Motor Variability in occupational health and performance

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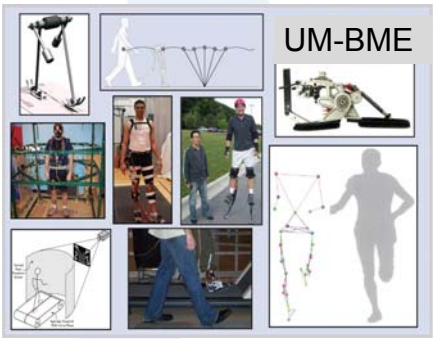
Centre for Musculoskeletal Research:

Forte centre:
The Body at Work –
from problem to potential

Variation i fysisk belastning



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Repetitive work

- Repetitive work: long periods of similar work tasks performed again and again (Kilbom 1994)
  - E.g. Short cycle electronics assembly, meat cutting
- MSD caused by repetitive work is a 'critical' and 'urgent' problem (NIOSH 1997; Arbetsmiljöverket 2003, 2007)

Repetitive work

Arbetsmiljöverket; AFS 2012:2:

7 § Arbetsgivaren ska se till att det normalt inte förekommer arbete som är repetitivt, starkt styrt eller bundet. Om en arbetstagare ändå måste utföra sådant arbete på grund av särskilda omständigheter, ska arbetsgivaren förebygga riskerna för ohälsa eller olycksfall till följd av hälsofarliga eller onödigt tröttande belastningar. Det förebyggande arbetet ska leda till ökad variation i arbetet till exempel genom arbetsväxling, arbetsutvidgning eller pauser.

Variation in repetitive work

Extrinsic methods:

(i) Job rotation:

- No firm empirical support
- May not be realistically possible in many job situations
  - Different task alternatives available in job may not promote "enough" variation (cf. Mathiassen 2006)

(ii) Breaks in between work:

- No firm empirical support in real life
- May not be possible to the extent necessary in many job situations

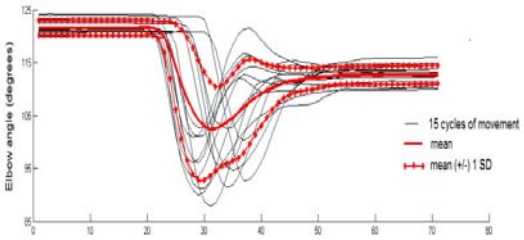
...Variation in repetitive work

Intrinsic method: Motor variability

- Natural variability inherent in all movements
- Observed at different levels in the motor system:
  - Kinetic or kinematic movement patterns (forces, torques, joint angles, velocities…)
  - Muscle activity and recruitment patterns (motor units within a muscle region, muscle fibres within and outside the same synergy…)
- Present even in highly controlled repetitive tasks (Hammarskjöld 1990, Christensen 2000, Möller 2004)

Motor variability - introduction

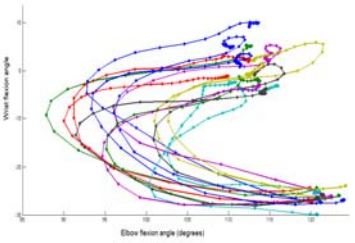
- Present even in the simplest of movements
- Cycles of repetitive work overlaid on top of each other



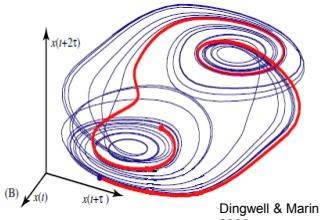
- More variability does not imply worse performance:
  - E.g. In multi-jointed movements, variability in shoulder, elbow and wrist joints occur but end-point precision unaffected

...Motor variability - introduction

- Size of motor variability:
  - Cycle-to-cycle analyses:
    - Single joint movements
    - Coordinated joint movements



- Structure of motor variability:
  - More complex computations
    E.g.: Partitioning variability into task-relevant and task-irrelevant components
    Variability from a chaos theory perspective



Dingwell & Marin 2006

Why is motor variability of interest in an occupational context?

1. Motor variability is related to important short-term outcomes
   - Pain, fatigue and performance
2. Motor variability may differ between individuals
   - Why do some people develop disorders while others don't, despite doing the same work?
3. Motor variability can be manipulated
   - Individualized interventions: training & skill development
   - Work organizational factors – work pace, precision, physical and cognitive demands

Motor variability and pain

Madeleine et al. 2008: Neck-shoulder pain in butchers

- Acute experimental pain increased arm movement variability
- Chronic pain decreased movement variability

Madeleine et al. 2009: Butchers followed through 6 months of employment

- Skill improved with experience
- Kinematic variability also increased with experience
- Motor variability was higher among experienced butchers in a no-pain group than in the pain group.

...Motor variability and pain

Reduced motor variability – cause or effect of pain?

- Pain-protective adaptation: Pain decreases variability
  Heiderscheit (2000): Gait variability in a pain group increased to almost that of a healthy group when pain was temporarily reduced (by patella taping)

- Variability-overuse hypothesis: More variable motor strategies are used as a protective measure against pain
  Moseley and Hodges (2006): Subjects with more motor variability recovered more effectively from experimental low back pain than those with less variability

Motor variability and fatigue

Increased variability => longer endurance times

van Dieen et al. 1993: Healthy subjects performed trunk extensions until endurance (70% MVC for 4s, 2s of rest repeated until exhaustion)

- Surface EMG recorded from several locations over the erector spinae muscle
- People with more spatial variability in the erector spinae EMG had longer endurance times

Shoulder : Falla and Farina 2007, Farina et al. 2008
Repetitive knee extensions: Skurvydas et al. 2010

...Motor variability and fatigue

However, negative effects of fatigue on performance has been extensively documented!

Differences in individual capacity to alter variability in response to fatigue is influenced by "skill" (Bosch et al. 2011, Aune et al. 2008)

...Motor variability and performance

In a study of repetitive lifting (Mirka and Marras, 1993):

- Muscle activity levels of the right and left trunk muscles varied significantly between repeated lifts
- But the changes were coordinated so that the external torque produced by both sides acting together was constant

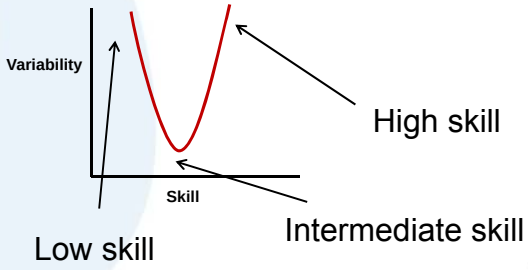
'Compensatory variability' is *required* for maintaining motor performance (Button et al., 2003; Robins et al., 2006; Arutyunyan et al., 1969; Kudo et al., 2000; Muller and Loosch, 1999)

…Motor variability and performance

Motor variability and skill level:

Studies of basketball shooting, high jumping

(e.g. Robins et al. 2006; Wilson et al. 2008; Preatoni et al. 2010)



Manipulating MV – At the individual level

Training – biofeedback techniques (Palmerud et al., 1995, 1998):

- Arm in an isometric, abducted position
- EMG of the trapezius muscle provided as feedback.

- When instructed to reduce EMG amplitude but still keep the isometric posture, subjects could lower trapezius EMG by 22–47%.

The target posture was maintained by redistributing activity to the rhomboids and transverse part of trapezius

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Current research in CBF - motivation

- So there is some evidence from the literature that motor variability has the potential to positively impact pain, fatigue and performance.
- Do individuals differ in motor variability?
- Can motor variability be systematically 'manipulated' in occupational settings?
- If yes, what are the physiological consequences of performing movements with more or less variability?

Systematic manipulation of motor variability using work factors

"Pipetting" used as work model of repetitive work requiring high precision.

Effect of the following work factors on motor variability tested:

1. Work pace
2. Task precision
3. Placement of components in workstation
4. Different cognitive loads

8 tubes, 25 repeats
=> Each pipetting session is 200 cycles long

Measurements

Motor patterns:
- Kinematics of head, right arm and hand
- EMG from upper trapezius and forearm flexor and extensor
- Thumb force exerted on the pipette

Performance:
- Precision mistakes – liquids spilled?
- Timing mistakes: How many tubes were missed in the sequence?

Fatigue:
- subjective and objective measurements
- cardiovascular indicators (heart rate, heart rate variability)

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Questions

Relationships between kinematic variability and muscle activity

Reliability of within-subject size of motor variability

Size of between-subject motor variability

Effects of different task conditions on motor variability

Relationships between motor variability and fatigue, performance

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Tack!

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