Ergonomic Interventions for Office Workers with Work-Related Upper Extremity Musculoskeletal Disorders: What is the Evidence?

Hand therapists treat frequently treat patients with work-related upper extremity musculoskeletal disorders; which are often complex in their **origin** including:

- Physical
- Environmental
- Pyschosocial factors

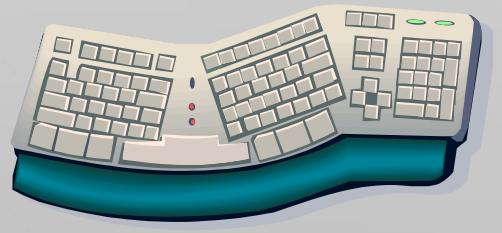
And complex in their **treatment** including:

- Physical Agent Modalities
- Stretching/Mobilization
- Strengthening/Muscle Balance
- Ergonomic
- Relaxation/Yoga
- Behavioural/Pyschosocial intervention

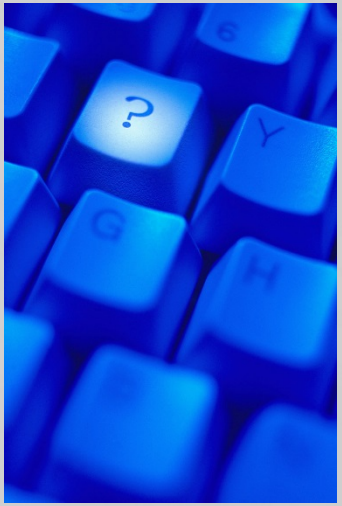
(Beckmann-Fries, 2013)

Ergonomic Interventions for Office Workers with Work-Related Upper Extremity Musculoskeletal Disorders: What is the Evidence?

- The economic cost is enormous and it is rising: «Eine SECO (Staatssekretariat für Wirtschaft) Studie zeigt, dass Beschwerden im Bewegungsapparat in den Betrieben mit 3,3 Milliarden Schweizer Franken zu Buche schlagen» (SUVA, 2012).
- In the US, the number of computer keyboard users with WRUDs is as much as 12 times the number of nonkeyboard users with WRUDs (Jacobs, 2008).
- 73% of Swiss persons work in the service industry. (http://www.bfs.admin.ch/bfs/portal/en/tools/search.html, Available: 25.6.2013).
- Computer usage is now typical for children and adolescents, which is increasing exposure risk particulary for the younger generations.
- Ergonomic equipment has become trendy with many products flooding the market to meet the needs of persons with a variety of symptoms.
- What is the science behind these products?
  How effective are they?

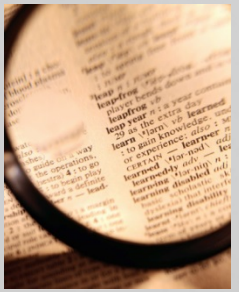


Do ergonomic interventions decrease WRUED symptoms in office workers? If so, which ones are most effective?



- **P**: Office workers with WRUDs
- **I**: Ergonomic Intervention
- **C**: No Ergonomic Intervention
- **O**: Decrease in symptoms of WRUDs
  (measured by pain/discomfort, quality-of-life scales, productivity)

Definition: Work-Related Upper Extremity Musculoskeletal Disorder



- Synonymous with: Repetitive stress injury, cumulative trauma disorder (occupational) overuse syndrome.
- **«Wear and Tear Theory»: wear and tear of the muscles, tendons, and nerve tissue exceeds the ability to heal itself (Goodman et al., 2012).**
- **Wear and tear is caused by repetitive motion, excessive force, and awkward working posture . These factors are closely associated with the development of WRUDs in keyboard operators. Simultaneous presence or two or more risk factors dramatically increases the risk of developing an WRUD (Jacobs, 2008).**
- Studies demonstrate intrinsic and extrinsic factors leading to WRUDs.
- Psychosocial factors include: personal characteristics, role conflict/ambiguity, excessive workload and work stress, and negative social interaction (Jacobs, 2008).

Work-Related Upper Extremity Musculoskeletal Disorder: Why is Ergonomics Relevant?

Typical WRUDs include:

Lateral Epicondylitis
Medial Epicondylitis
Tendintis/Tendionpathy of the wrist and hand
Carpal Tunnel Syndrome
Cubital Tunnel Syndrome
(Jacobs, 2008; Sluiter, 2001)

Guyon's Canal Syndrome
De Quervain's Syndrome
Radial Tunnel Syndrome
Finger-joint Osteoarthritis
Non-specific diffuse forarm/arm pain

(N.B. these diagnoses are not exclusively caused by repetitive work)

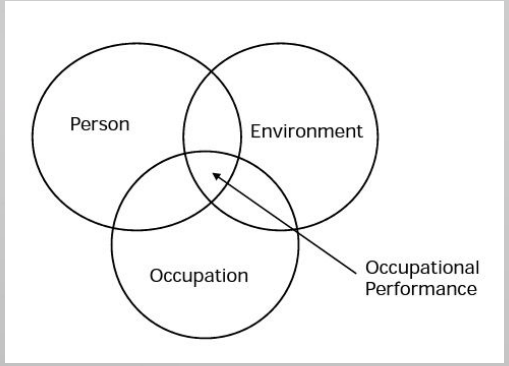
Definition: Ergonomics

«*ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and other methods to design in order to optimize human well-being and overall system performance*» (International Ergonomics Association, 2013).

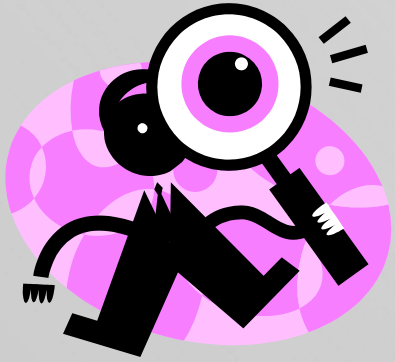
«***Ergonomists contribute to the design and evaluation of tasks, job, products, environments, and systems in order to make them compatible with the needs, abilities, and limitations of people.»*** (IEA, 2013).

Participatory Ergonomics: The implementation of ergonomic solutions involving participation of the worker and other workplace staff (Jacobs, 2008).

The concept meshes well with the Person-Environment-Occupation Framework and client-centred practice (Jacobs, 2008).



Literature Search Strategy



- Databases: Pubmed, OT Seeker, Pedro, and Cinahl
- Key Words: Ergonom* and (cumulative trauma disorder, repetitive stress injury, work-related upper extremity disorder, or upper extremity).
- Languages (included): English, German, and French
- Articles that were not available via the ZHAW library or via public access were excluded.
- All levels of evidence were considered.
- The most recent systematic reviews are emphasized regarding practice recommendations, as the authors of the reviews filtered and analyzed the quality of the previous studies of the same topic.

Challenges Synthesizing the Evidence

- Variable scope of Ergonomic Intervention: ex. stretching/strengthening, job coaching.
- Many different types of studies: ex. Some studies compare different ***types*** of ergonomic intervention to each other; others ergonomic intervention to no intervention.
- The follow-up time-span is variable (3 weeks to 2 years).
- Outcome Measures are variable (ex. absenteeism, self-reported pain/ discomfort, typing errors).
- Designing high-quality randomized control-trials in a multi-factorial work environment.

The Evidence

- There is moderate evidence indicating that office ergonomic interventions reduce symptoms (Leyshon et al., 2010; Goodman et al., 2012).
- There is not enough evidence to link the interventions with improved productivity (Tompa et al., 2010). Though evidence so far indicates an improvement (Robertson, 2008).
- Some authors (Leyshon et al., 2010; Brewer et al., 2006; Boocock et al., 2007) highlight that treatment is too multi-factorial to create a guideline for ergonomic management.
- Ergonomic strategies which address cultural/institutional and biopsychosocial aspects have not yet been validated due to weak evidence (Leyshon et al., 2010).

A Proposed Ergonomic Intervention Model

- Goodman et al. (2012) propose an evidence-based structure for intervention in their study:

Effective interventions for cumulative trauma disorders of the upper extremity in computer users: Practice models based on systematic review

Study included a review of 4600 abstracts. 25 studies met the inclusion criteria.

Best evidence for:

Education and Training in Ergonomics
Forearm Supports
Ergonomic Keyboards
Ergonomic Mice
Exercise/Rest Breaks

Systematic Review – Analyzing the Evidence

- Two models are proposed in the article; one for prevention and one for treatment.
- Goodman et al. (2012) state that they were less stingent than the similar systematic review from Brewer et al. Qualitative studies were included. Studies regarding primary, secondary, and tertiary prevention were included.
- **Education/Ergonomics Training**:

5 studies with ***high*** levels of evidence indicated that this is an effective strategy in reducing WRUD symptoms in office workers.

- **Bohr (2000**): 2 hour Workshop – Ergonomic principles at workstation.
- **Marcoux (2000):** 7 x 45 minute Workshop – posture, body mechanics, information booklets, email postural hints, keyboard template with stretching and stress-relieving activities.

Systematic Review – Analyzing the Evidence

- **Greene (2005)**: focussed on determinig that one can successfully change office workers habits to include ergonomic principles to prevent and treat WRUDs.
- Sense of self-efficacy, belief in benefits of ergonomic intervention, work organization, and exercise practices improved. Workshops were focussed on problem-based learning and applying ergonomic principles.
- **Roberston (2008)**: demonstrated that by rearranging the desktop in a semi-circular shape, with an adjustable chair & storage area combined with ergonomic training; that there was a significant decrease in symptoms in the shoulder, arm, and hand as well as an increase in pyschosocial well-being.
- He compared one group who had simply a workstation adjustment to another group that had training and workstation adjustment. Both groups demonstrated increased productivity (7,500$ vs. 15,000$).

Systematic Review – Analyzing the Evidence

- **Forearm Supports - 3 high quality studies:**

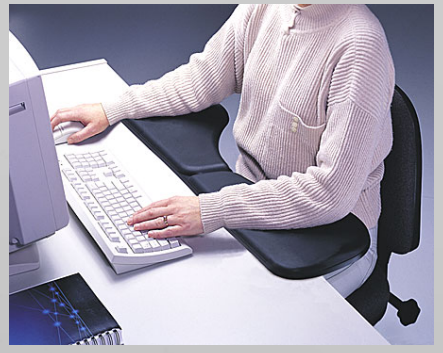
Rempel (2006): Forearm support can decrease pain in neck and shoulder by 50%.

Conlon (2008): Forearm support board decreases right upper extremity discomfort.

Aaras & Walsoe (2001): Workstation adjustment to allow the forearm and hand to rest on the tabletop demonstrated a significant reduction of pain in the neck and forearm.

http://www.ergodirect.com/product_info.php?products_id=14079

Wrap-around padded Arm Support (Rempel, 2006)



http://www.masterlockmalaysia.com/index.php/Ergonomics/Ergonomics.html

Systematic Review – Analyzing the Evidence

- **Ergonomic Keyboards – 4 high-quality studies:**
- **Ripat (2006):** Microsoft Natural Light-Touch and Microsoft Natural Multimedia keyboards reduced symptoms in persons with WRUDs after 12 weeks, and remained so after 24 months. 93% of participants wanted to keep the keyboards afterwards.
- **Swanson & Sauter (2006):** Less symptoms in group with ergonomic keyboard.
- **Tittiranonda et al. (1999):** No improvement of clincial tests for carpal tunnel and tendonitis, but decreased reported pain severity and improved client satisfaction. Microsoft Natural Keyboard was used.
- **Stevenson et al. (2005):** Applied a continuous passive motion device under the keyboard. The idea is that the movement increases blood flow. Symptomatic users showed an increase in typing speed, decrease in symptoms, and increase in upper extremity function.

Recommended Keyboards

Microsoft Natural Multimedia

(Ripat, 2006; Tittiranonda, 1999)

http://www.microsoft.com/hardware/en-us/p/natural-ergonomic-keyboard-4000/B2M-00012

EasyMotion CPM

Moves from 5° extension to 15° flexion; cycle time: 90 seconds (Stevenson, 2005)

http://www.tifaq.org/images/activeinput-cpm.jpg

Apple Split Design

Adjusted at 28° or user comfort (Tittiranonda, 1999)

Systematic Review – Analyzing the Evidence

- **Ergonomic Mouse – 3 High Quality Studies**
- **Conlon (2008):** Renaissance mouse (3M) had a protective effect, but not a significant effect in decreasing upper extremity symptoms already present**.**
- **Rempel (2006):** No significant decrease in symptoms with trackball use after one year.
- **Aaras et al. (2002):** At 36 month follow-up, the Anir mouse demonstrated decreased symptoms in the shoulder, forearm, wrist and hand**.**

Renaissance Mouse

//ergonomicinfo.com/reviews/3m-ergonomic-vertical-mouse-review

Track Ball

http://www.geekstuff4u.com/5-buttons-wireless-trackball-mouse.html#.UdGeSDE6nwo

Anir Mouse

http://solutions.3m.com/wps/portal/3M/en_US/ergonomics/home/products/ergonomicmouse/

Systematic Review – Analyzing the Evidence

- **Exercise/Rest Breaks – 3 good quality studies**
- **Omer et al. (2003/2004):** mobilization, stretching, strengthening, and relaxation exercises for one hour 3 times a week decreased pain and depression in computer users with WRUDs after two months.
- **Desai & Shah (2004):** Workstation adjustment, with an exercise program (depending on diagnosis), and rest breaks were effective in reducing pain, awkward and static postures, and repetitive motion.
- Desai describes 3 effective break strategies:

1) 2-minute micro-break (different task but still working)
2) Rest break every 30-60 minutes requiring getting up and moving.
3) Exercise break every 1-2 hours to stretch the neck, shoulder, elbow, wrist, and hand.

- **Bernaards et al. (2008):** exercise and break reminders via a software program were effective methods of integrating ergonomic strategies.

A Proposed Ergonomic Intervention Model

- The model consists of 3 levels of intervention and begins with most cost-effective strategies. The levels could be considered an evidence-based «start» for treating WRUDs in general.

- **Goals: relieve pain and decrease symptoms.**

- Does not address stress and pyschosocial issues since the evidence is still weak in these areas. These issues should be addressed during patient assessment and the patient be referred to a specialist as needed.
- Does not address specific symptom management for particular diagnoses. This would occur during the rehabilitation process based on patient assessment.
- The authors recommend further research to develop more detailed best-practice guidelines.
- They also recommend 1) ergonomic instruction in all new computer packaging, 2) further investigation of laptop ergonomics.

A Proposed Ergonomic Intervention Model

Level 1

Education: on safe working posture; risk factors (force, repetition, static loading); info regarding exercise, rest breaks, and healthy working habits.
Workstation Adjustment: assessing and modifying tools, parts, materials, and machines; analyzing the physical enviroment & job tasks.

Level 2

Exercise Program: stretch, strengthening, range-of-motion; and posture exercises.
Integrating Rest Breaks: getting up from the workstation; integrating relaxation techniques at the desk; mini-break every hour.

Level 3

Specific Ergonomic Equipment: Trial and integration of new tools; typically a forearm rest, mouse, and/or keyboard.

Additional Studies & Future Directions:

Workplace management of upper limb disorders: a systematic review **(Dick et al., 2011)**

- **Purpose**: evaluate evidence for treatment guidelines for WRUDs carpal tunnel, non-specific arm pain, tenosynovitis, and epincondylitis.
- **Results**: 4 articles met the stringent review criteria. Difficult to draw any conclusions based on so few studies.
- Limited but high quality evidence that workers absent for more than 4 weeks with nonspecified arm pain may benefit from multidisciplinary rehabilitation: including both physical (including ergonomics strategies) and psychosocial approach.
- SIGN method favours stringent RCTs; a lot of studies are then excluded. Should different criteria be established for evaluating studies in the domain of occupational health?
- Recommendations for future studies include: a better definition of population, factors, and interventions; determining a core set of outcome measures as well as an analysis of the cost-effectiveness of ergonomic intervention. This would decrease the heterogeneity of the studies which affects the quality of the evidence (Dick et al., 2011; Leyshon, 2010).

***The effectiveness of a training method using self-modeling webcam photos for reducing musculoskeletal risk among office workers using computers* (Maimon et al., 2011)**

- **Purpose:** Determine if a photo-training program combined with workstation adjustment and ergonomic education (breaks, stretching, posture) would be more effective than traditional workstation adjustment and education.
- The computer took a picture of the worker every 20-25 minutes and displayed it on the screen next to a photo of his/her ideal position to reinforce proper posture.
- **Results**: Both intervention programs were effective; particularly for older workers and workers with WRUDs.
- The photo-training program demonstrated a sustained improvement in symptoms in comparison to the traditional program.

***Physical Rehabilitation with Ergonomic Intervention of Currently Working Keyboard Operators With Non-Specific/Type II Work-Related Upper Limb Disorder: A Prospective Study* (Povlsen, 2012)**

- **Purpose:** To determine if keyboard operators with non-specific arm pain demonstrate decreased pain and improved typing performance after a combination of self-administered physical training and ergonomic workstation intervention.
- Patients with a specific diagnosis were excluded!
- **Results:** The patients had less pain, and had improved typing speed and endurance (no difference with control group after treatment).
- A RCT is recommended to further develop this hypothesis (small sample size: n=16)

***Effectiveness of an ergonomic intervention on the productivity of workers with upper-extremity disorders – a randomized control trial* (Martimo et al., 2010)**

- **Purpose:** Investigate the effectiveness of an ergonomic intervention on productivity loss at work caused by upper-extremity disorders.
- **Results**: Early ergonomic intervention is effective in preventing and restoring *self-reported* productivity loss for person with WRUDs.
- Included persons in all domains of work (not just office).
- The intervention was only statistically effective for persons experiencing 1%-20% loss of productivity before the intervention.
- Impact of ergonomic intervention was statistically different only after 12 weeks.

***Ergonomic Training Reduces Musculoskeletal Disorders among Office Workers: Results from the 6-Month Follow-Up* (Mahmud et al., 2011)**

- **Purpose**: Mahmud et al. (2010) conducted a randomized control trial to determine the effectiveness of ergonomic intervention in office workers (included persons with WRUDs of the neck and back).
- **Results**: An effective decrease in symptoms for the neck, right shoulder, right and left upper limbs, lower back, and left and right lower limbs at 6 months follow-up.
- Intervention was workstation adjustment and ergonomic training.
- Benefits **did not** translate in better reported psychosocial well-being; nor less absenteeism.

Ergonomic positioning or equipment for treating carpal tunnel syndrome (O'Connor et al., 2011)

- **Purpose:** To assess the effects of ergonomic positioning or equipment compared with no treatment, a placebo or another non-surgical intervention in people with CTS.
- **Results**: Due to rigorous inclusion criteria only two trials were included in the review. Both assessed the effectiveness of alternative keyboards.
- There is insufficient evidence to determine whether ergonomic positioning or equipment is beneficial or harmful for treating carpal tunnel syndrome.
- In my opinion, an example of authors excluding potentially useful information due to rigorous research methods standards.

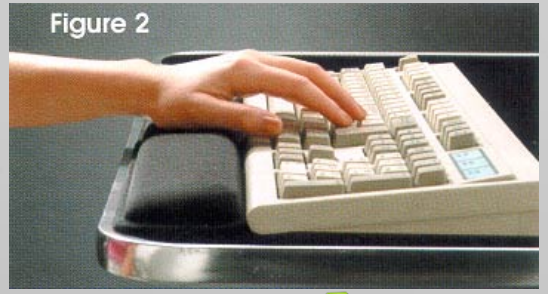
Recommendations based on Biomechanical Principles

- Many products exist that do not meet the rigorous standards of a evidence-based systematic reviews.
- Sound biomechanical principles can guide the ***selection and application*** of many ergonomic interventions that were not the subject of a study (Jacobs, 2008).

Example – Wrist Typing Pad:

Effective if it is supporting the ball of your hand. Can make carpal tunnel symptoms worse if you rest your wrist on the pad as it increases pressure!

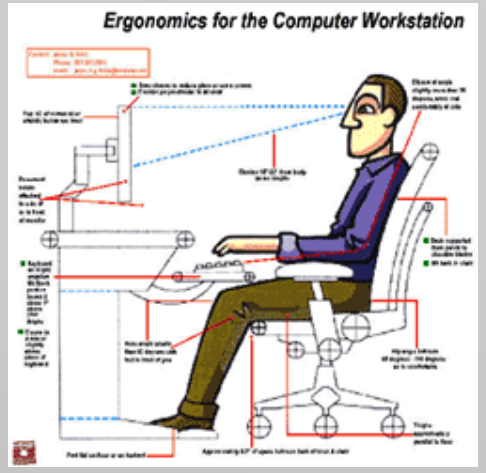
Pad maintains the wrist in a neutral position



http://ergocanada.com/ergo/rests/ergonomic_usage_of_wrist_rests.html

Workstation Position: General

- Guidelines from various sources are very similar with only slight variations.
- The Eidegenössische Koordinationskommission für Arbeitssicherheit has an interactive website and brochures: http://www.ekas.admin.ch/index-de.php?frameset=113.
- It is important to address posture and position of the entire body (Jacobs, 2008).
- The ideal position is not the complete solution; we are made to move and any static posture for over 4 hours has a detrimental effect on muscle, tendon, and nerve tissue (Jacobs, 2008).



Workstation Position: General

- Neutral Posture is universally recommended (Jacobs, 2008):
  - Head, neck, and trunk aligned at midline
  - Head upright (not too far foward)
  - Shoulders retracted and relaxed
  - Upper arms relaxed at the side of body
  - Elbows flexed to approximately 90°
  - Forearms not completely pronated, preferably close to midline
  - Wrists aligned with forearms with minimal ulnar or radial deviation and minimal flexion or extension

Common Errors

- **Elbow Height**: Arm discomfort increases as keyboard height is increased above elbow level (Jacobs, 2008). Setting the keyboard at elbow level, or a bit lower is dependent on user comfort.
- **Wrist Angle at Keyboard**: The two pop-up buttons to increase the angle of the keyboard usually increase extension in the wrist; which increases pressure in the carpal tunnel (Jacobs, 2008). A neutral, or very slightly flexed or extended wrist is acceptable.
- **Document Placement**: Placement flat on the tabletop, away from the midline puts alot of stress on the neck extensors and sternocleidomastoid (Jacobs, 2008). Placement in the midline and slightly elevated is ideal (between the keyboard and screen).

Practical Application of Effective Ergonomic Strategies

- **Environmental/Physical Modifications - Keyboard**
- An adjustable split keyboard decreases ulnar deviation.
- A lateral tilt from 10-30° combined with a small opening angle decreases muscle activitiy in the shoulder girdle and arm region (Jacobs, 2008).
- The position of lowest pressure on the carpal tunnel is with the wrist slightly extended and slightly ulnarly deviated (Jacobs, 2008).

Practical Application of Effective Ergonomic Strategies

- **Environmental/Physical Modifications – Mouse**
- Not all devices are equal in terms of speed and accuracy; also dependant on the software used.
- Dennerlein and Johnson (cited by Jacobs, 2008) demonstated that frequent mouse use is associated with more constrained and non-neutral postures of the wrist and shoulder compared with keyboarding.
- Ullman (cited by Jacobs, 2008) demonstrated less muscle activity with a pen model.
- Dragging and dropping is most detrimental (sustained load on finger flexors). Software or mouse options which "lock-in" the click reduce the frequency of sustained loading (Jacobs, 2008).

http://www.penclic.se/nyheter--produkter/

Practical Application of Effective Ergonomic Strategies

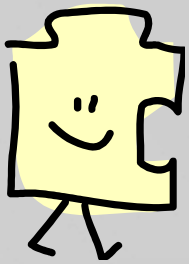
- **Environmental/Physical Modifications – Mouse**
- The Anir mouse is frequently cited in studies. Aaras (cited by Jacobs, 2008) demonstrated that persons exhibited lower muscle activation of th EDC, ECU, and trapezius even when compared to a normal mouse accompanied **with** a forearm support!
- With the Anir, the forearm is in netural (instead of pronated) and the mouse buttons are activiated by slight movements of the thumb.
- An award-winning design, not proven yet in an RCT is the roller mouse (Jacobs, 2008). The mouse is integrated in front of the keyboard; in the optimal ergonomic position.

Practical Application of Effective Ergonomic Strategies

- **Environmental/Physical Modifications – Chair**
- The shoulder and trunk muscles will tense up if the seat is improperly adjusted (Jacobs, 2008).
- Features described in «Praktische Tipps zur Einrichtung Ihres Büroarbeitsplatzes»
- A dynamic chair that allows opposite movement of the seat and back support (to accommodate a reclining posture) is ideal (Jacobs, 2008).
- A dynamic chair also allows for easily varied sitting postures which permits movement of the spine.
- Lumbar support between L2-L5 is recommended (Jacobs, 2008).

Ergonomics in a broader Context

- Strategies for prevention are very similar to those for treatment. Prevention strategies are proven as most effective (Goodman et al., 2012; Brewer et al., 2006; Leyshon et al., 2010).
- Many checklist and assessments exist ***for all industries*** (eg. watch-making).
- At this time there any more studies linking the causality of symptoms to the task (repetition, awkward posture, etc.) than evaluating the effectiveness of treatment interventions (Jacobs, 2008).
- Treatment strategies so far are biomechanically-based; using the same principles that explain the development of symptoms.
- There is very minimal risk of applying the principles despite only moderate level of evidence for the effectiveness of ergonomic strategies.
- **All studies reviewed indicate either a positive impact or no impact on symptom reduction** (Dick et al., 2011; Leyshon et al., 2010; Brewer et al., 2006; Boocock et al., 2007; Goodman et al., 2012; Tompa et al., 2008).



Take Home Message

- Ergonomic intervention is only a piece of the puzzle for treating WRUDs.
- It is an essential part since ergonomic intervention eliminates or minimizes the repeititve motion, awkward postures, and excessive force required to work.
- This allows the body to heal; breaking the cycle of «wear and tear»; decreasing the risk of symptoms becoming chronic (Jacobs, 2008).
- When the patient understands ergonomic principles, he/she can actively participate in finding solutions and try out various models of equipment/ strategies. This increases acceptance and a successful intervention (Jacobs, 2008).

Helpful Resources: Assessment, Intervention Guidelines, and Continuing Education

- International Ergonomics Association: www.iea.cc
- Schweizerische Arbeitsgemeinschaft für Rehabilitation: http://sar-reha.ch/
- **Ergonomics Guidelines for all major industries** (eg. «Pisten Bully» and watch production). SUVA in collaboration with the Eidegenössische Koordinationskommission für Arbeitssicherheit: http://www.ekas.admin.ch/index-de.php?frameset=113.
- United States Department of Labor (eg. meat/processed food manufacturing). http://www.osha.gov/SLTC/ergonomics/guidelines.html.
- **Stress Questionnaire and Intervention Strategies**. SUVA in collaboration with Staatssekretariat für Wirtschaft SECO : www.stressnostress.ch

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