti ripetitivi degli arti superiori

- ❑ (2000) Checklist OCRA: modello per la stima rapida dell'indice di esposizione OCRA (Strumento di screening agile e poco costoso)

Check-list OCRA

- Utilizzabile per screening
- Valuta:
  1. frequenza
  2. recupero
  3. forza
  4. postura
  5. fattori complementari

- Assegna un punteggio finale
- identifica delle aree di rischio (poste in relazione con le aree dei valori ricavati dall'OCRA-Index)
- Applicabile a "*multitask repetitive jobs*"

OCRA Index

- Metodo semi-quantitativo
- Analisi complessa, maggior dettaglio analitico "time consuming"
- Applicabile a "*multitask repetitive jobs*"
- Valuta:
  1. Ripetitività
  2. Forza
  3. Postura
  4. Periodi di recupero
  5. Fattori complementari (amplificatori del rischio)

Indice Ocra =

$$\frac{\textbf{N° complessivo azioni tecniche svolte nel turno}}{\textbf{N° complessivo azioni tecniche raccomandate nel turno}}$$

OCRA

- Il metodo OCRA è stato sottoposto ad un **primo processo di validazione nel 1997** sulla base di studi, di disegno trasversale, svolti in un campione complessivo di 462 lavoratori esposti e 749 non esposti
- (*Colombini D, Occhipinti E. Le applicazioni dell'indice sintetico di esposizione (OCRA) a compiti con movimenti ripetitivi degli arti superiori in diverse realtà produttive: prime esperienze di validazione [The application of the concise exposure index to repetitive movement tasks of the upper limbs in various production settings: preliminary experience and validation]. Med Lav. 1996 Nov-Dec;87(6):704-15. Italian; Grieco A. Application of the concise exposure index (OCRA) to tasks involving repetitive movements of the upper limbs in a variety of manufacturing industries: preliminary validations. Ergonomics. 1998 Sep;41(9):1347-56*).

- Sono così pubblicati i primi parametri di riferimento relativi all'associazione tra indice di esposizione OCRA e prevalenza di patologie muscoloscheletriche dell'arto superiore.

Occhipinti E, Colombini D. Metodo OCRA: aggiornamento dei valori di riferimento e dei modelli di previsione della frequenza di patologie muscolo-scheletriche correlate al lavoro degli arti superiori (UL-WMSDs) in popolazioni lavorative esposte a movimenti e sforzi ripetuti degli arti superiori

- Successivamente alla pubblicazione della Check list OCRA (anno 2000) gli Autori **aggiornano i valori di riferimento** su un campione più ampio (4624 lavoratori esposti e 749 non esposti) ottenuto sempre mediante studi a disegno trasversale. Propongono una **nuova classificazione dei risultati dell'indice di esposizione OCRA (e per derivazione della Check list OCRA) in sei zone corrispondenti ad una classificazione del rischio di sviluppare patologie muscoloscheletriche dell'arto superiore**
- (*Occhipinti E, Colombini D. Metodo OCRA: aggiornamento dei valori di riferimento e dei modelli di previsione della frequenza di patologie muscolo-scheletriche correlate al lavoro degli arti superiori (UL-WMSDs) in popolazioni lavorative esposte a movimenti e sforzi ripetuti degli arti superiori [The OCRA method: updating of reference values and prediction models of occurrence of work-related musculo-skeletal diseases of the upper limbs (UL-WMSDs) in working populations exposed to repetitive movements and exertions of the upper limbs]. Med Lav. 2004 Jul-Aug;95(4):305-19. Italian*).

Occhipinti E, Colombini D. Metodo OCRA: aggiornamento dei valori di riferimento e dei modelli di previsione della frequenza di patologie muscolo-scheletriche correlate al lavoro degli arti superiori (UL-WMSDs) in popolazioni lavorative esposte a movimenti e sforzi ripetuti degli arti superiori

- Come specificato nel testo da parte degli stessi Autori ***"gli indici di esposizione sono stati calcolati dagli Autori, caso per caso, sulla base dei videofilmati e della documentazione cartacea disponibili; tali indici sovente sono tuttavia valori medi di gruppi di compiti e mansioni la cui esposizione può essere considerata omogenea, ma non identica"*** **(pagg 308-309)**

Occhipinti E, Colombini D. Metodo OCRA: aggiornamento dei valori di riferimento e dei modelli di previsione della frequenza di patologie muscolo-scheletriche correlate al lavoro degli arti superiori (UL-WMSDs) in popolazioni lavorative esposte a movimenti e sforzi ripetuti degli arti superiori

I dati utilizzati per la validazione provengono da studi svolti all'interno di **realtà industriali e hanno considerato attività di assemblaggio / montaggio, confezionamento, lavorazione carni (macellazione, disosso), carteggiatura**

Tabella 2 - *Principali caratteristiche dei gruppi esaminati: composizione numerica totale e per genere, indici di esposizione (indici OCRA e punteggio* checklist*), prevalenza di singoli casi diagnosticati di UL-PMSDs (PC) e di soggetti ammalati di uno o più di UL - WMSDS (R4)*

Tipo di lavoro	Numero totale	Numero maschi	Numero femmine	*Checklist* punteggio	OCRA indice	% diagnosi PC	% malati PA
Montaggio motori elettrici 1	431	126	305	15,2	4,7	20,4	11,4
Montaggio motori elettrici 2	288	173	115	12,0	3,4	19,4	8,7
Assemblaggio surgelatori	374	264	110	11,5	3,2	16,0	8,6
Assemblaggio frigoriferi A	350	270	80	14,7	4,5	24,6	15,4
Assemblaggio frigoriferi B	42	32	10	13,0	3,8	23,8	14,3
Assemblaggio frigoriferi C	31	31	o	14,4	4,3	32,3	19,4
Assemblaggio frigoriferi D	118	63	55	15,0	4,6	22,9	15,3
Assemb+cablag. frigoriferi	42	22	20	19,4	7,2	69,0	31,0
Assemblaggio forni	650	150	500	10,2	2,8	21,8	13,2
Assemblaggio ammortizzatori	242	159	83	19,5	7,3	60,3	24,0
Macellazione tacchini e polli	943	o	943	20,0	7,7	31,5	22,4
Rifinitura ceramiche	22	o	22	24,0	21,0	109,1	63,6
Carteggiatura legrii per atto	121	55	66	21,0	13,0	18,2	17,4
Carteggiatura legni per infissi	25	o	25	34,0	24,7	108,0	72,0
Cassiera supermarket	100	o	100	17,0	7,0	53,0	26,0
Confezione verdure	29	o	29	29,0	21,0	217,2	72,4
Tappezzeria sedili	59	33	26	32,0	41,7	203,4	79,7
Disosso carni	86	67	19	28,0	23,8	224,4	47,7
Cernita piastrelle	46	o	46	30,0	41,0	315,2	93,5
Assemblaggio motori 1	467	355	112	10,0	3,4	8,6	3,9
Assemblaggio motori 2	53	37	16	12,0	3,9	13,2	7,5
Assemblaggio statori	105	42	63	17,0	5,8	24,8	13,3
Gruppo di riferimento	749	310	439	1,5	0,5	5,6	4,4

Occhipinti E, Colombini D. Metodo OCRA: aggiornamento dei valori di riferimento e dei modelli di previsione della frequenza di patologie muscolo-scheletriche correlate al lavoro degli arti superiori (UL-WMSDs) in popolazioni lavorative esposte a movimenti e sforzi ripetuti degli arti superiori

- *"Tutti gli studi su cui è basato il presente lavoro di analisi sono studi di prevalenza. Si è pienamente consapevoli che i dati provenienti da tali studi, quando usati per indagare ipotesi di relazione tra condizioni di esposizione (nella fattispecie ad un fattore di rischio lavorativo, e corrispondenti effetti collettivi di salute, sono suscettibili di diversi effetti di distorsione non controllabili.*
- *Studi controllati di incidenza (retrospettivi o prospettici) sarebbero certamente più adatti allo scopo: essi sono tuttavia di più difficile e lunga realizzazione e pertanto al momento scarsamente disponibili."* (pag.316) …

Prevalenza di Singoli casi diagnosticati di UL-PMSDs (PC) o Soggetti ammalati di uno o più UL-WMSDs (PA)

Occhipinti E, Colombini D. Metodo OCRA: aggiornamento dei valori di riferimento e dei modelli di previsione della frequenza di patologie muscolo-scheletriche correlate al lavoro degli arti superiori (UL-WMSDs) in popolazioni lavorative esposte a movimenti e sforzi ripetuti degli arti superiori

- **….** **“***Poiché il metodo OCRA è ormai utilizzato in molti contesti anche per finalità di vigilanza e di carattere medico-legale, preme sottolineare che* ***nelle intenzioni degli Autori il sistema di classificazione proposto, basato sui nuovi valori critici dell’indice OCRA, vuole essere prevalentemente una guida per l’interpretazione dell’analisi valutativa e per orientare i conseguenti interventi preventivi piuttosto che uno standard rigido di valori limite da utilizzare acriticamete per finalità diverse da quelle qui dichiarate*”. (pag.317)**