"Toto, I have a feeling we're not in Kansas anymore."
Dorothy, Wizard of Oz

Over 1,000 postures we can sustain

Our postures often reflect national, cultural and gender differences.

Culture and being

© Ugo Pozzi/Photography with permission

Males and females sitting postures differ

© Ugo Pozzi/Photography with permission

Gender and cultural differences


There are more things in heaven and Earth, Horatio, than are dreamt of in your philosophy.

Women sit differently

Courtesy of Cindy Burt, OTR, CPE

... than (some) men

Today's office workers (mostly) don't lean back

Courtesy of Cindy Burt, OTR, CPE

Humanics ErgoSystems, Inc.
Rethinking Sitting and Seating

Tasks dictate postures

Comfort ≠ what’s best
With unsupported postures → people try to minimize amount of muscle effort.

Comfortable ≠ best
Healthy ligament
Damaged ligament (below)


Ligaments and loading
Ligaments are far from simply restraining structures that support & stabilize joints.
They are sensory organs that provide proprioceptive input to the CNS and associated muscles and are therefore major elements for stabilization of joints.
Chatow (2009)


Loading and ligaments
Prolonged loading increases injury risk ...
→ destabilizes the spine
→ laxity of viscoelastic tissues.
Dolan & Green (2006); Le et al, (2009)

Slouching for 10 minutes
→ transfers loads to ligaments & discs.
Solomonow et al. (2003)

Lumbar support

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**Movement alone is not enough**

Poor spinal stability or a deficit in proper alignment of various structures while moving...

→ excessive and impaired movement, injury and substantial loss of work days.

Le et al (2009)

**Seat pressure and comfort**

Most consistent predictor of seat comfort

→ Seat pressure distribution much stronger

→ ...Than EMGs & spinal profiles.


**Seat pressure and comfort**

Strong correlation between discomfort amount of pressure applied to buttock


**Seat pressure and comfort**

“Tissue stress probably plays a major role in determining if a given tissue is painful...”

...it is tissue stress rather than overall loading which influences the metabolism of connective tissue cells”.

Dolan & Adams (2001)

**Sitting comfort concepts**


**“Rotatory” movements**

Rethinking Sitting and Seating

The Nottingham Chair

Using the use of the existing chair, you can sit or stand, to the touch with ease. The use shows the development of the sitting chair as an essential part of the work in today.

www.humanics-es.com/sit-stand-seating.htm

Centers of gravity


JFK’s rocking chair

Seat pivot


Shifting centers of gravity

SwingChair.com

Postural support

www.humanics-es.com/sit-stand-seating.htm
Rethinking Sitting and Seating

- Variable Balans

- Head support

- Neck support?

- Head support?

- Training isn’t always the answer
  - Critical information is missing
  - Content is wrong
  - “Blame the victim” (for bad design)

- Poor equipment design...
  - ... or inadequate training?

www.varierfurniture.com

www.humanics-es.com/clumsy.htm
## Training effects
- Practice effect
- Order effect
- Direction of adjustment effect

## Training: Practice effect
- Practice as a group, using their own chair (stay away from work surface)
- Demonstrate all chairs they need to adjust
- Find a way to fully adjust in one minute

## Training: Order effect
- Seat height (away from desk)
- Seat pan depth
- Backrest height & angle
- Backrest tension - unlocked
- Armrest width & height

## Training: Direction of adjustment effect
- Seat height: Down, then up, then down
- Back height: Down, then up, then down
- Seat tension: Low, then high, then down

## Adaptive design

## Download handout presentations
www.humanics-es.com/rethinkingseating.htm
Thank you!

www.humanics-es.com/rethinkingseating.htm

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Rethinking sitting, seating and symptoms: new findings

Jenny Pynt PhD (USyd)
The Education for Practice Institute CSU

Introduction
- I am an Australian physiotherapist
- I have spent the last 12 years addressing statements by important people in the seat design world
- “Ergonomic criteria need to be applied selectively, because many of them are contradictory” (Cranz, 1998, p.93, Professor of Architecture at Berkeley)
- “My early approach to the chair was something between contempt and despair” (Frank Lloyd Wright, 1971, p. 170)

My aim
- Overall is to dissuade people from following the cult of the designer
- By distilling the scientific literature into logical and readable format
- To refute the claims of designers that the scientific literature is too confused and confusing to be noteworthy

Format of this presentation
- Brief history of the flexion/extension debate
- And according to current best knowledge the winner is …
- Brief history of how aesthetic seating has consistently overridden functional seating design from 3000 BC to present day
- Taking ergonomic seating design beyond the office

Brief history of the flexion/extension debate

1700s to c. 1948

- Lordosed seated postures were considered healthier than kyphosed
- Prevented scoliosis
17/1800s emphasis on child posture
• Subscribed to the popular theory that kyphosed postures caused “poor breathing, pulmonary tuberculosis, venous congestion, constipation, haemorrhoids, etc.” (cited in Åkerblom, 1948, p. 32)
• Staffel (1884) preempted Mandal by advising forward tilt seating for school children
• But settled for this innovative school seating

1800s emphasis on traction and extension exercises
• “the orthopedist of the 19th century was not primarily a surgeon, and his reputation grew in proportion to his ability to effectively utilize mechanical principles” (White & Panjabi, 1990, p.477)
• E.g. traction to maintain lordosis and prevent scoliosis

Institutions to treat or prevent scoliosis
• Based on maintenance of lordosis through exercise and traction 24/7
• Delpech 1825, “made [a] deliberate attempt to apply gymnastics to the deformities of the body” (Coulter, 1932, p.33)

Early 1900s beginning of the confusions re best seated posture
• Overall medical opinion continued to favour some degree of lordosis
• Because some lordosis formed “a shelf to support the floating viscera” (Kellogg, 1932, p.289)
• Although hyperlordosis led to a lack of support for the abdominal contents leading to constipation, indigestion.
• Kyphosed postures compressed the abdominal and pelvic contents

Theories for causes of low back pain abounded
• Lovett (1914) tried to shift emphasis from pelvis and abdominal contents to stress on ligaments and muscles
• Relaxation of the sacroiliac joints leading to sciatica (Meisenbach, 1911)
• Arthritis, posture, balance, leg length & pelvic disorders (Dickson, 1931)
• Dynasty of the disc (Mixter & Barr, 1934)
• Poor sitting posture (Åkerblom, 1948; Williams, 1948; Keegan, 1953)

1940-1960 seating research focused on the effect of “cubist” or right angled sitting

90 degree hip trunk angle consists of 60 degrees hip flexion and 30 degrees posterior pelvic rotation flattening the lumbar spine
(De Carvalho et al., 2010; Keegan, 1953; Lord et al., 1987; Van Ingen et al., 1987)
• Keegan’s 1953 radiographic study demonstrating the effect of sitting postures on the lumbar spine.

• Having established that cubist seating did not maintain the natural curve of the low back, the scientific world now divided into 2 camps. Those who thought kyphosed postures maintained spinal health and those who thought lordosed postures were the least damaging.

Williams’ recommended posture

“You should always sit in such a fashion that the hollow in the low back is eliminated.”

(Williams, 1974, p. 27)

By 1970s two schools of thought


• Lordosed seated postures (Andersson et al., 1974; Hedman & Fernie, 1997; Lotz et al. 1998; McKenzie, 1981, 2006; McGill & Brown, 1992; Solomonow et al., 2003a,b,c,d; Solomonow 2004; 2009)

Williams became popular worldwide

• Seated postures recommended by Farnhi, 1966, p. 30 (top)

• And Cailliet, 1981, p.191

• The designers of supposedly comfortable lounge chairs have created monstrosities of over stuffed half beds which provide neither a comfortable sitting, nor a comfortable reclining position, permit no change of position, and are impossible to rise from without assistance

• (Keegan, 1953, p.589)
Demise of the Dynasty of the Disc

- Nachemson’s disc studies may have been flawed by transducer technology available in the day.
- Today implanted transducer into nucleus pulposus (Wilke et al., 1999, 2001), and studies of spinal shrinkage and internal fixator loads (Althoff et al., 1992; Lievseth & Drerup, 1997; Rohmann et al., 2001) infer that similar or marginally greater intradiscal pressure (IDP) is likely in standing than sitting (Claus et al., 2008).

Demise of the Dynasty of the Disc

- “It can be cautiously concluded that the intradiscal pressure during sitting may in fact be less than that in erect standing” (Wilke et al., 1999)
- Wilke et al. (1999) still found that sitting with maximum flexion caused a higher IDP: 0.83 MPa, than sitting erect but unsupported; 0.46 MPa

Slouched postures still increase IDP

- XR images by Dunk et al. (2009) showed:
  - “Each of the lower three intervertebral joints [of the lumbar spine] approached their total flexion angles in the slouched sitting posture” (p. 164)
  - Then increased tension from the spinal ligaments could cause increased IDP in slouched sitting (Claus et al., 2008). This includes tension from the iliolumbar ligaments (Snijders et al., 2004)
  - Which would explain why sitting flexed causes higher IDP than sitting erect

Demise of the Dynasty of the Disc

- “Current studies indicate that IDP [intradiscal pressure] in sitting is unlikely to pose a threat to non-degenerate discs, and sitting is no worse than standing for disc degeneration or low back pain incidence. If sitting is a greater threat for development of low back pain than standing, the mechanism is unlikely to be raised IDP.” (Claus et al., 2008, p. 550)

So what is likely to be the cause?

- Creep (represents microtrauma) in ligaments, muscles, discs, capsules (viscoelastic tissues)
- Creep triggers inflammatory response
- Inflammation becomes chronic with insufficient rest
- Cumulative trauma disorder
- 20 minute sustained slouch
- Pynt, 2010
5 stages of neuromuscular disorder resulting from sustained flexion

- Decrease in reflex mm activity
- 1st hour: brief mm excitability to protect ligaments
- 2-6 hours: increasing mm excitability following 1-2 hours rest
- Decrease in reflex mm activity
- 24 hours: slow recovery of reflex after providing no further provocation
- Spasm of spinal muscles

Sustained slouched sitting results in chronic low back disorder (CLBD)

- 20 minutes sustained flexion followed by 10 minutes rest is insufficient rest to prevent chronic low back pain.
- "a short rest period of 2:1 load-to-rest ratio leads to CLBD, longer rest at 1:1 and 1:2 load-to-rest ratio are more favorable for preventing or attenuating the development of CLBD. Short rest periods between sessions of static lumbar flexion, therefore, are a risk factor for the development of CLBD" (Courville et al. 2005, p.37).

More recent research shows:

that after 10 minutes of sustained flexion with a load comparable to that which is exerted on the spine in slouched sitting, followed by a 10 minute rest and repeated 6 times, (2 hours all up) laxity occurs in the visco elastic tissues, and multifidus activity is decreased for 3-4 hours after.

(Le et al, 2009; Yusuf et al, 2008, Ben Masaud et al., 2010)

Slouched sitting

- Ligaments, muscle reflex, joint stability compromised
- Risk of CTD
- Increases incontinence
- Increased head & neck flexion c/f erect sitting
- Increased activation of neck extensors c/f erect sitting
- Beneficial posture for symptoms from canal stenosis and/or spondylolisthesis

Erect sitting

- Inconsistent appearance of compressive peaks of stress in posterior disc where degeneration is prone
- Facet joint loading
- Increased lumbar spine muscle activity in the absence of a backrest
- Beneficial posture for those with symptoms from disc and facet joints

(Adams et al., 1994; Adams et al., 2000; Caneiro et al., 2009; McKenzie, 2006; O'Sullivan, 2006a, 2010)

Is slouched sitting more damaging to the health of the lumbar spine than sitting with some degree of the lumbar lordosis maintained?

YES

So the next research question is how much lordosis is healthy?

- Varies with each individual.
- Depends on the underlying natural posture, any muscle imbalances causing pain (Claus et al., 2009a,b; Dankaerts et al., 2006; McGill & Karpowicz, 2009; O’Sullivan et al., 2006a, 2010) and disc and joint degeneration (McKenzie, 2006).
- Overall it is that posture that is pain free during and following sitting (including the next morning).
• Is lumbar support necessary? If it reduces pain during sitting and/or following sitting, YES. (Andersson et al., 1979; Snijders et al., 2004; Carcone & Keir, 2007)
• How much lumbar support? That which reduces pain during and/or following sitting. Carcone & Keir (2007) found 3 cm depth most comfortable.
• Static or dynamic lumbar support? Increase muscle blood flow and oxygenation with dynamic (Durkin et al., 2006), anterior pelvic tilt during inflation (Aota et al., 2007) but there was no difference in erector spinae activity or subjective comfort (Beach et al., 2005; Aota et al., 2007).

How is lumbar lordosis maintained in sitting?
• By opening the trunk/thigh angle, taking the tension off the hamstrings, and allowing the pelvis to rotate anteriorly (Bennett et al., 1990; Bettany-Saltikov et al., 2008; Link et al., 1990; Shenoy & Aruin, 2007).
• By placing a lumbar support in the backrest. (Carcone & Keir, 2007) especially in the reclined position (Andersson et al., 1979).
• Or by altering the pelvic position (Noro, 2007).

Opening the trunk/thigh angle maintains lumbar lordosis

Maintaining lordosis without a backrest
• “The highest activity levels at multifidus and obliquus internus abdominis muscles occurred in the short lordosis posture [lumbar spine only].
• The lowest activity levels were observed at most muscles in the flat posture” (Claus et al., 2009a p. E213).

• Sustaining short lordosis without a backrest may well be beyond the endurance capacity of the majority of people (Claus et al., 2009a).
• To do so requires 16.8% of maximum voluntary contraction (MVC) of the deep and superficial multifidi (Claus et al., 2009a).
• Given that the multifidus can work at 5% of MVC for 30 minutes maximum without depleting oxygen to the muscle (van Dieen et al., 2009) the sustained muscle work required to maintain lordosis without a backrest is not feasible.

However maintaining a flat L/S may be sustainable (Claus et al., 2009a)
And Yet

- Increased erector spinae activity sitting on a posture ball c/f sitting in an office chair (Kingma & Dieen, 2009: Gregory et al., 2006)
- Significant fatigue-related EMG changes were found as low as 2% of maximum voluntary contraction (MVC) sustained for 30 minutes
- “The results suggest that motor tasks requiring low-level activity of trunk extensor muscles could lead to fatigue development, resulting in impaired function and discomfort or pain” (van Dieen et al., 2009, p.405)

• So even working with a flat lumbar spine where the spinal extensors are less active than when actively maintaining lordosis (Claus et al., 2009a), fatigue will ensue and the sitter will…. slouch

Studies of sitting on a posture ball without backrest show:

- Decreased pelvic tilt i.e. slouching, with increased discomfort c/f office chair (Gregory et al., 2006)
- Increased creep (indicating slouch) c/f office chair (Kingma & van Dieen, 2009)
- No improvement in posture or spinal activity when c/f sitting on a stable surface (McGill et al., 2006; O’Sullivan et al., 2006b)

Are seats without backrests beneficial to spinal health?

Constant activation of spinal extensor muscles as is required when sitting without backrest is detrimental to spinal postural health.

Is a backrest necessary to maintain lumbar lordosis in sustained sitting?

YES

Importance of movement during seated postures

- Movement can be divided into that which the seated person performs – pause exercises in sitting and standing
- That which the chair assists
Movement by exercising from slouch to erect is important

“constantly changing position is important to promote flow of fluid (nutrition) to the disc” (Wilke, 1999)

(From Pynt, 1998, p.25)

Dynamic chairs

Swing Chair by SmartMotion Technology

Thatsit by Stokke

Dynamic chairs and movement

• Less lumbar spine creep on a dynamic chair (van Dieen et al., 2001)

• “when sitting on the dynamic chair the average spinal length increased in comparison to the spinal length in the static chair, where average spinal length decreased. It was concluded that there is spinal distress relief due to the passive motion of the chair” (van Deursen et al., 2000 p. 95)

The best posture is the next posture

• Providing the working posture maintains some degree of the lordosis

Optimal posturally healthy seating:

• Maintains some degree of the natural curve of the low back
• Assists in task performance
• Allows movement
• Affords stability
• Aesthetically pleasing providing function is not subordinated

Which brings us to today’s leisure seating
The next frontier: taking ergonomic seating beyond the office

• Approximately 87% of Australians over the age of 15 watch television for an average of just over 3 h/day (Australian Bureau of Statistics, 2007).

• “Consideration of leisure hour seating as a cause of back pain is therefore important. The question arises: can the manner in which a person sits in leisure hours affect the health of the spine in office hours?” (Pynt et al., 2008, p.36)

If we consider that sustained slouched sitting causes a “creep hangover” then YES

• Neuromuscular abnormalities occur in multifidus over next 24 hours
• After 20 minutes, back is unstable for up to 7 hours
• Predisposes to injury the following day
• Inflammation, cumulative trauma and degeneration
• Creep continues to develop over next 7 hours & may not be resolved over 24 hours

(St. Masaud et al., 2009; LaBry et al., 2004; Sbricolli et al., 2004; Solomonow, 2004; Solomonow, 2009)

We need to educate people that poor leisure seat design and use can preset tomorrow’s back pain

As can design icons such as the cantilever chair

• “designed so that by the time the main course arrived, at least one guest had pitched face forward into the lobster bisque”

(Thomas Wolfe, From our House to Bauhaus, 1982)

We need to dissuade designers from thinking of seating as art

• Wilson rarely sits on any of his chairs and obviously does not view them as utilitarian objects.
• “I have so many [chairs] in my loft that there’s no place to sit. Instead, I just like to look at them.”

• (an acknowledged steal from a Gertrude Stein comment)

We need to educate designers about research findings

• “I am often told that the furniture is not comfortable, and in that not functional… The furniture is comfortable to me...A straight chair is best for eating or writing”

(Judd, 1993, p.21)
And dissuade the critics from applauding art over function

- “I find this a rather uncomfortable chair as the back rung cuts painfully across the spine, but it is undoubtedly a beautiful chair” (Meadmore, 1974, p. 119)

And what about the poor sods who have to live with it?

- “I have been black and blue in some spot, somewhere, almost all my life from too intimate contacts with my own furniture.” (Frank Lloyd Wright, 1960, p. 49)

As furniture historian Caplan observed:

- “Designers who pride themselves on a disciplined focus upon understanding and forming materials, often neglect such materials as flesh and blood – although the flesh is weak and the flow of blood has been greatly impeded by a number of prize-winning chairs” (1978, p. 15).

The next frontier

Recreational seating that considers spinal postural health by facilitating:

- lumbar lordosis,
- tasks such as dining, TV watching
- movement

AND considers aesthetics

Opsvik’s Gravity balans (above)
Pendulum seating (left), Actulum seating (right)


Andry, N. (1743). Orthopaedica: Or, the art of correcting and preventing deformities in children (Vol. 1). Birmingham, AL: Classics of Medicine Library.


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