CRE-MSD

Centre of Research Expertise
for the Prevention of
Musculoskeletal Disorders

WEBINAR

The Space Between Sitting and Standing: Hybrid Seating - Is the Juice Worth the Squeeze?

Dr. Jack Callaghan | March 8, 2023

UNIVERSITY OF WATERLOO

RESEARCH MEETING PRACTICE TO PREVENT MUSCULOSKELETAL DISORDERS (MSD)

The Centre receives funding through a grant provided by the Ontario Ministry of Labour, Immigration, Training and Skills Development.

DESIGN AND IMPLEMENTATION OF HYBRID SEATING – IS THE JUICE WORTH THE SQUEEZE

Alternative Title: I thought of this while ~~riding my~~ sitting on my ~~bicycle~~ motorbike

**Disclaimer*

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Canada Research Chair in Spine Biomechanics & Injury Prevention

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UNIVERSITY OF WATERLOO | FACULTY OF HEALTH

CRE-MSD
Centre of Research Expertise for the Prevention of Musculoskeletal Disorders

Killer Chairs: How Desk Jobs Ruin

Sitting all day is hurting more than just your behind, study

Prolonged sitting time associated with obesity in men

Barlow CE, et al. *Prev Chronic Dis.* 2016;doi:10.5888/pcd13.160263.

January 16, 2017

e Is

Posted: 09/29/2014 10:32 am EDT | Updated: 11/26/2014 5:59 am EST

Sitting for too long can kill you, even if you exercise: study

LIFE HEALTH & FITNESS

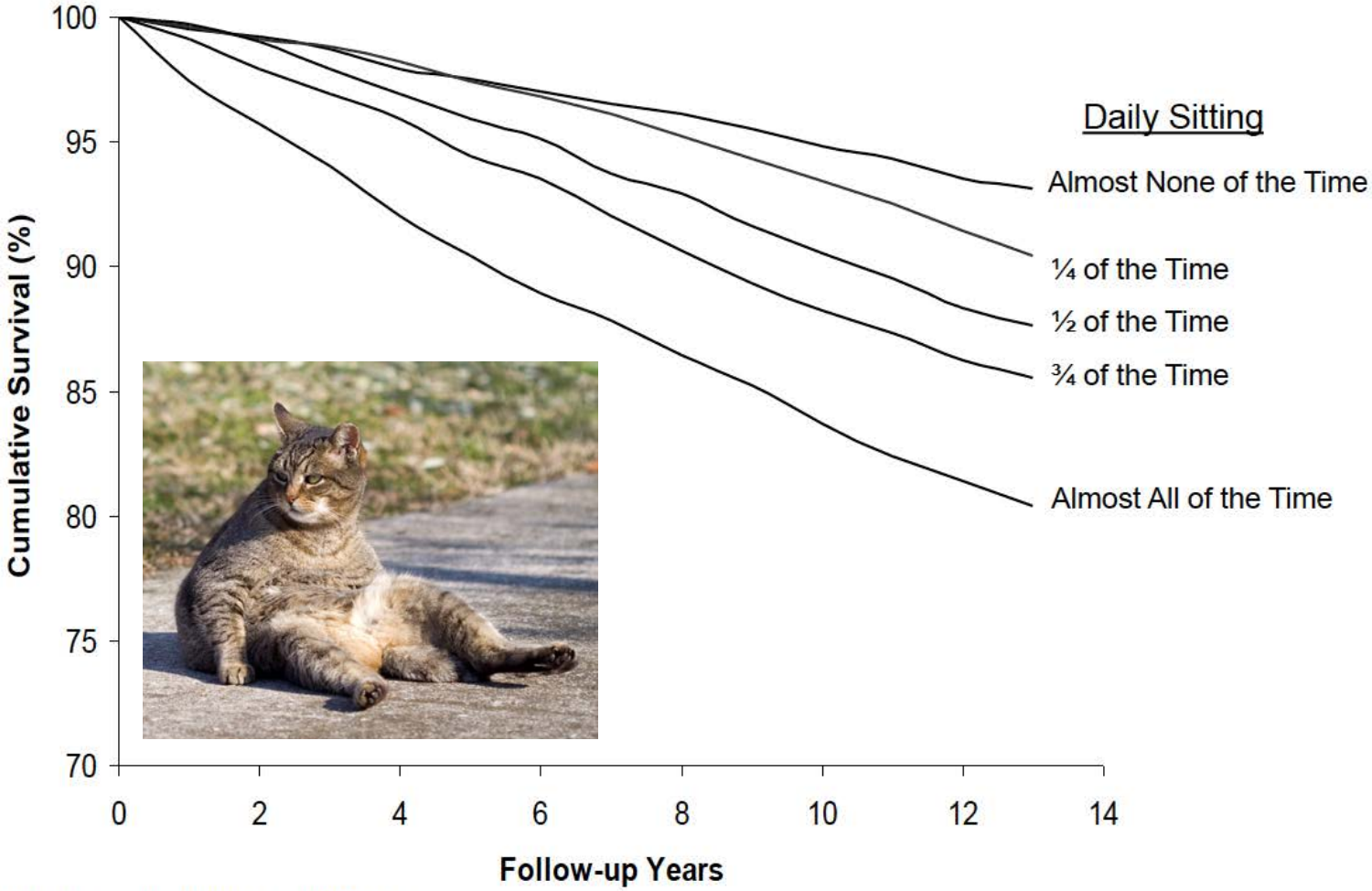
Sitting is more likely to lead to obesity – especially for men: Study

By Jackie Middleton

Sitting Time and Mortality from All Causes, Cardiovascular Disease, and Cancer

PETER T. KATZMARZYK[1], TIMOTHY S. CHURCH[1], CORA L. CRAIG[2], and CLAUDE BOUCHARD[1]

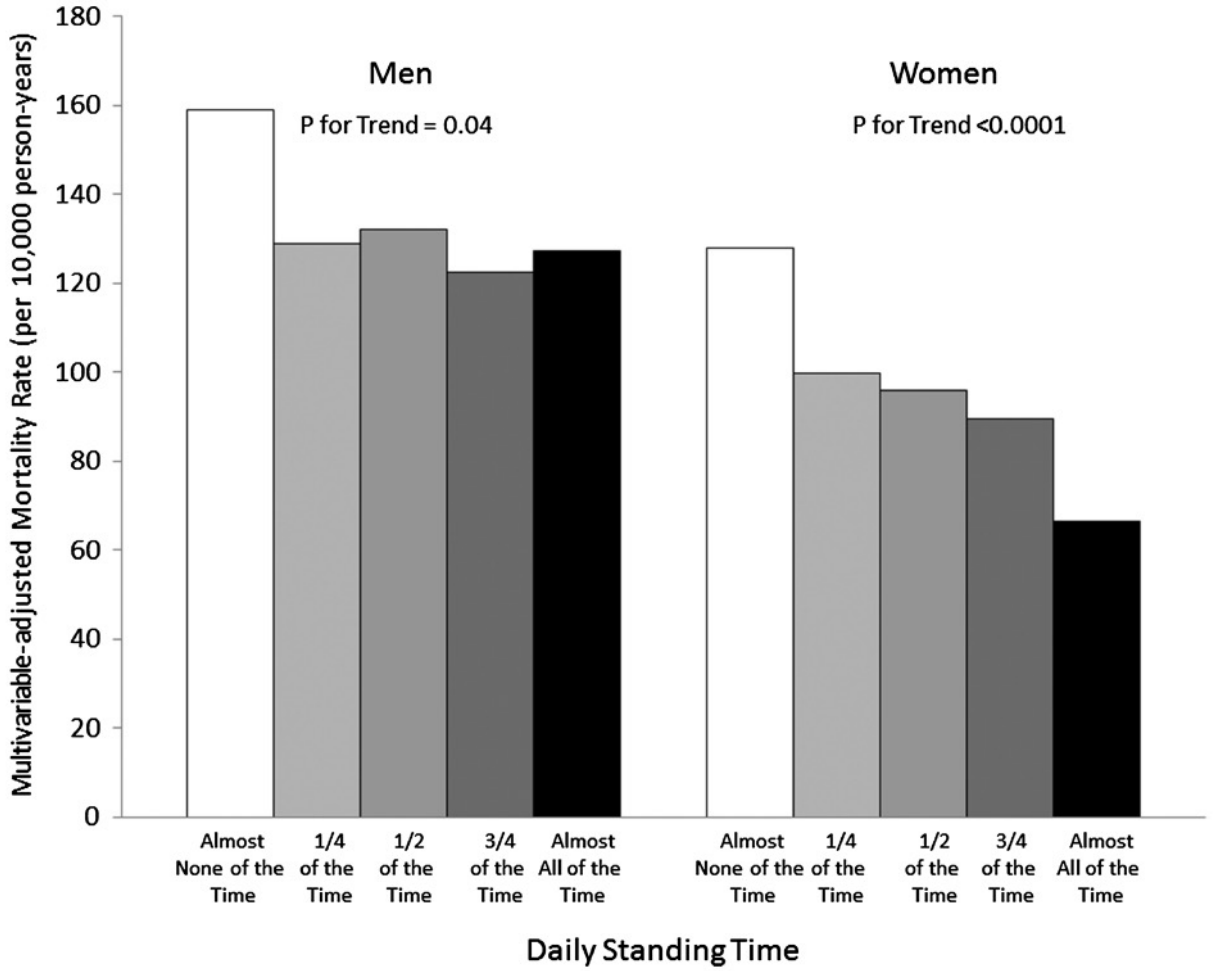
[1]Pennington Biomedical Research Center, Baton Rouge, LA; and [2]Canadian Fitness and Lifestyle Research Institute, Ottawa, Ontario, CANADA



17,013 Canadian Men and Women,
Canada Fitness Survey 12-year Mortality Follow-up, 1981-1993

Med. Sci. Sports Exerc., Vol. 41, No. 5, pp. 998–1005, 2009.

Daily Standing Time and All-Cause Mortality



Adjusted for age, smoking, alcohol, LTPA, physical activity readiness

Katzmarzyk (2014)

Standing and Heart Disease

- 7320 workers
- 12 year follow-up period (2003-2015)
- Occupations with predominantly standing exposure had a 2x (HR of 2.32 CI: 1.16-4.62) risk of heart disease compared to sitting jobs

Smith, P., Ma, H., Glazier, R. H., Gilbert-Ouimet, M., & Mustard, C. (2017). The Relationship Between Occupational Standing and Sitting and Incident Heart Disease Over a 12-Year Period in Ontario, Canada. *American Journal of Epidemiology*, 1–7. http://doi.org/10.1093/aje/kwx298

SECTIONS THERECORDER

Supreme Court Takes Stand on Suitable Seating

Ben Hancock, The Recorder

April 4, 2016 | 2 Comments

SHARE

PRINT

REPRINTS

Justice Carol Corrigan, California Supreme Court

Jason Doiy / The Recorder

LOCAL / L.

California's top court tells employers to give workers a chair

Workers whose jobs can be done at least partly while sitting should not be forced to stand, the California Supreme Court said Monday. Above, a worker at a Target store. (Jeff Chiu / Associated Press)

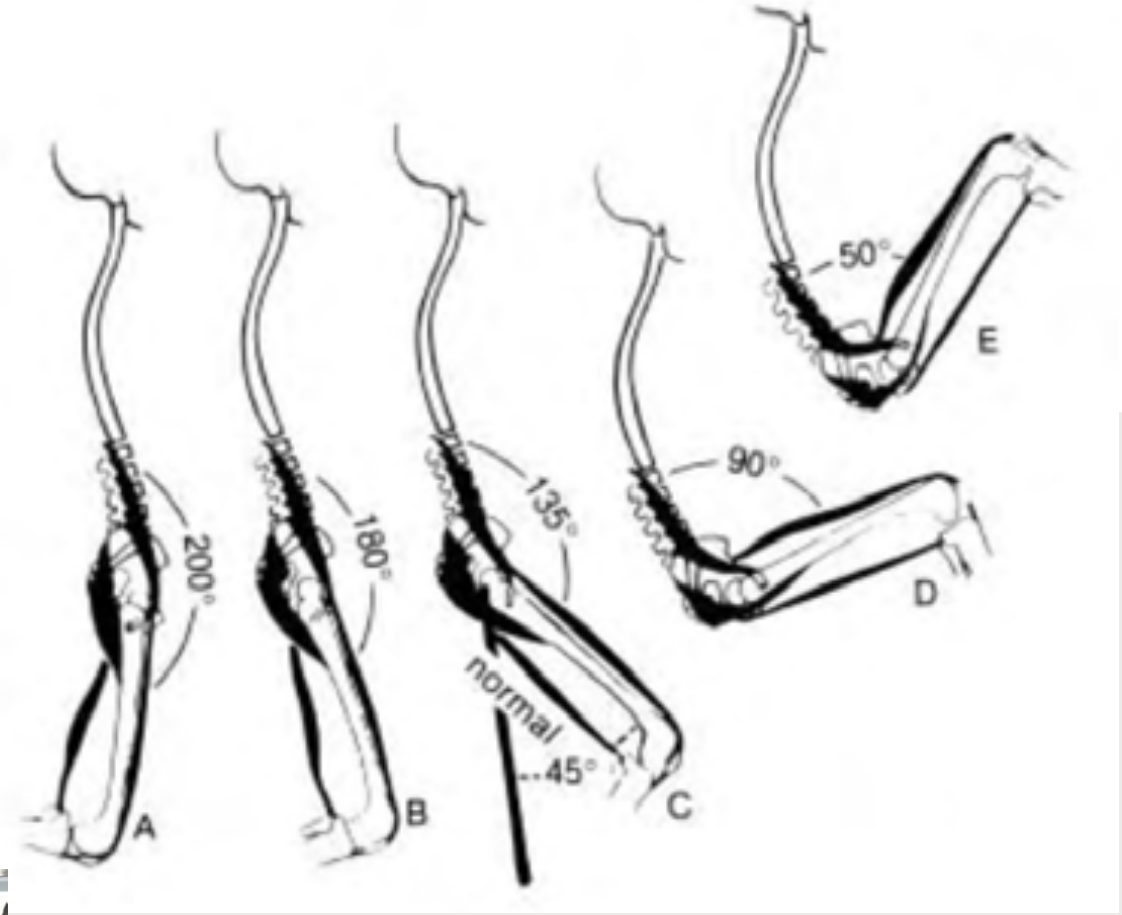
In Case You Missed It

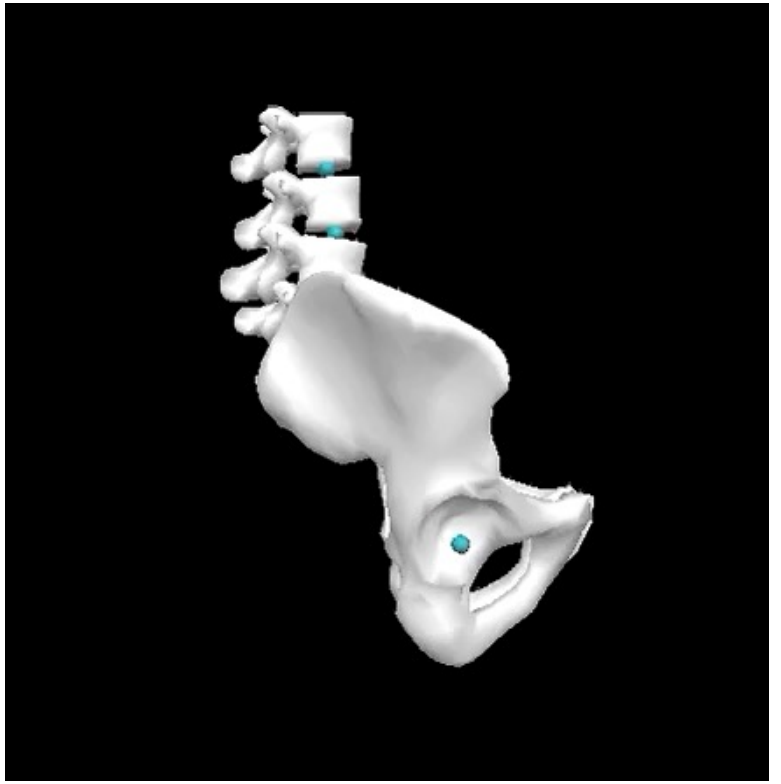
Santa Barbara fire bad om
dangerous California fire s

SITTING VS STANDING: CURRENT STATE OF THE LITERATURE CONCLUSIONS

- Total time sitting increases CVD
- Occupational sitting does not increase CVD
- Standing at work increases CVD
- Occupational physical activity does not decrease CVD
- No evidence that sit-stand workstations decrease CVD
- Metabolism ↑ with standing is inadequate to decrease BMI
- Standing strongly associated with Low Back Problems
- Sitting, weak evidence linking exposure with Low Back Problems
- Sit to stand workstations can decrease Low Back Problems

WHY?





"NATURAL LORDOSIS"

- 135° trunk-thigh (Keegan, 1953)
- a position of equilibrium for the muscles crossing the hip joint

  4 subjects in side-lying

  Primarily based off 1 Subject (JK)
- Has produced favourable findings in some imaging studies showing changes in IVD similar to standing (Alexander et al., 2007).
- No studies looking at this posture and impact of low back or health

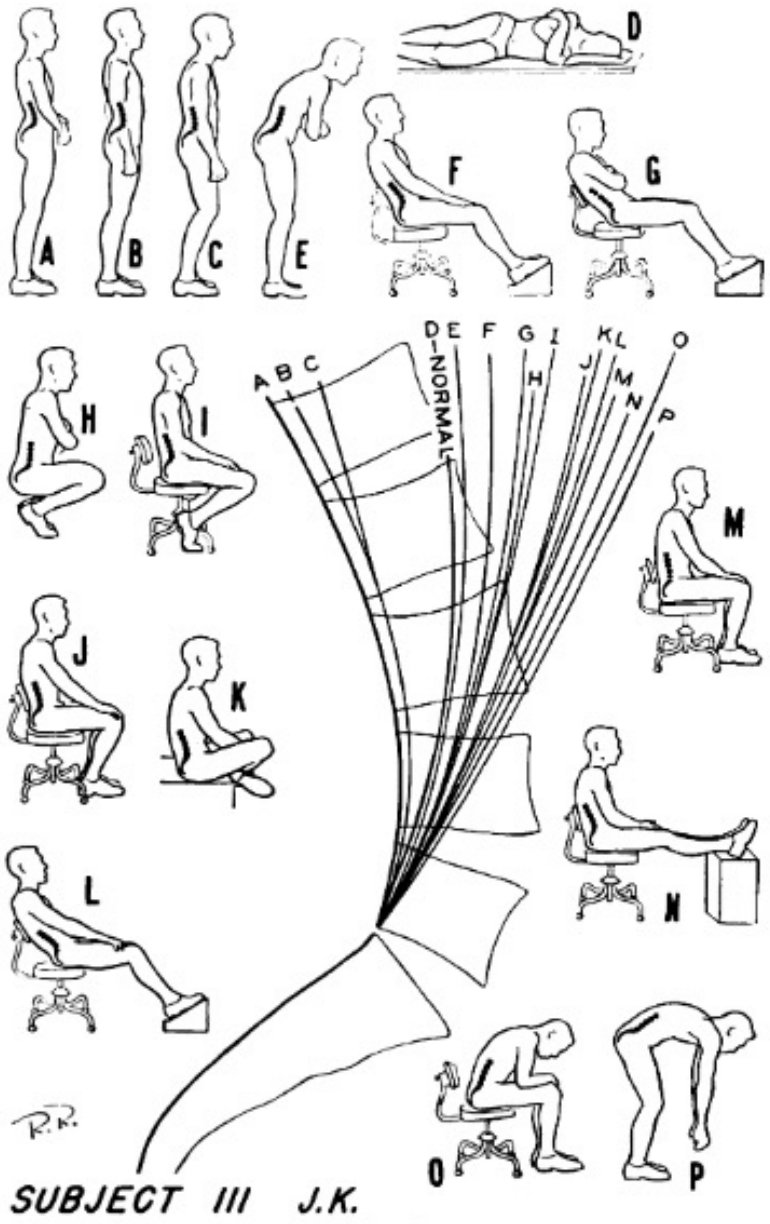


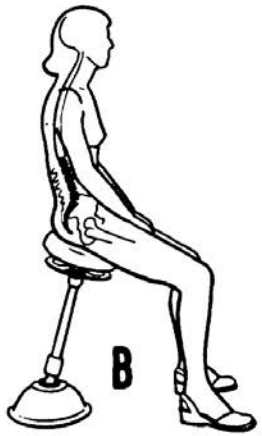
FIG. 8

Postures between Sitting and Standing

Sit

Low Back flexed

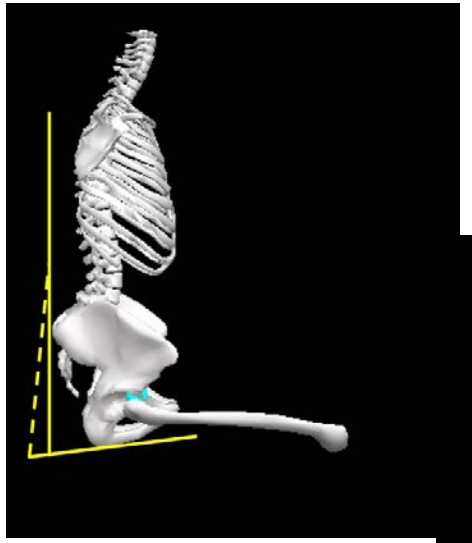
135°

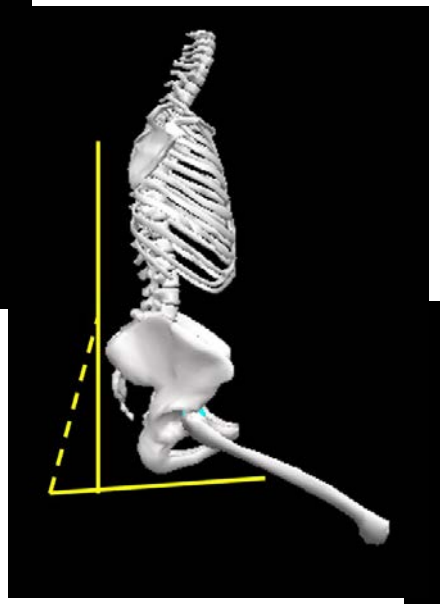


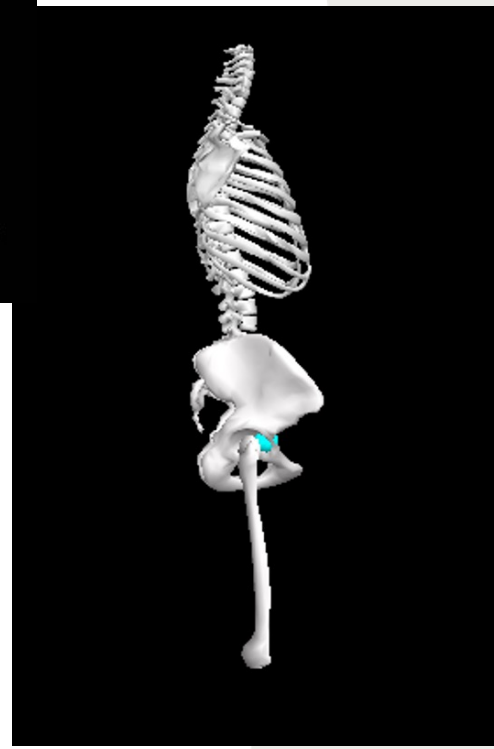
Low Back closer to neutral?

Stand

Low Back extended







ANSI/HFES 100 – DRAFT (ANYONE SEEN THE FINAL VERSION?)

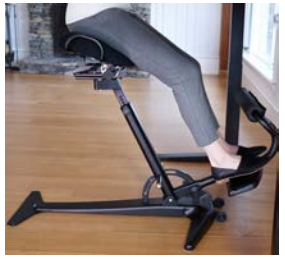
Definitions

Lean support –a type of support in which some of the body weight is supported by leaning against a contoured edge or vertical support. Minimal body weight is supported by the lean support, the rest is on the feet, which are always on the floor.

Perch – a type of seating support with a full seat, no back, and which supports most user weight on the seat but with some supported by the feet, which can be on the floor or on rings or rungs attached to the perch.

Stool – a tall chair with a full seat and back in which all the user's weight is supported by the stool. A stool may include arm rests, foot rings or foot rails and various styles of bases.

Prop – a type of seating support with a full seat, typically no arms, but feet are always in contact with the floor and the seat may pivot and or free float. Normally attached to a flat base that feet stay in contact with during use.



Best of
NeoCon
2022

Winners

Furniture

Seating: Ergonomic Desk/Task

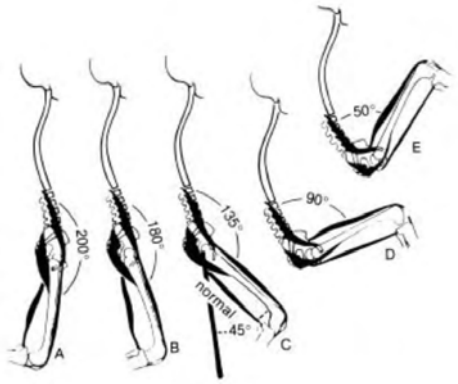
Exhibitor
Haworth, Inc.

Product
Zody II and Zody LX

Award
Silver

Booth
312

EVALUATION OF HYBRID SIT TO STAND POSTURES



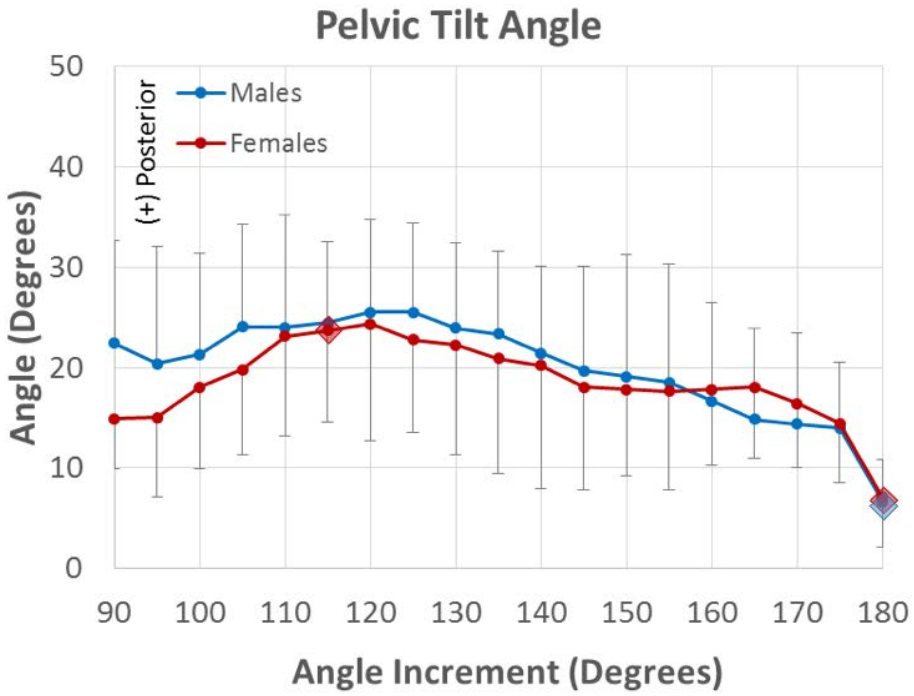
24 Participants (12 Female, 12 Male)

Hip Angles from 90° -180° in 5° increments (19 postures)

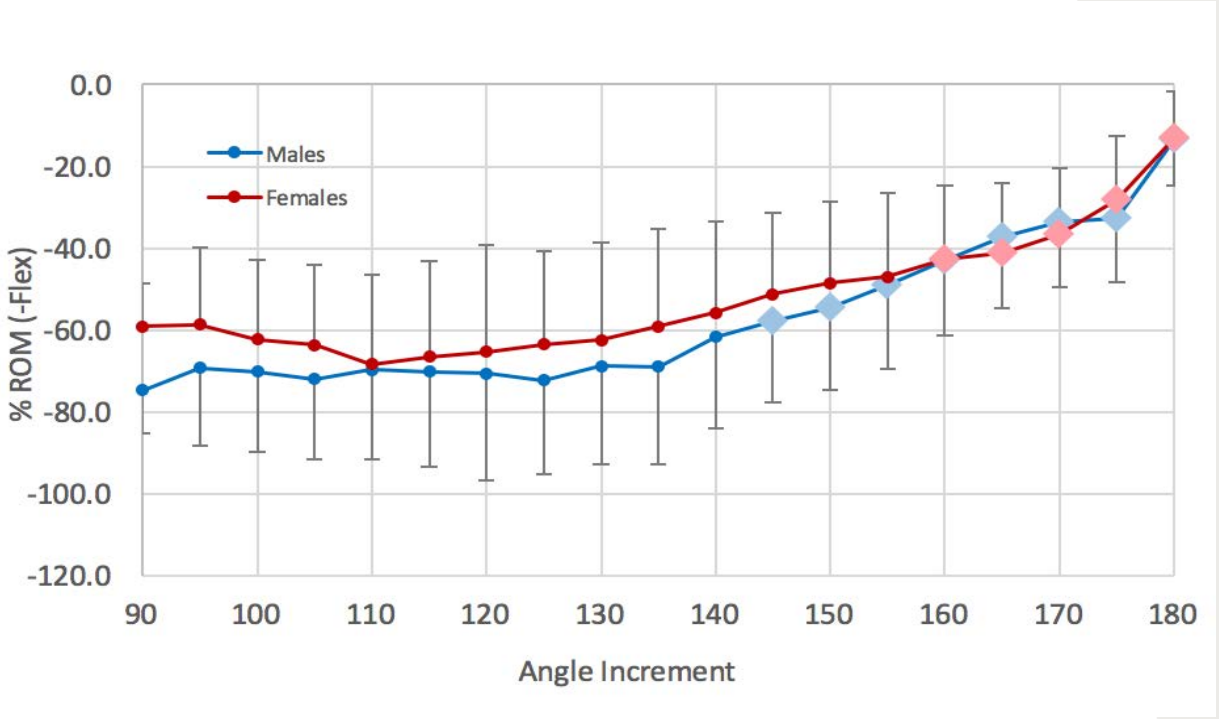
EMG, Kinematics, Ground Reaction Forces

Noguchi, M., Glinka, M., Mayberry, G., Noguchi, K., Callaghan, J.P. Are hybrid sit-stand postures a good compromise between sitting and standing?. *Ergonomics* 62(6): 811-822, 2019.

LUMBAR SPINE AND PELVIS RESPONSES



- Standing different than all



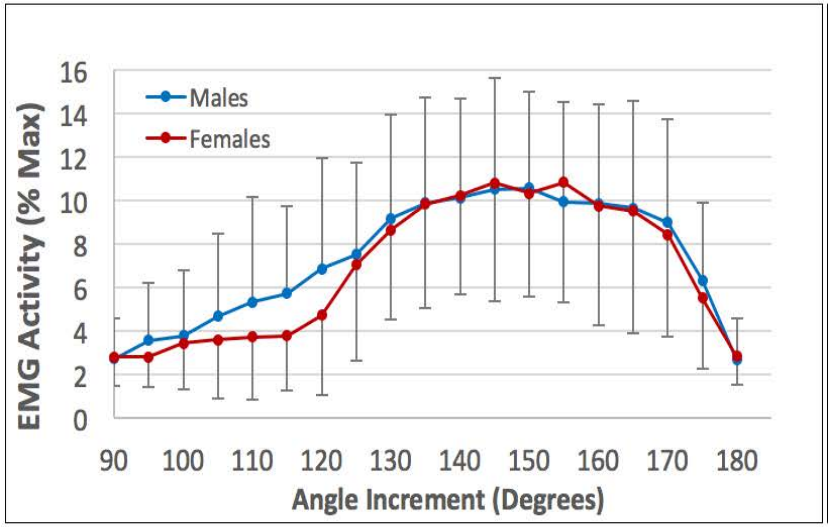
- Every angle different than Standing
- Sitting:

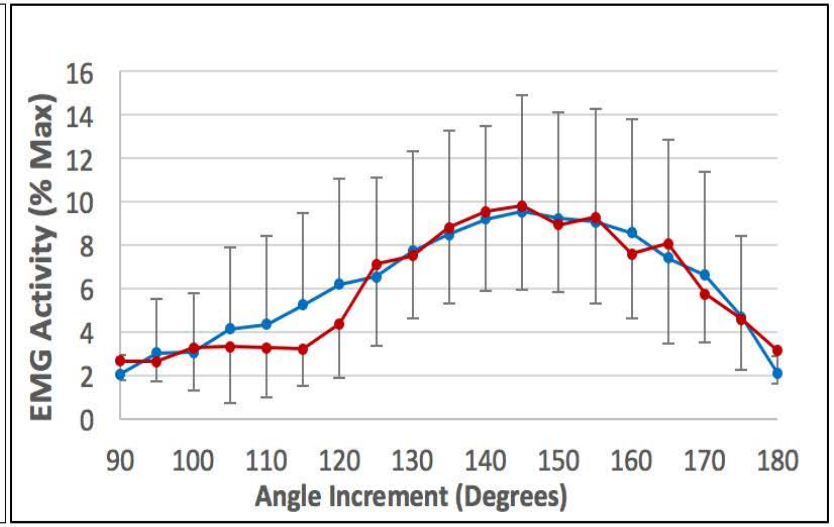
  Males 145-175 degrees

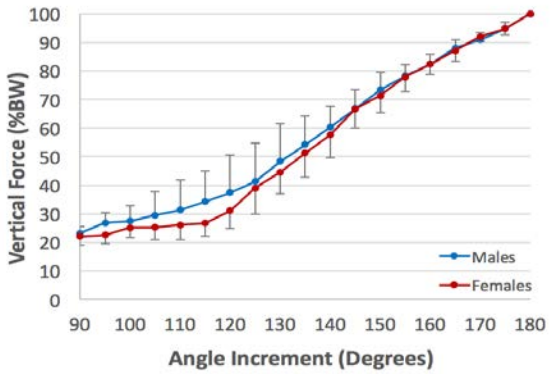
  Females 160-175 degrees

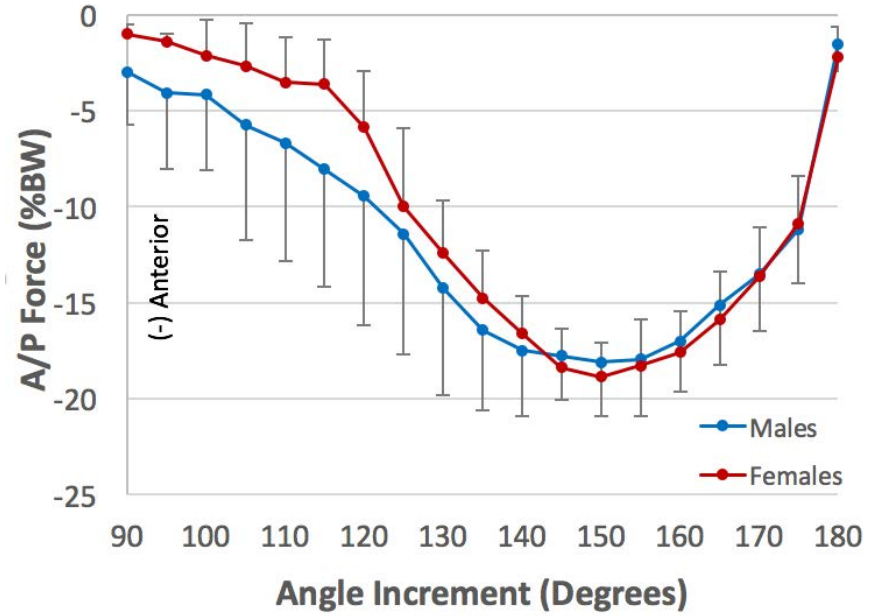
LEG RESPONSE

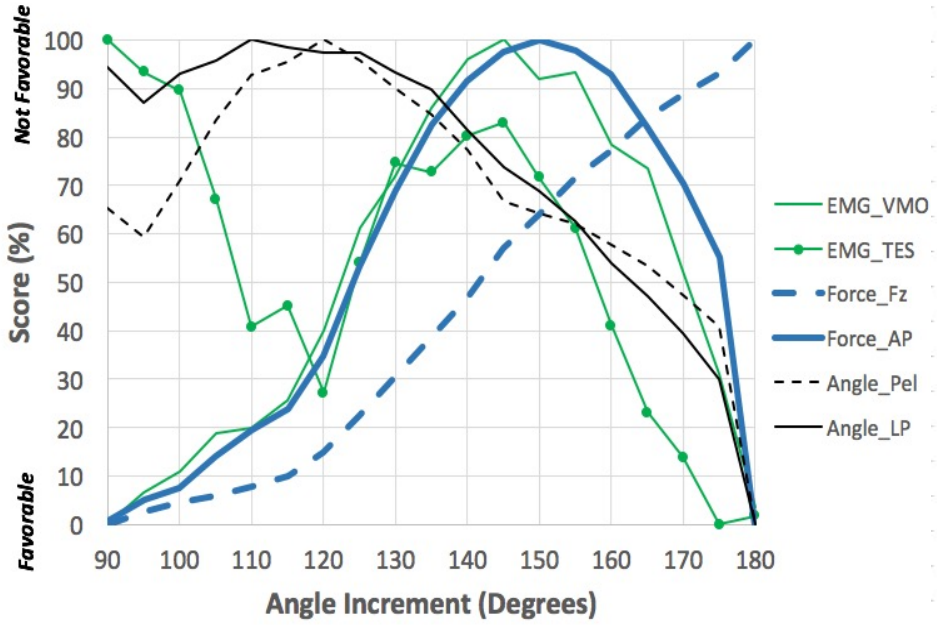
vastus medialis

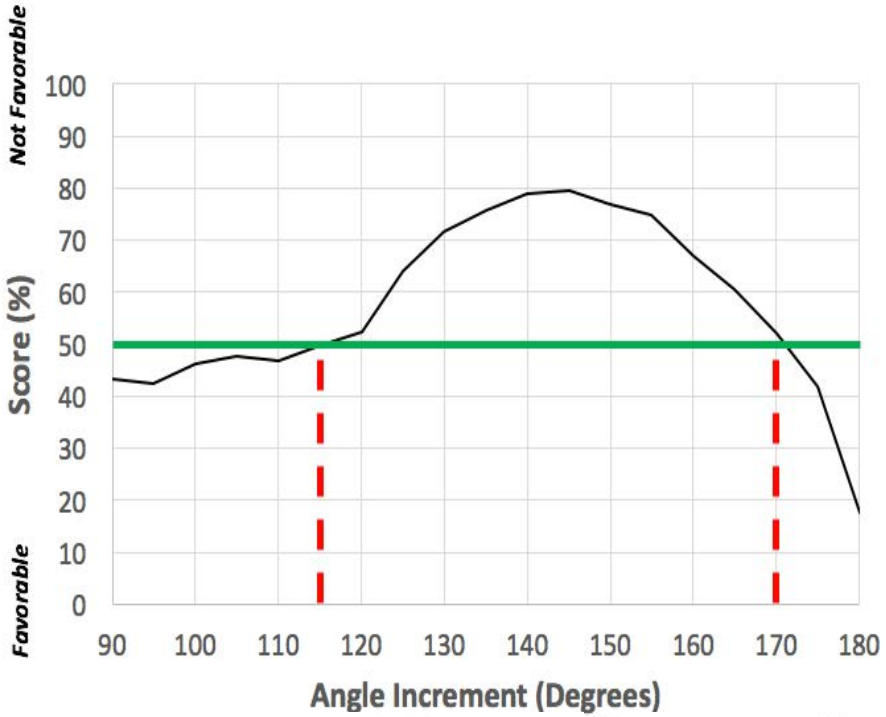


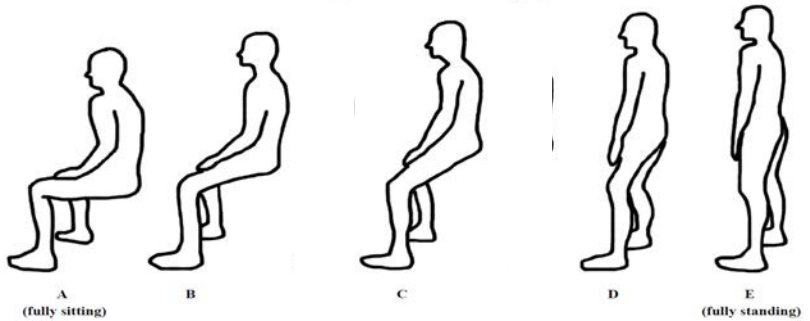


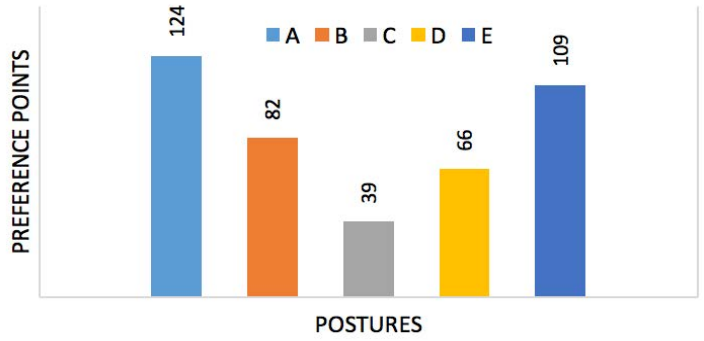












- 115 degrees to 170 degrees

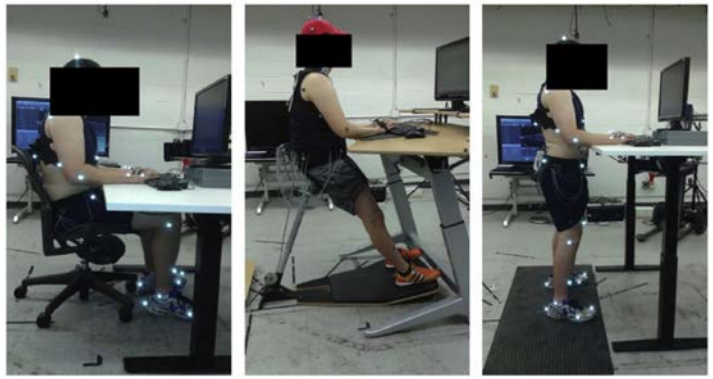
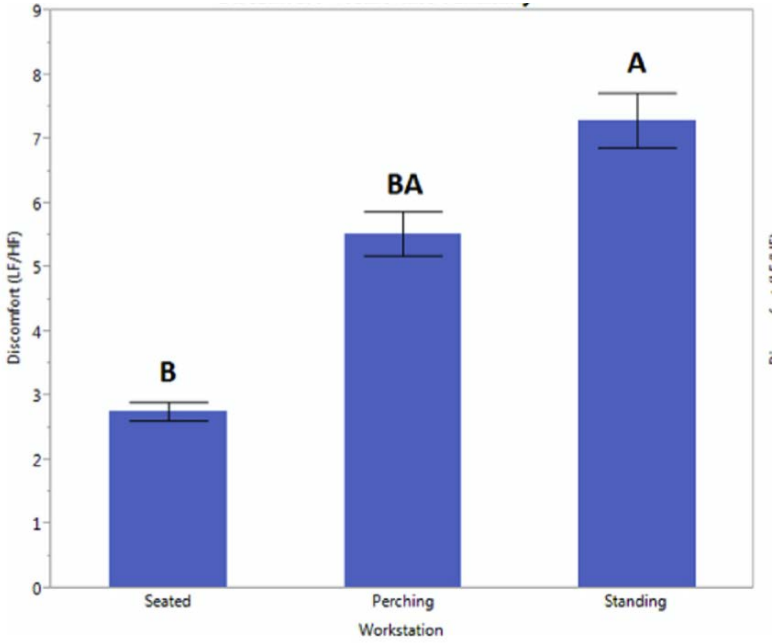


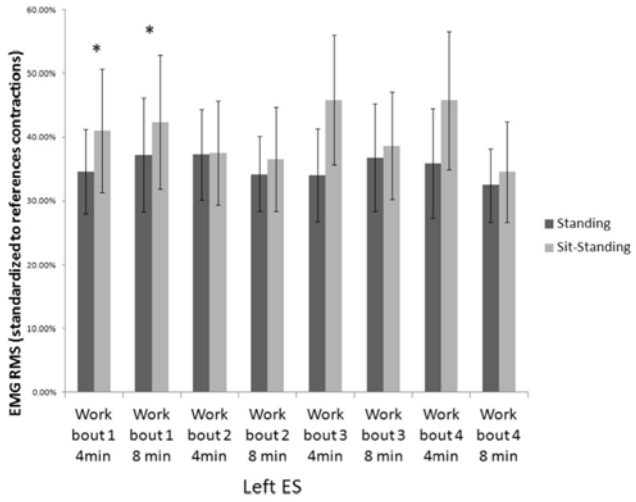
Fig. 1. Experimental setup for seating (left), perching (middle), and standing (right).

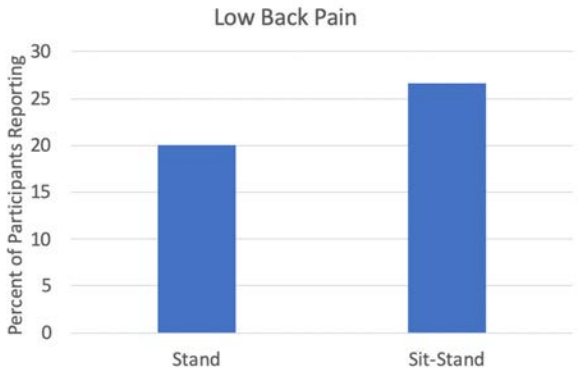
- Le, P., & Marras, W. S. (2016). Evaluating the low back biomechanics of three different office workstations: Seated, standing, and perching. *Applied Ergonomics*, *56*, 170–178. http://doi.org/10.1016/j.apergo.2016.04.001

Fig. 2. Example of the experimental task and use of the sit-stand stool.

- Antle, D. M., Vézina, N., & J. N. C. (2015). Comparing standing posture and use of a sit-stand stool analysis of vascular, muscular and discomfort outcomes during simulated industrial work. International Journal of Industrial Ergonomics, 45, 98–106. http://doi.org/10.1016/j.ergon.2014.12.009

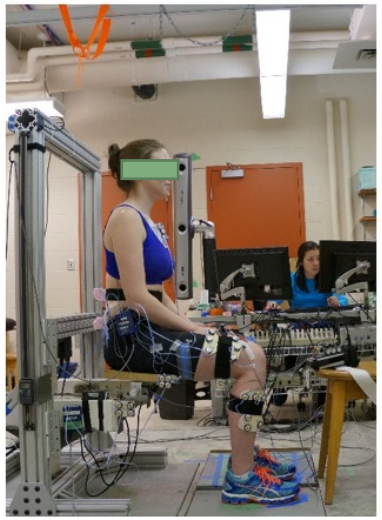


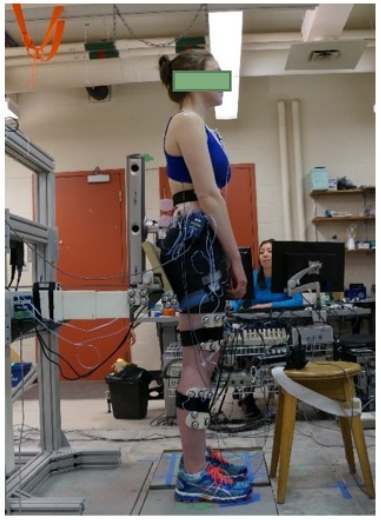


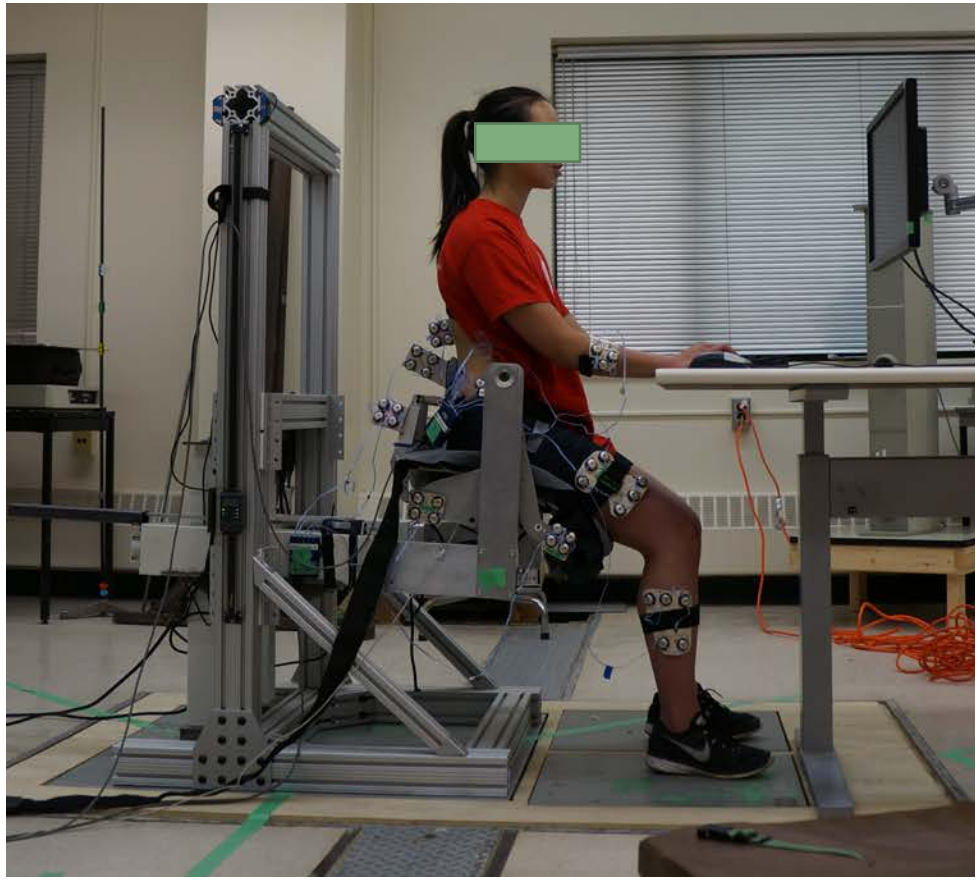


CAN SEAT PAN OFFSET LEG DEMANDS

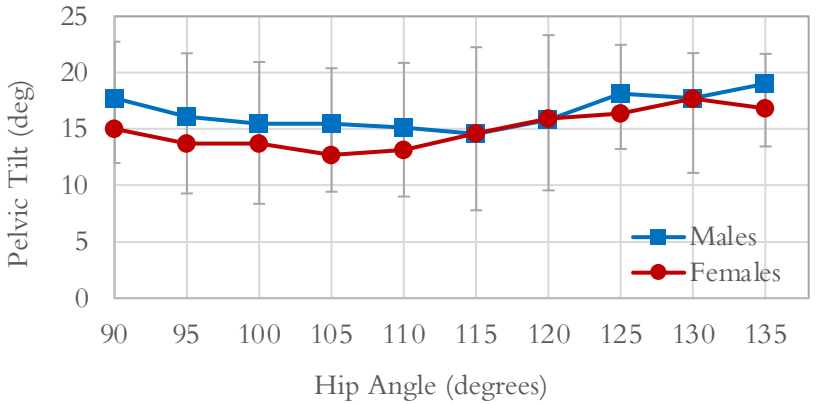
- *16 Participants (8 Female, 8 Male)*
- *Hip Angles from 90°–135° in 5° increments (10 postures)*
- *Kinematics, Ground Reaction and Seat Pan Forces, Seat Pan Pressure*

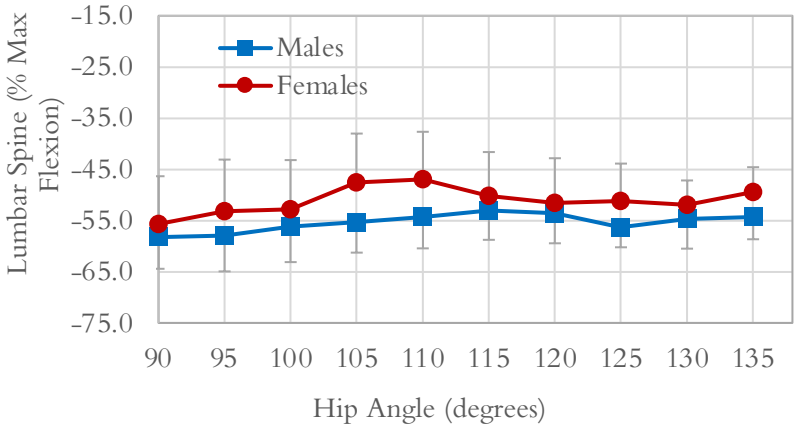


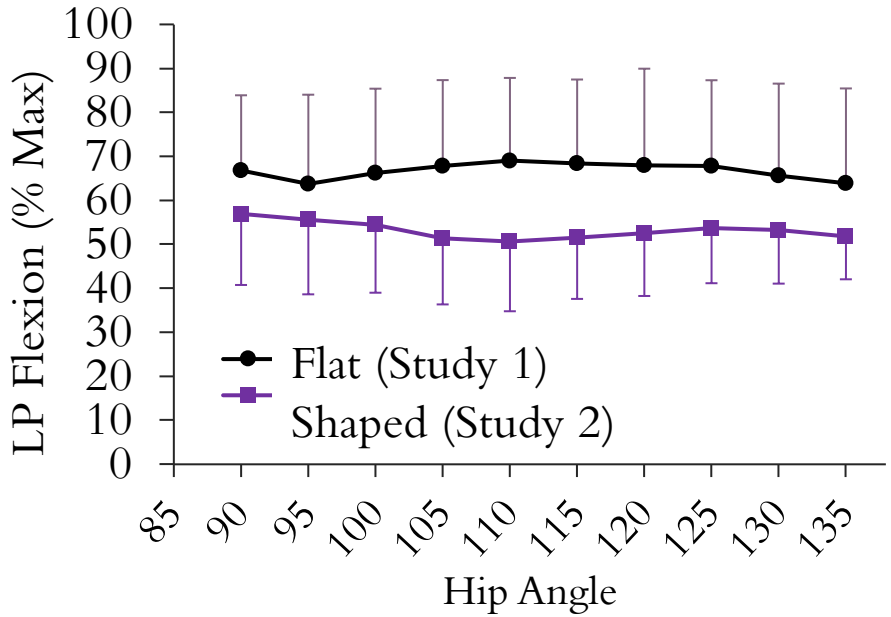




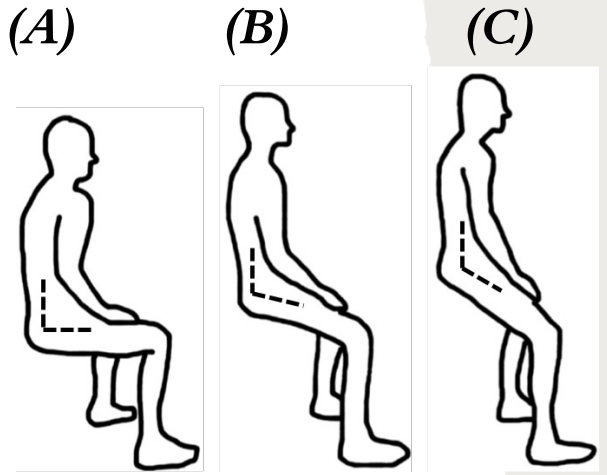
Lumbar Spine & Pelvis Posture

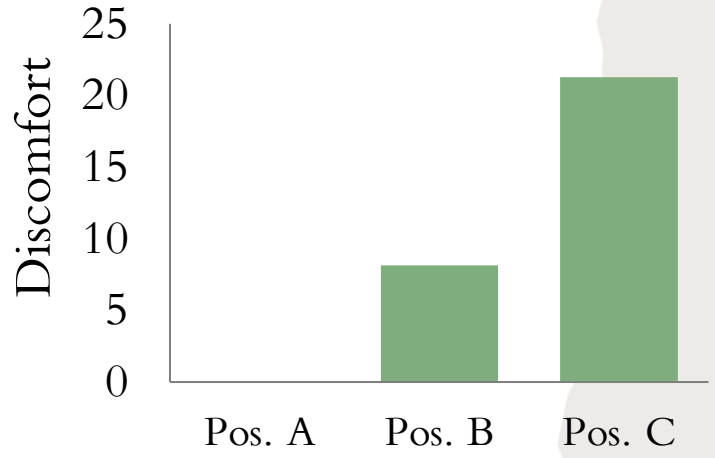




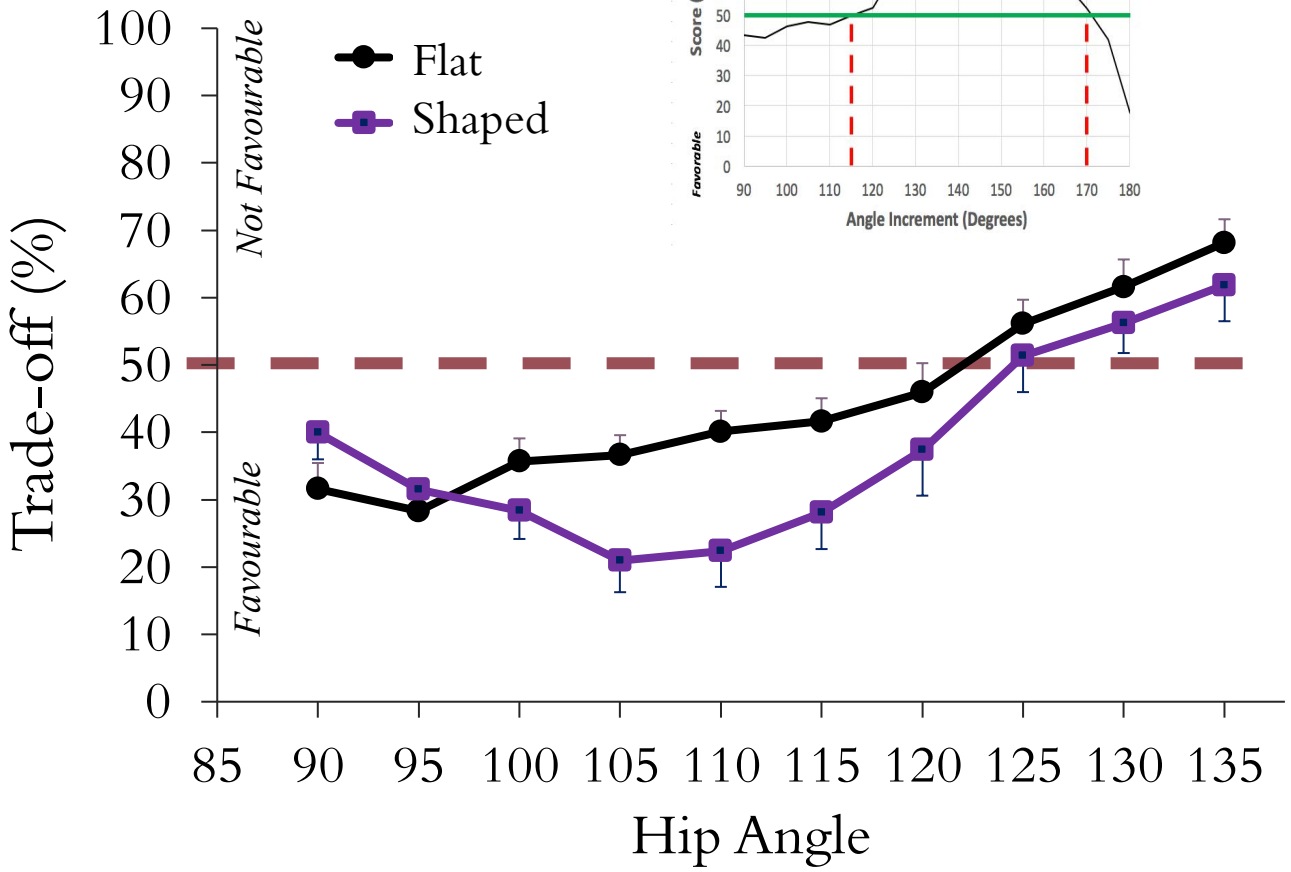


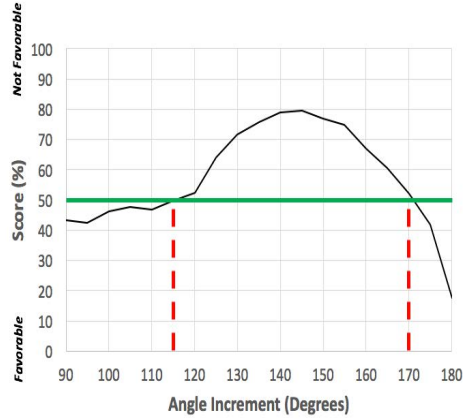
User Experience



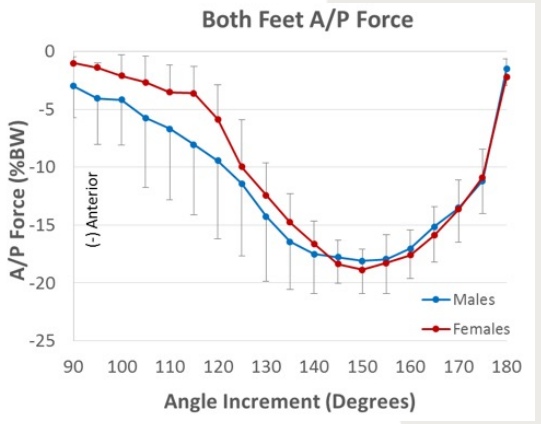


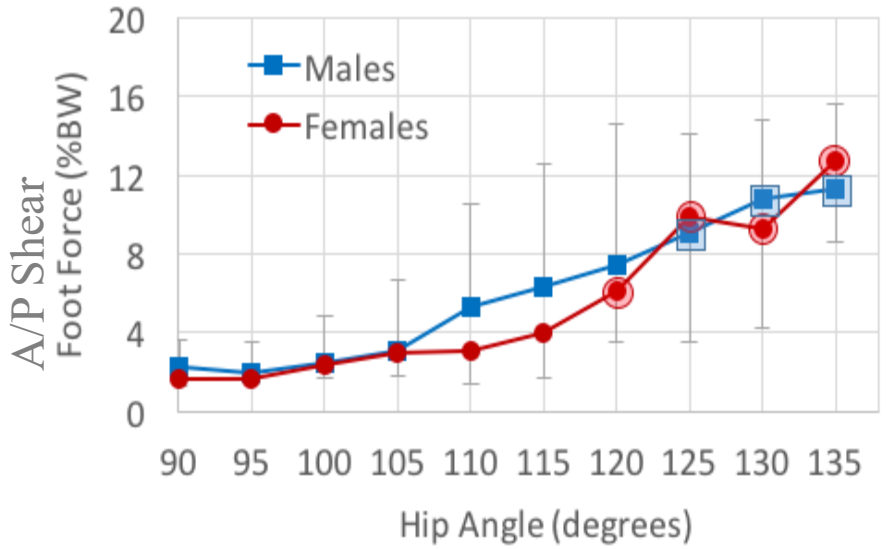
TRADEOFF: FOOT FORCE VS LUMBAR SPINE ANGLE





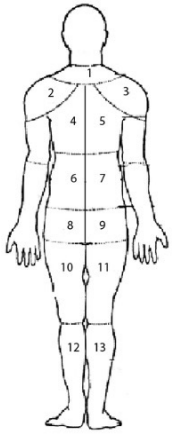
Shear force

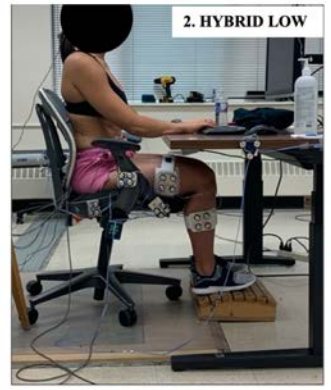


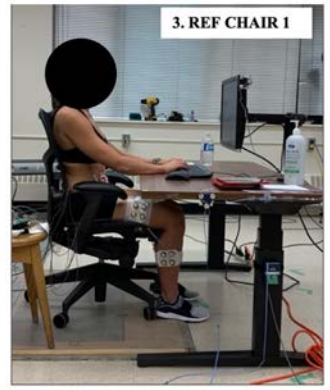


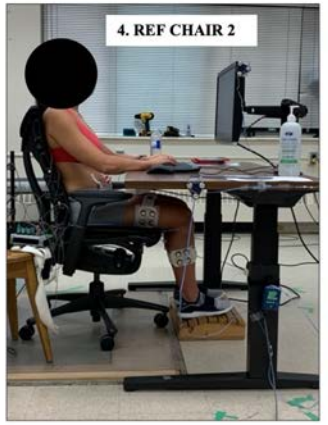
HYBRID CHAIR FOR PROLONGED SEATED WORK

- Two-hour bout of sedentary desk work in 5 conditions
- Six, 15-minute blocks of desk work were performed.
- 5-minute rest break; participant remained in the assigned posture
- Three tasks with performance tracking were performed twice each:
  - Typing: Standardized Text passages
  - Data Entry: Transfer of product, client, and company information into user interface
  - Reading Comprehension: Qualitative Reasoning section of the standardized Graduate Record Exam (GRE)
- Discomfort in 13 body regions









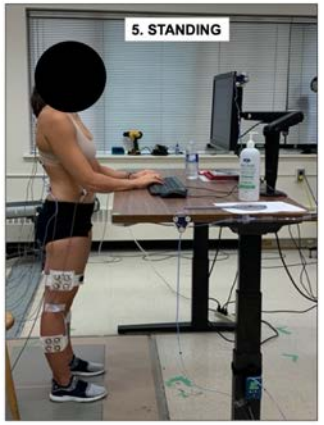
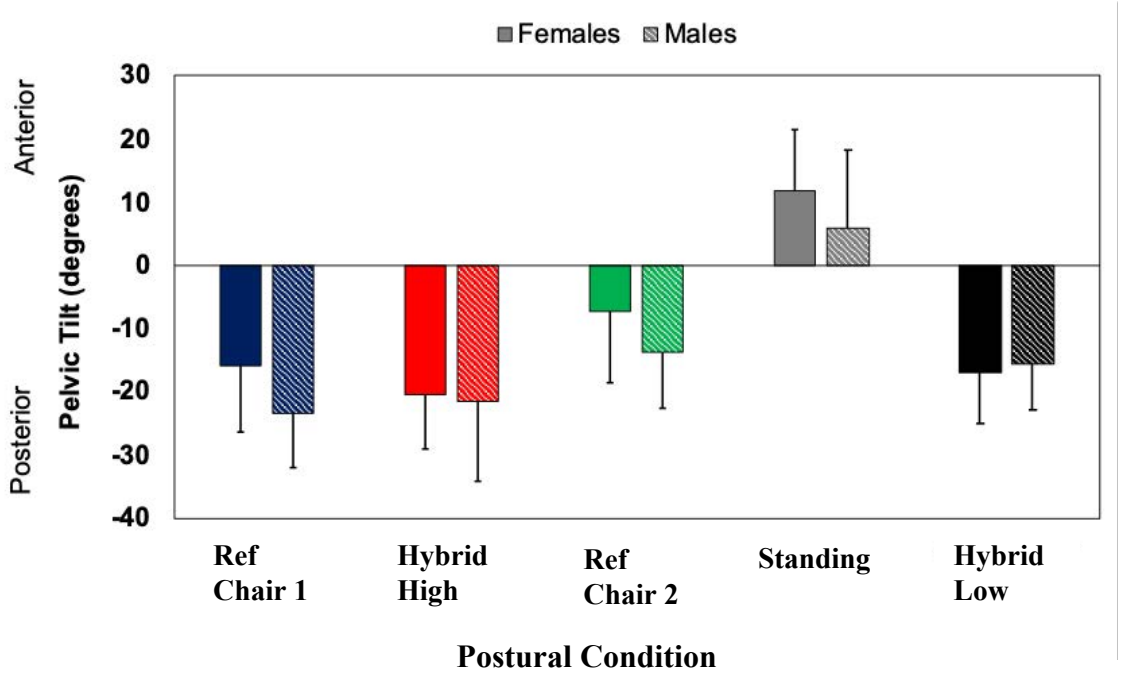
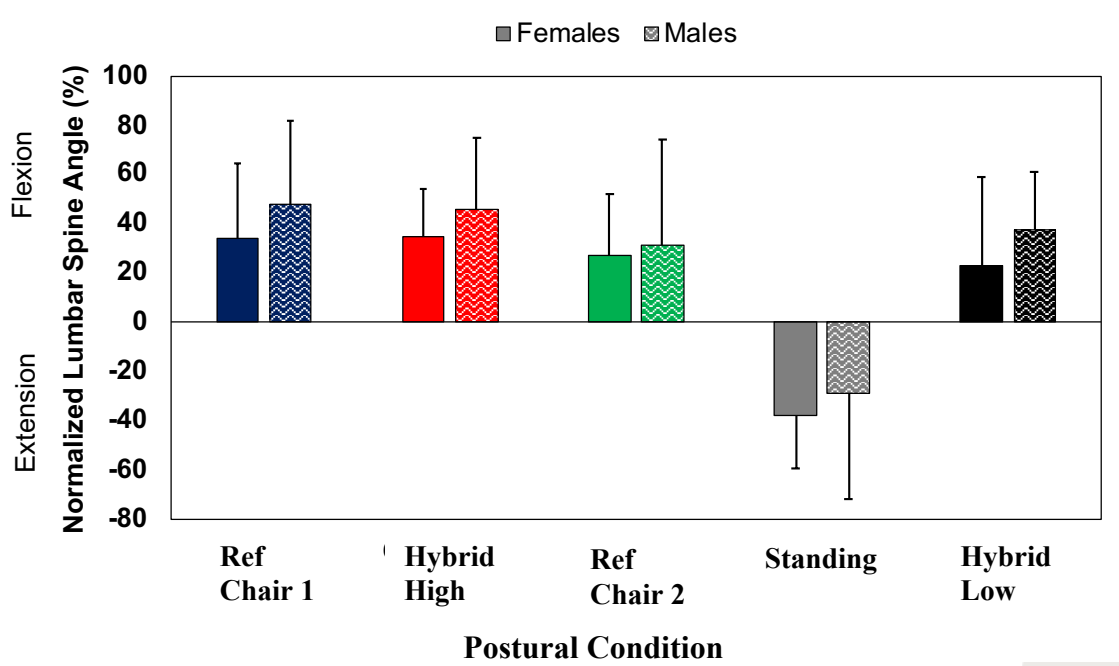


Table 1. The selected trunk-trunk angle by each participant for the Hybrid High condition.

Participant	Trunk-Thigh Angle (deg)
1	110
2	115
3	112
4	120
5	110
6	120
7	110
8	105
9	115
10	110
11	110
12	110

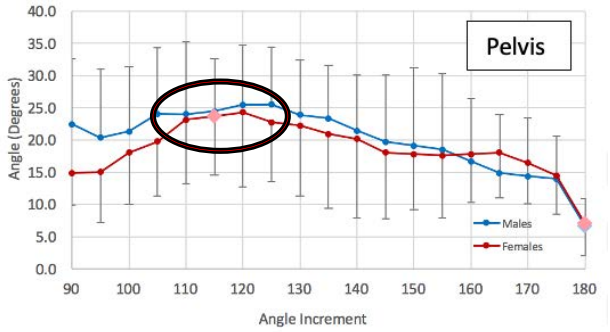
HYBRID IMPACT ON POSTURE

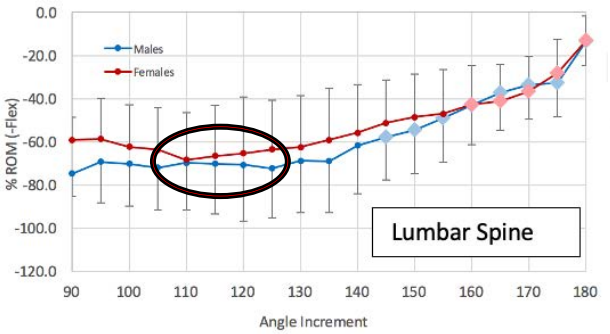




HOW DOES THIS ALIGN WITH PREVIOUS RANGE RESPONSES?

Study 1





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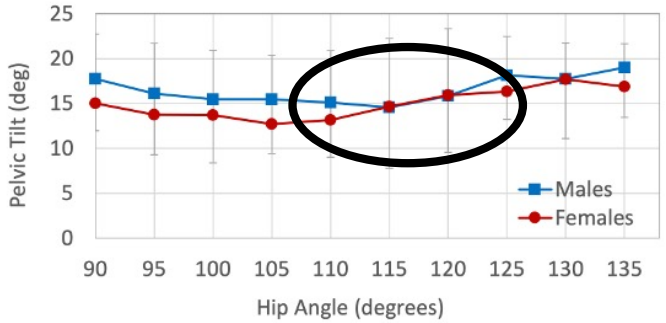
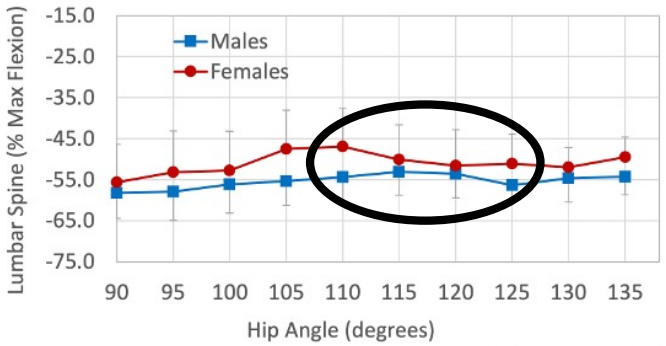
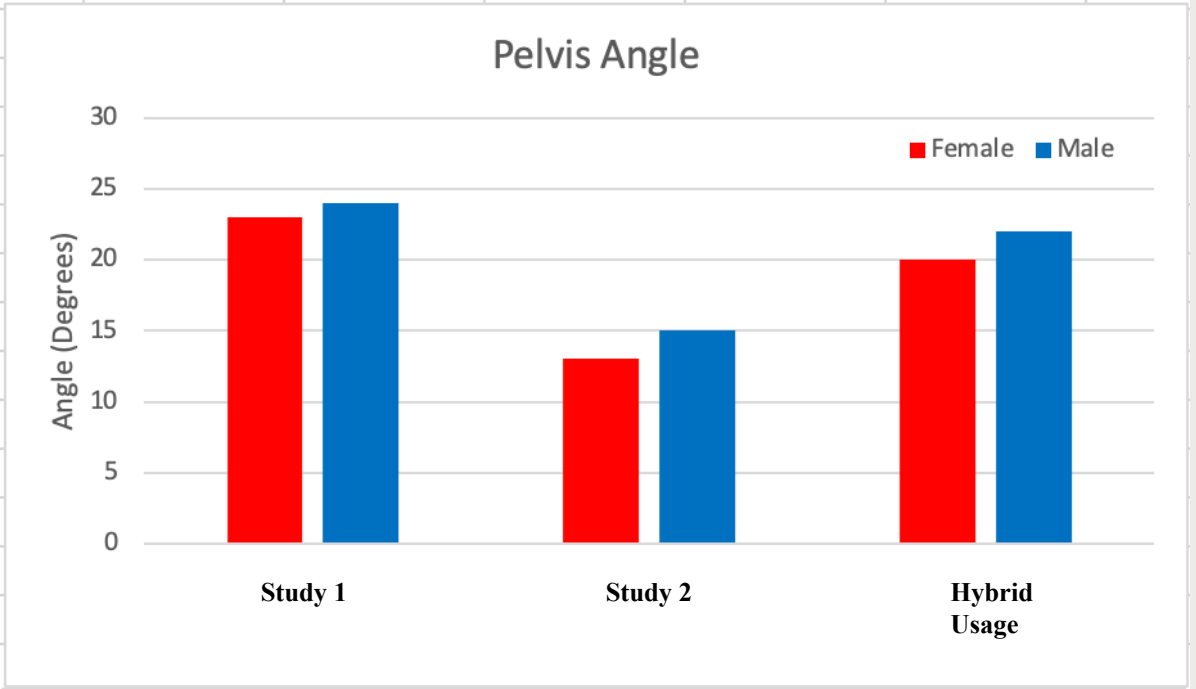
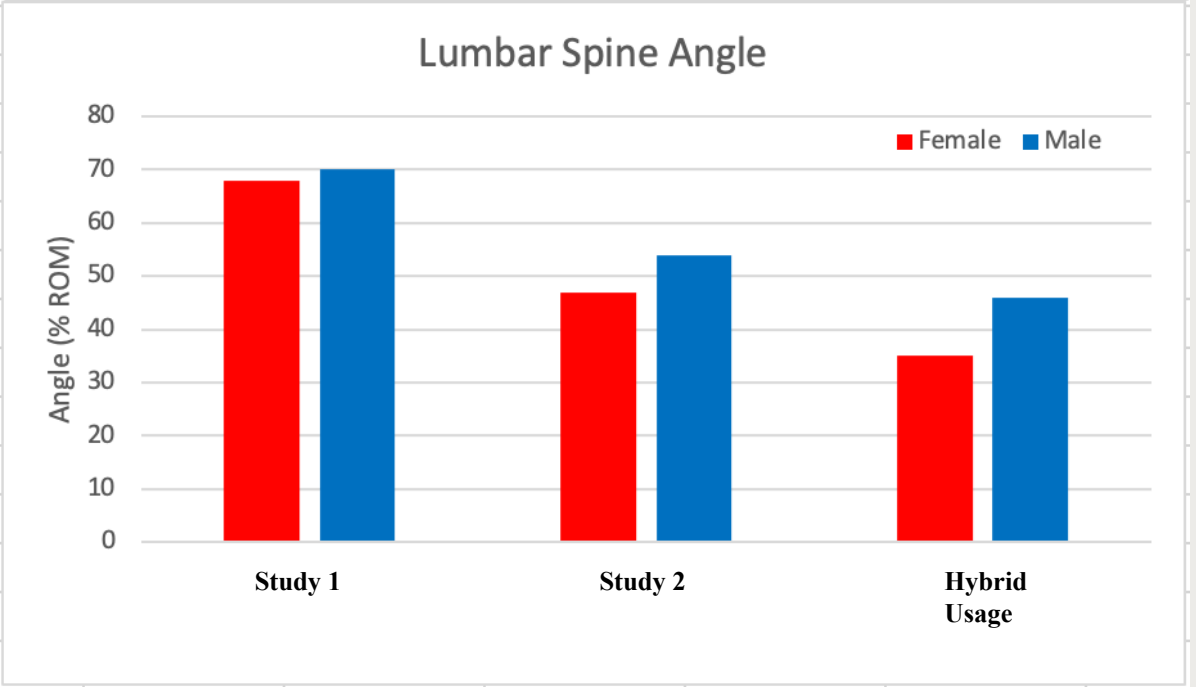
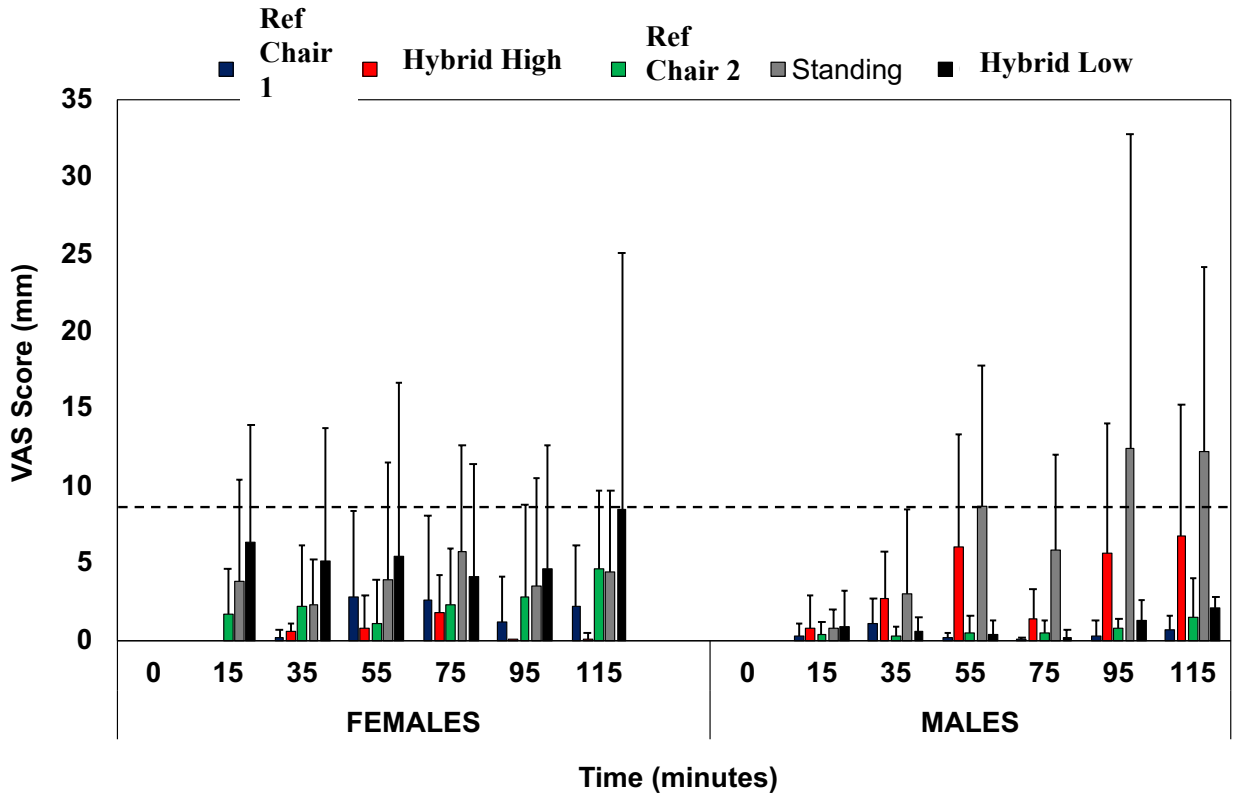


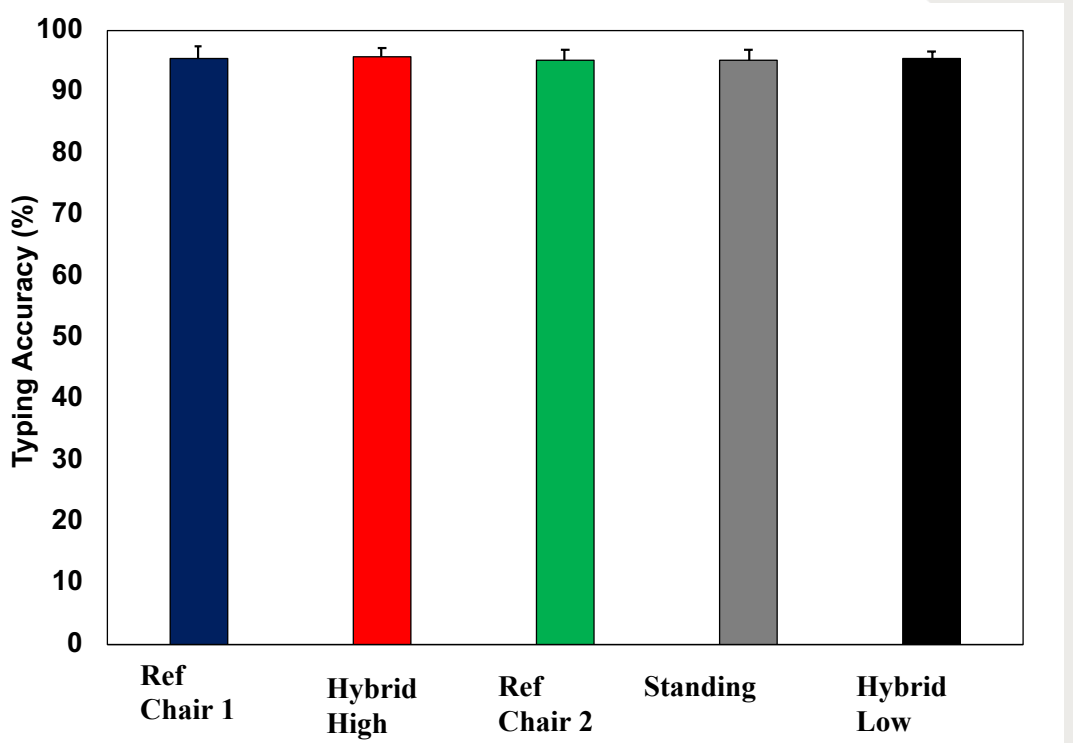




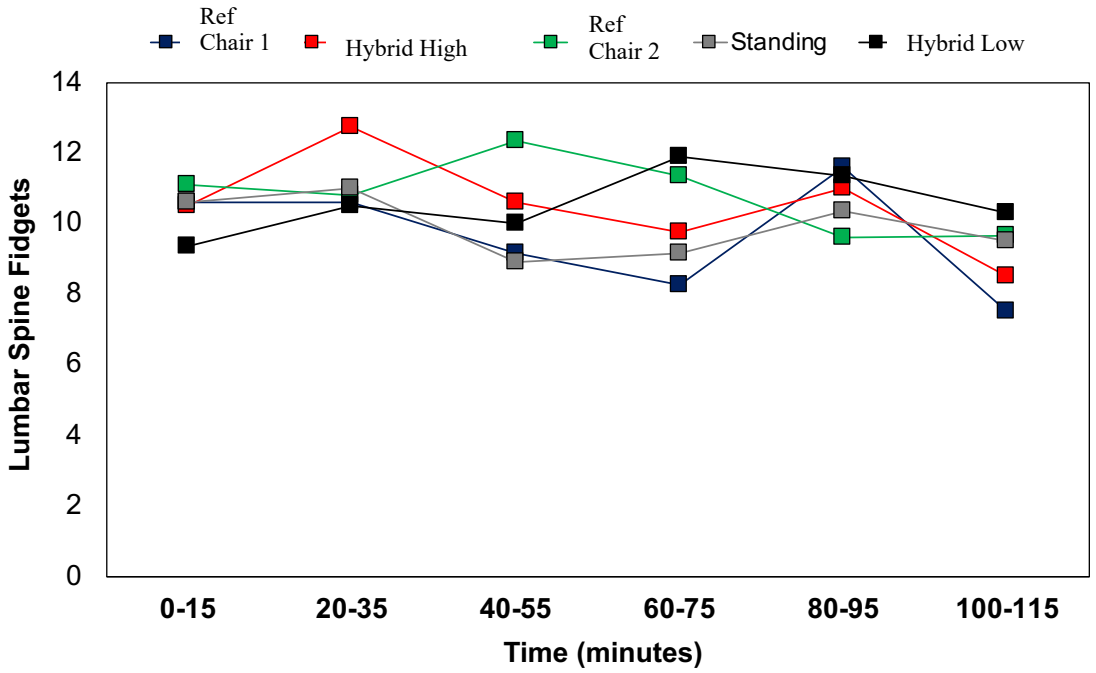


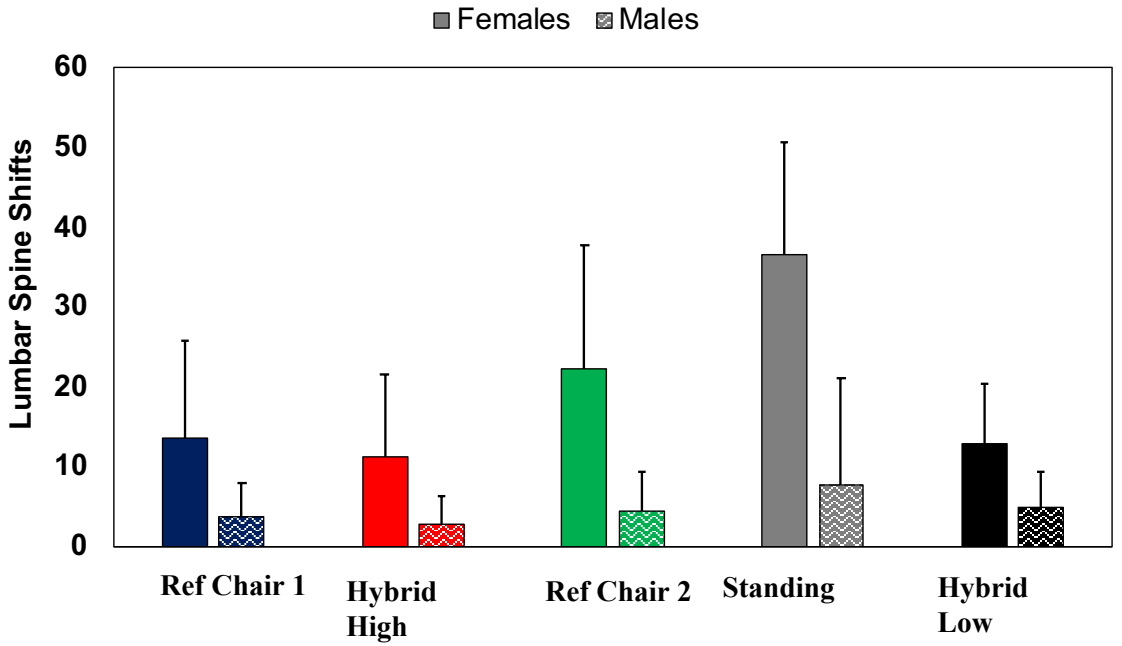
DISCOMFORT AND PRODUCTIVITY



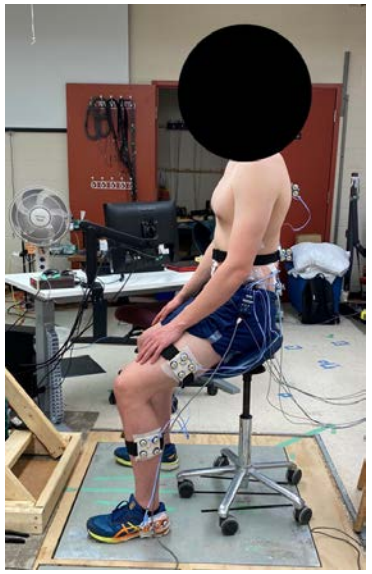
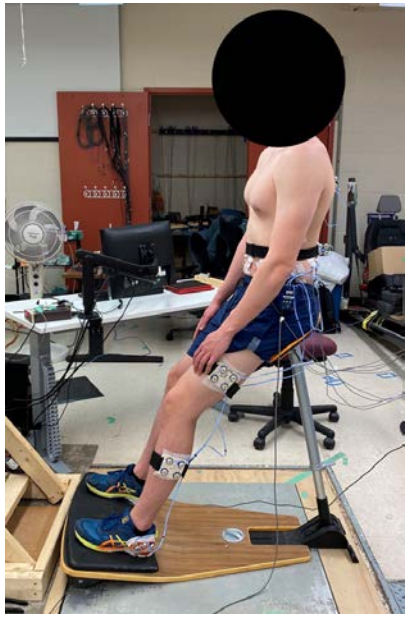
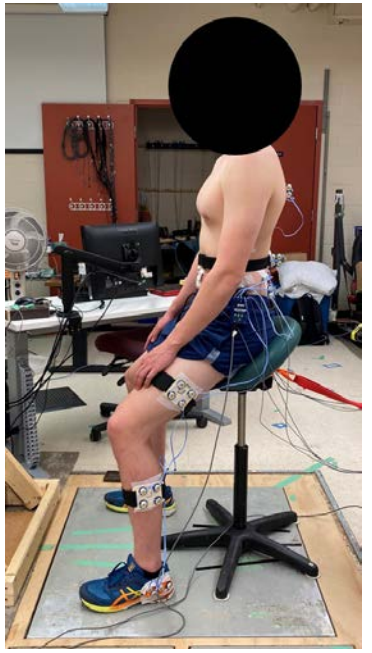
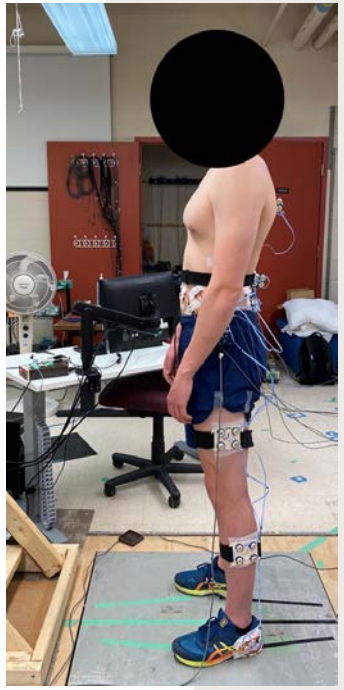


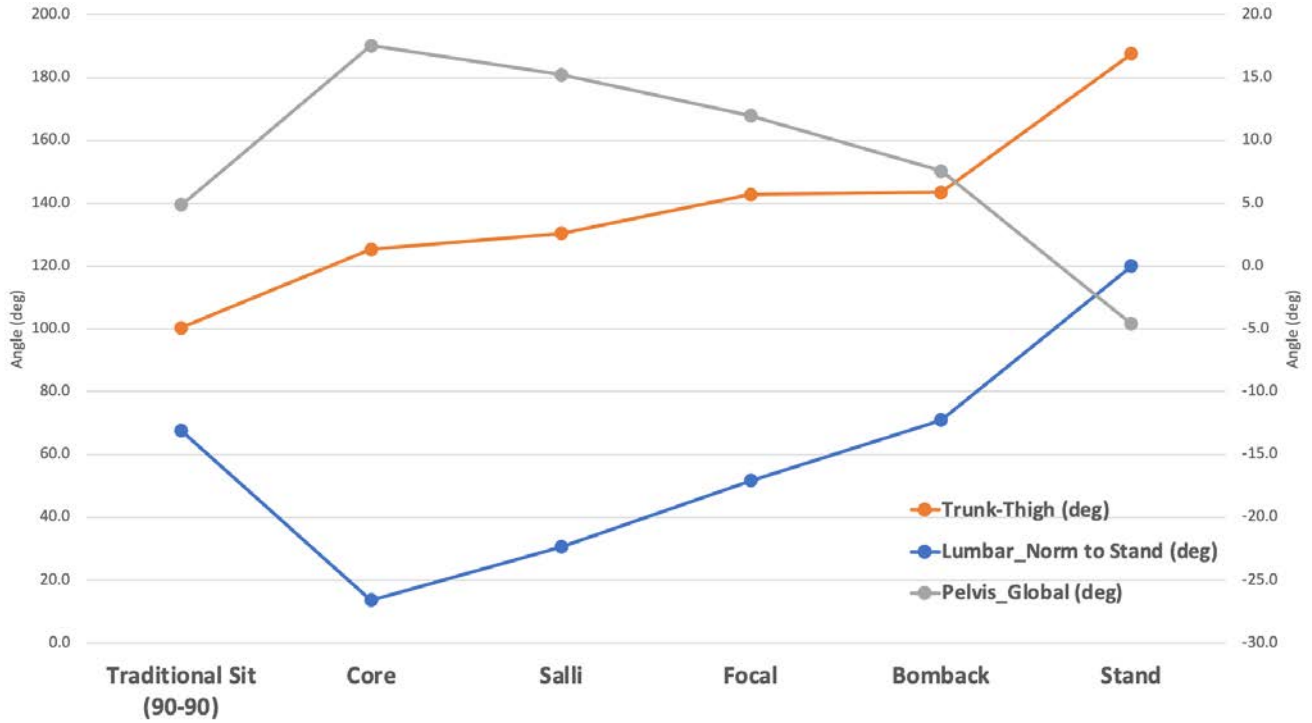
MOVEMENT

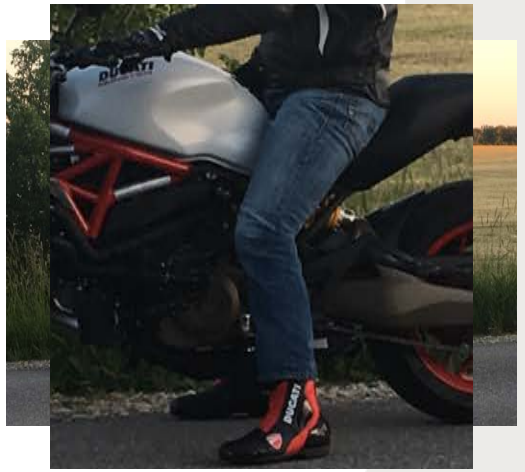

Ref Chair 1
Hybrid High
Ref Chair 2
Standing
Hybrid Low
Lumbar Spine Fidgets
14
12
10
8
6
4
2
0
0-15
20-35
40-55
60-75
80-95
100-115
Time (minutes)


Females
Males
Lumbar Spine Shifts
60
50
40
30
20
10
0
Ref Chair 1
Hybrid High
Ref Chair 2
Standing
Hybrid Low



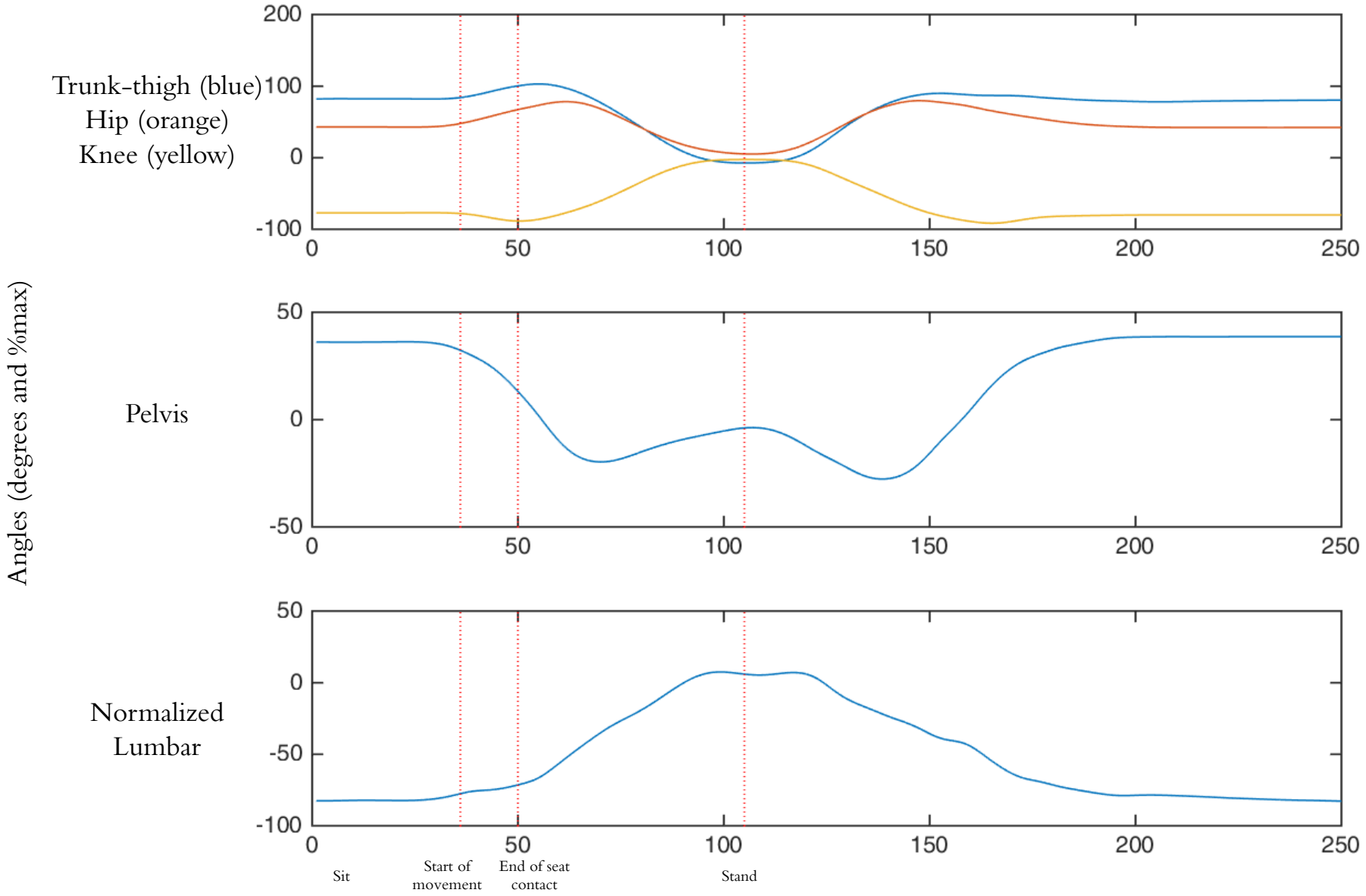

200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Angle (deg)
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
Angle (deg)
Trunk-Thigh (deg)
Lumbar_Norm to Stand (deg)
Pelvis_Global (deg)
Traditional Sit (90-90)
Core
Salli
Focal
Bomback
Stand



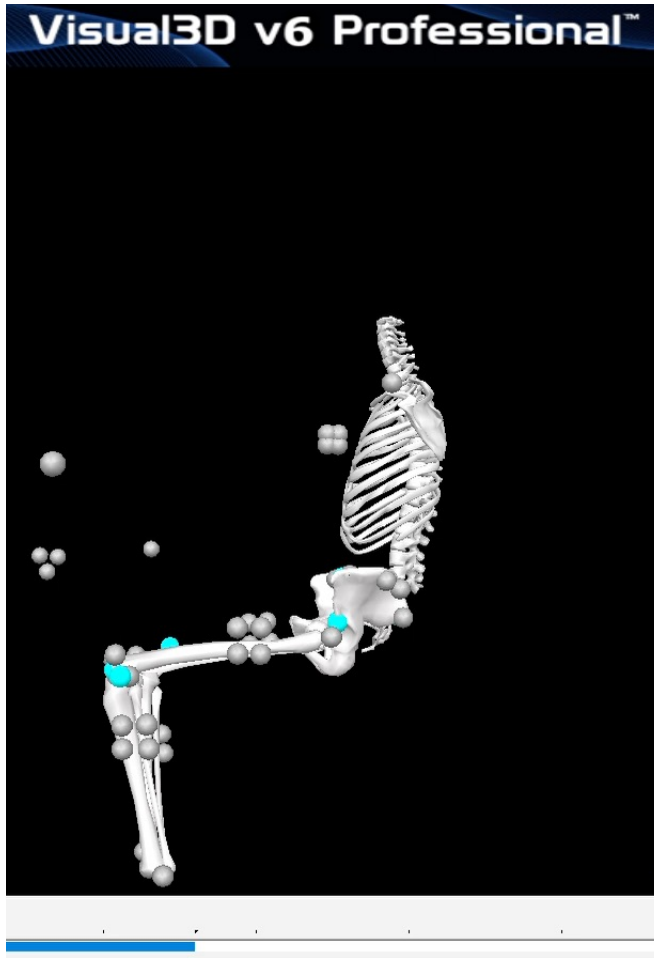
PAUSE

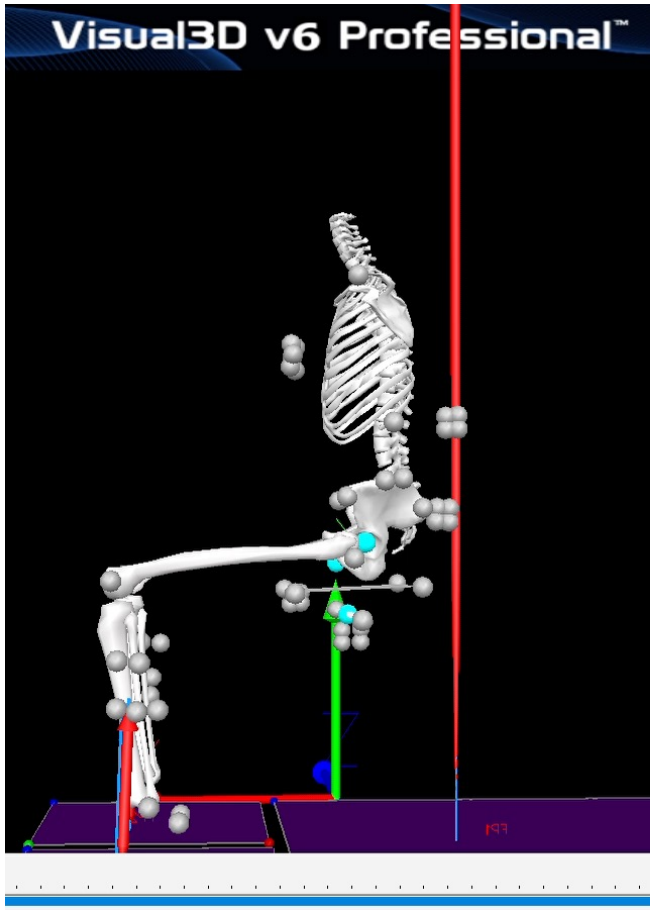
Free dynamic trial

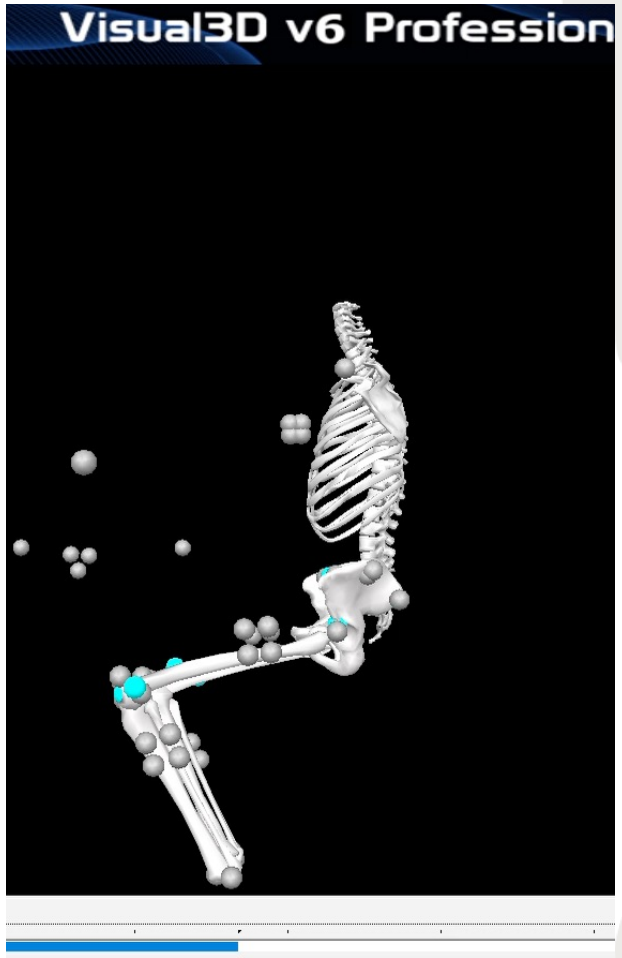
NATURAL SIT-STAND MOVEMENT



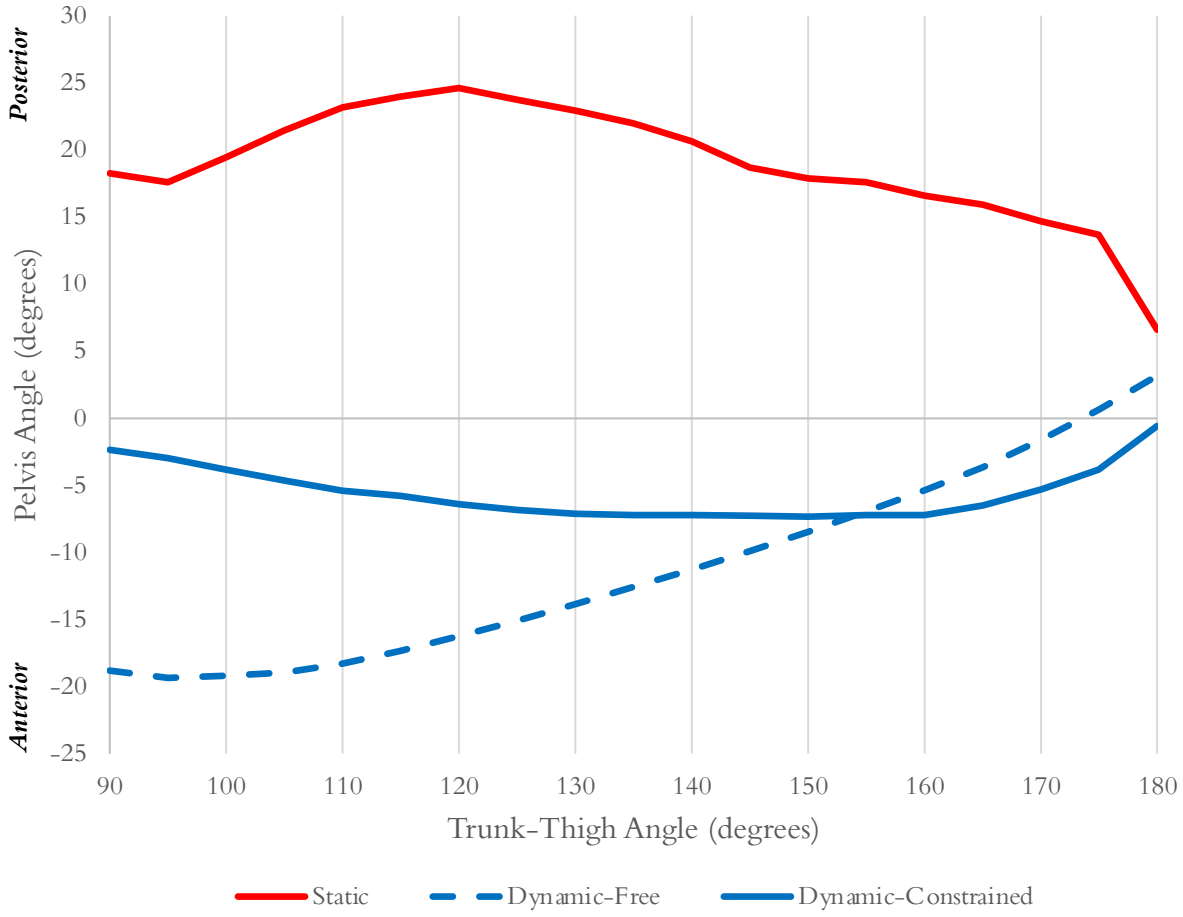
NATURAL VERSUS SEATED MOVEMENT

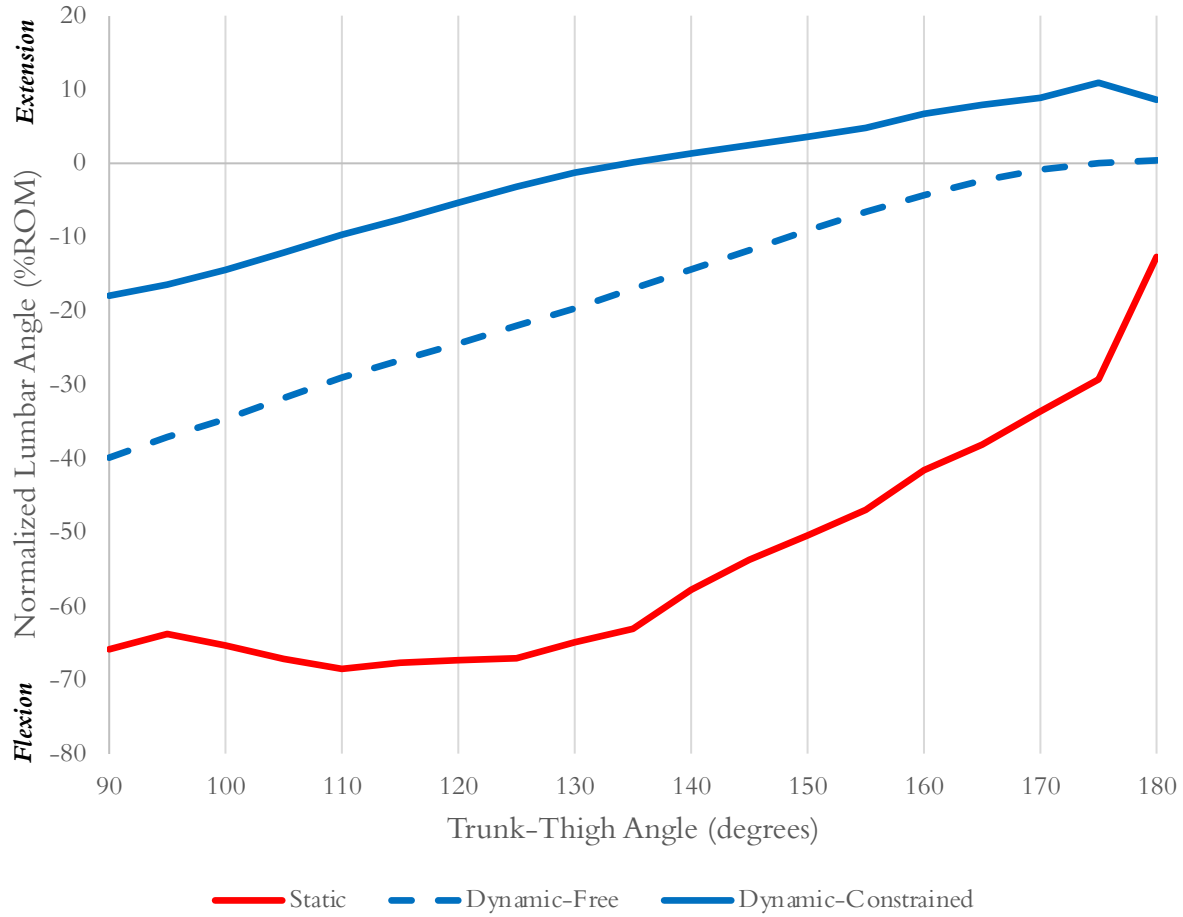




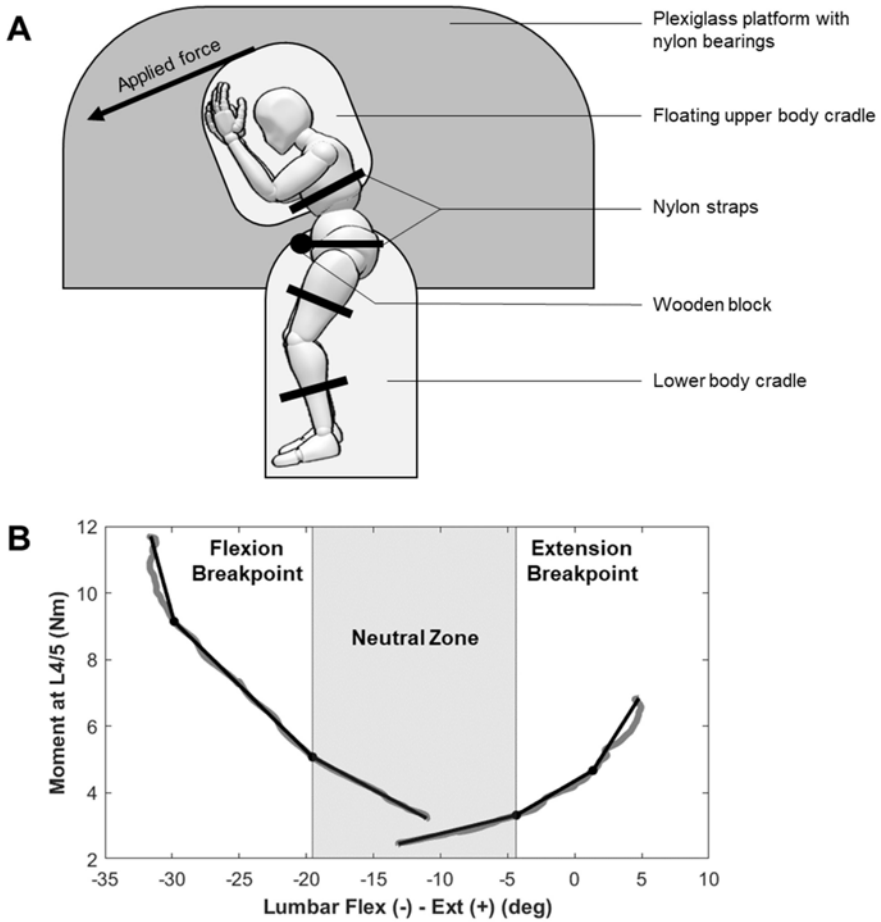


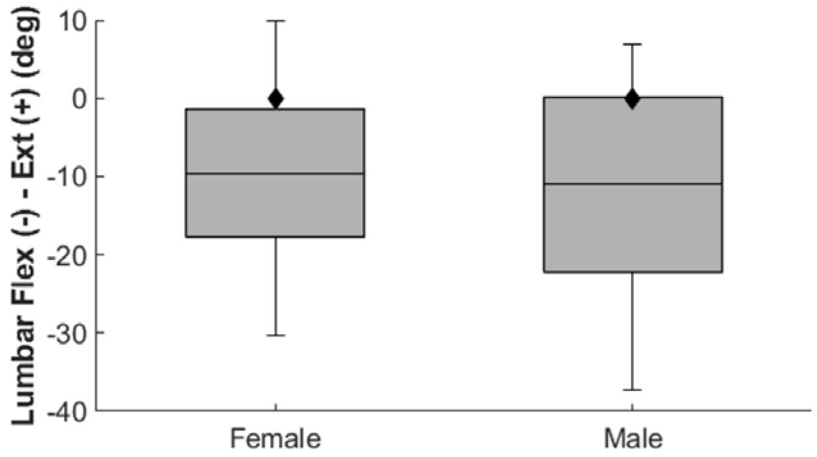
NATURAL SIT-STAND MOVEMENT VERSUS SIT-STAND SEATED RESPONSE

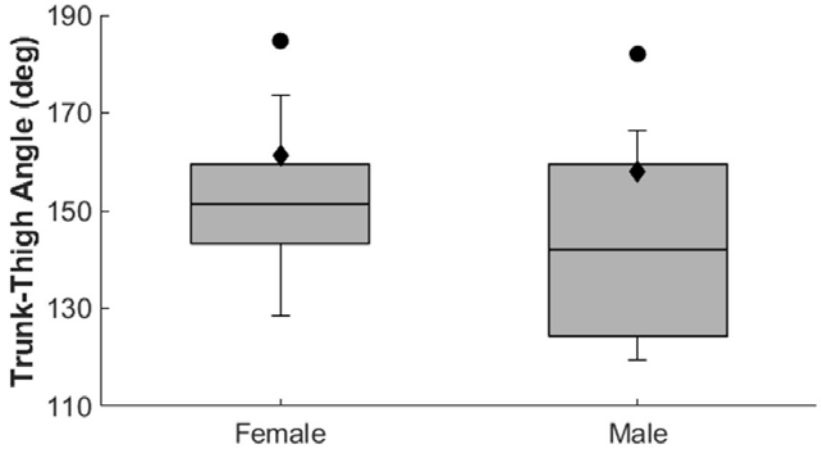




PASSIVE SPINE RESPONSE – AKA "NEUTRAL ZONE" OR "NEUTRAL POSTURE"

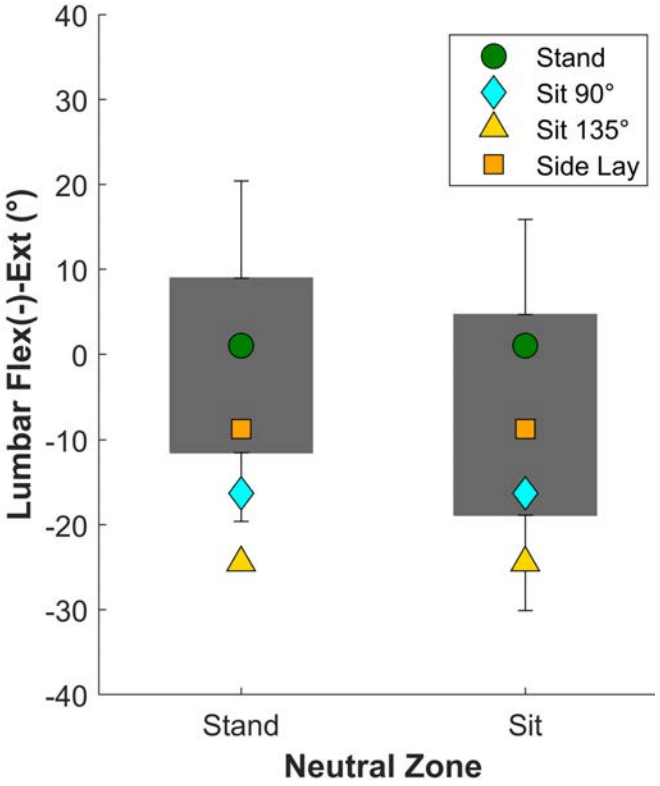


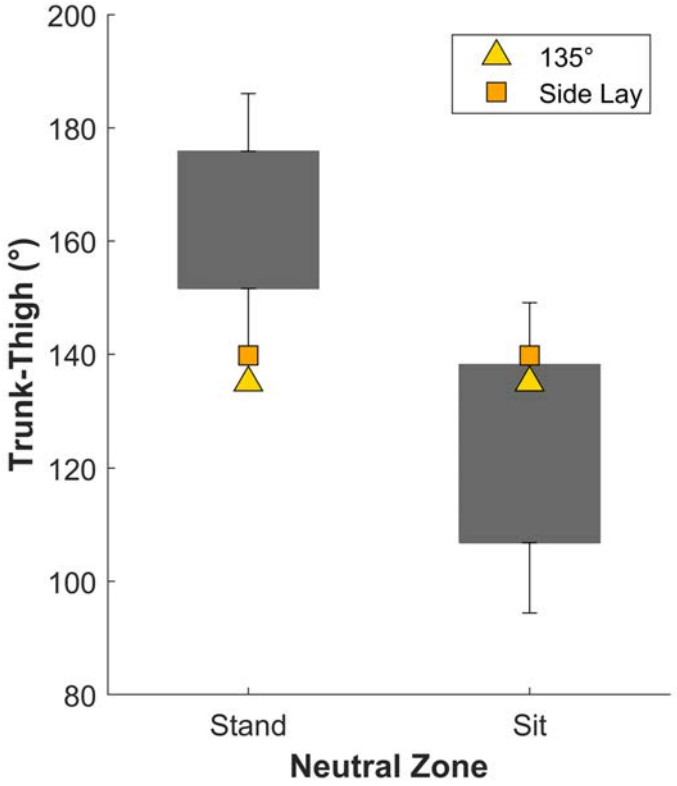


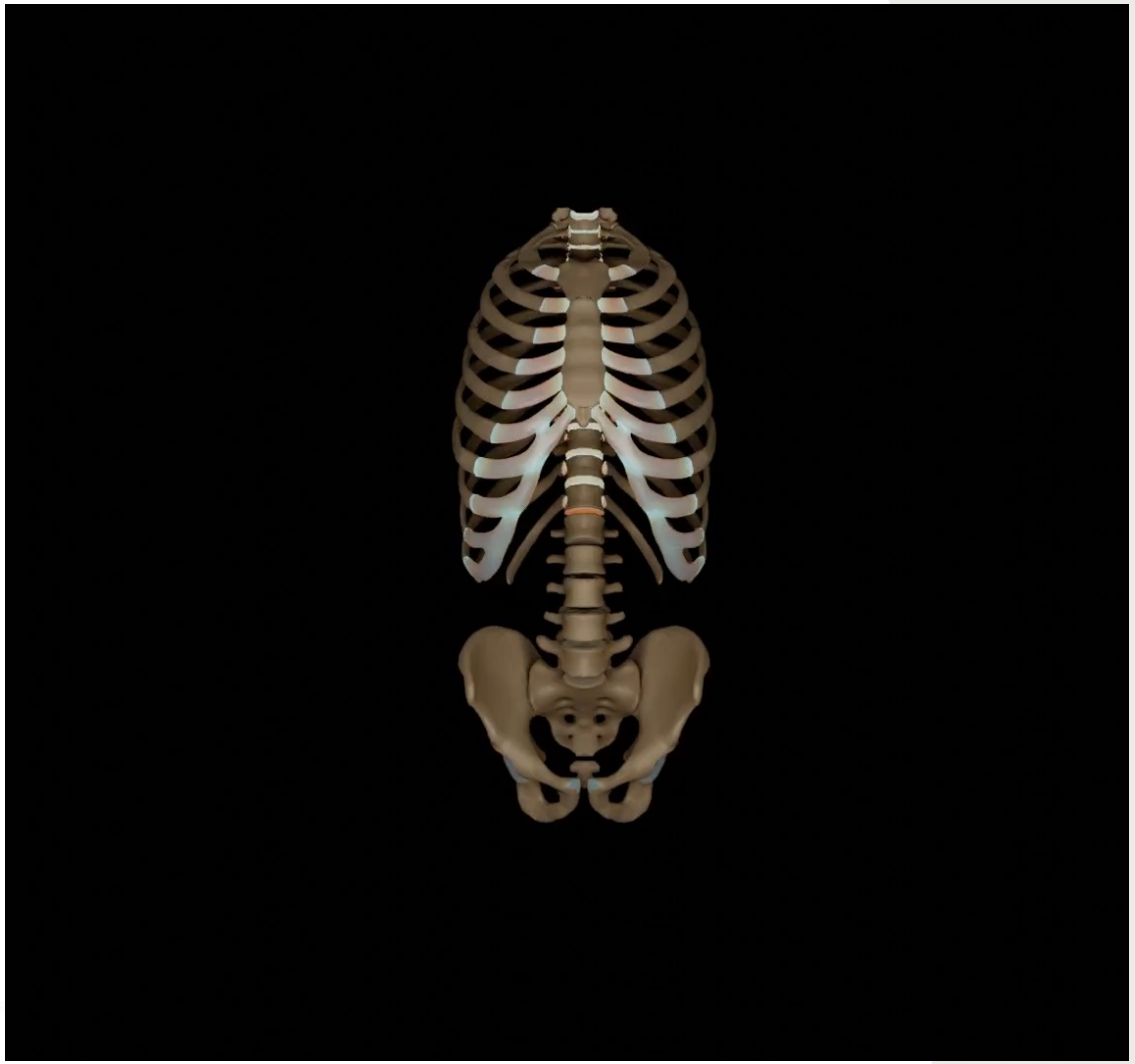


Buchman-Pearle, J.M., Gruevski, K.M., Gallagher, K.M., Barrett, J., Callaghan, J.P. Defining the lumbar and trunk-thigh neutral zone from the passive stiffness curve: Application to hybrid sit-stand postures and chair design. *Ergonomics* In Press, 2022.

NEUTRAL ZONE AND WORKING POSTURES



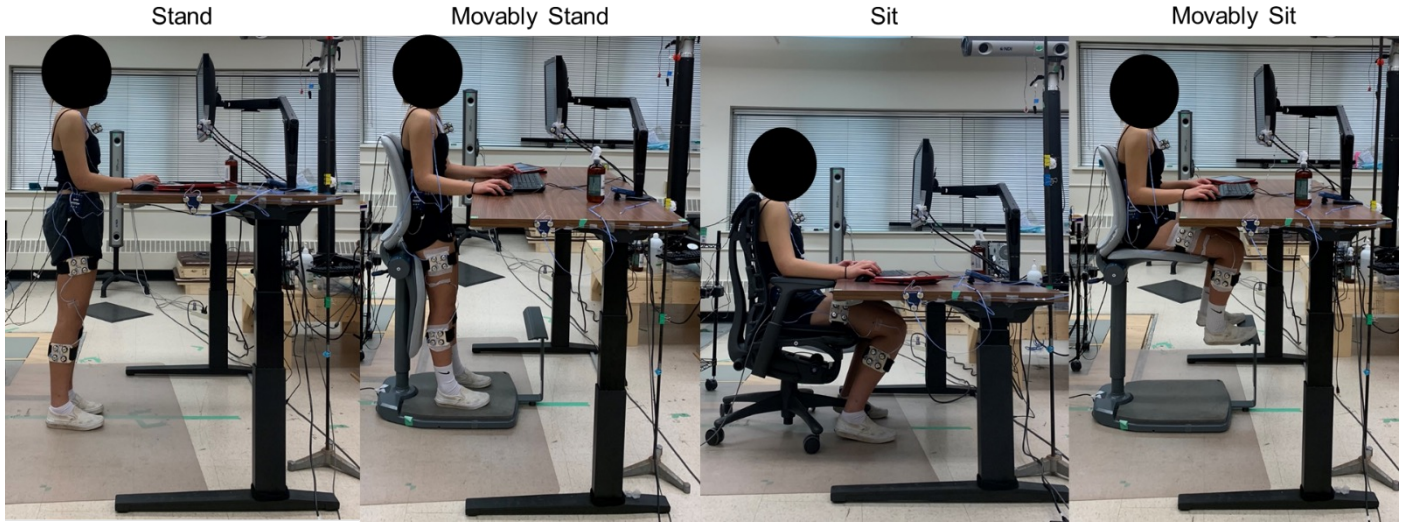




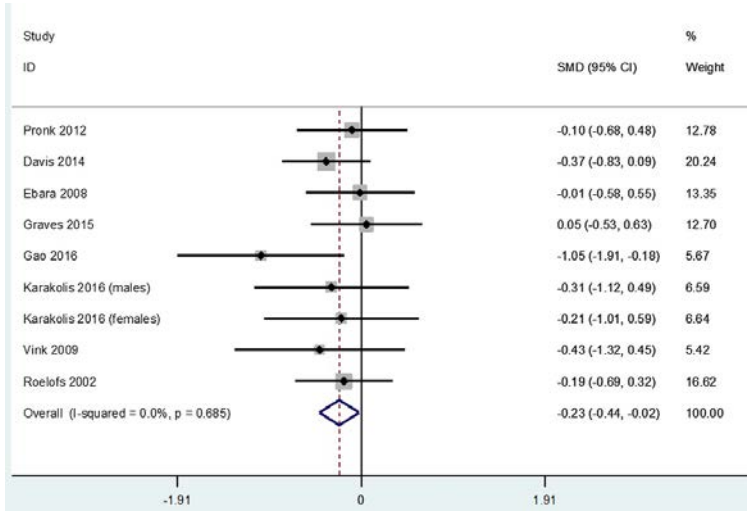
Buchman-Pearle, J.M., Pinto, B.L., Barrett, J.M., Callaghan, J.P. Does the lumbar and trunk-thigh posture adopted in sitting, standing and hybrid seated office work positions fall within the in vivo neutral zone?. *Journal of Applied Ergonomics* Submitted, 2022.

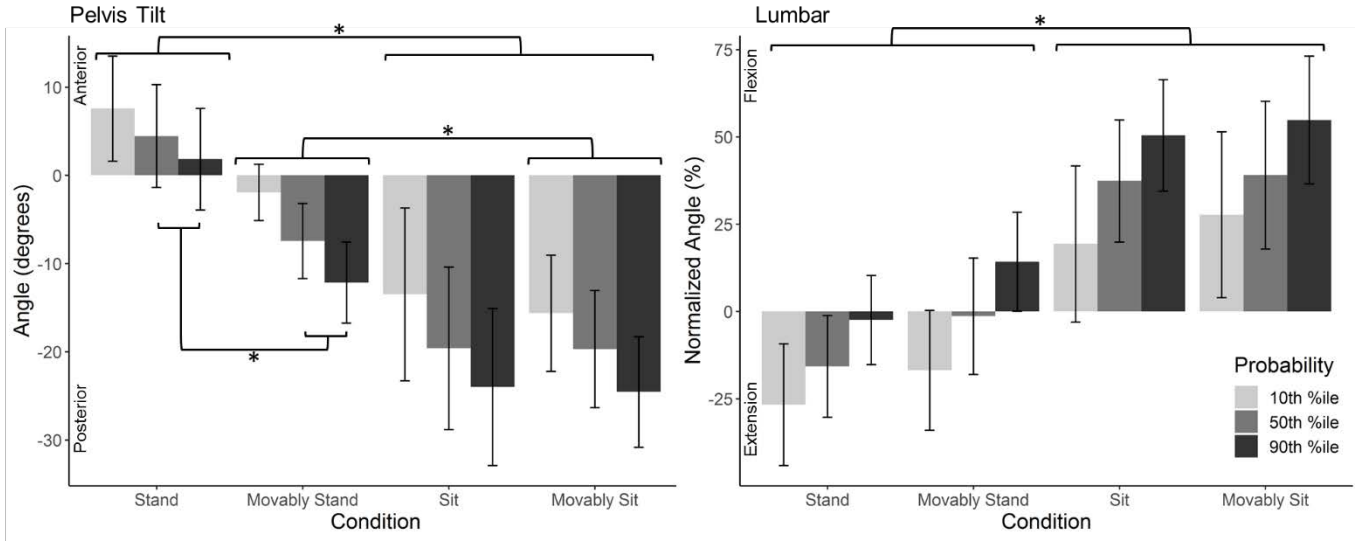
PAUSE

SIT AND STAND ROTATION



- Two-hour bout of sedentary desk work in 5 conditions
- Six, 15-minute blocks of desk work were performed.
- 5-minute rest break; participant remained in the assigned posture
- Three tasks with performance tracking were performed twice each:
  - Typing: Standardized Text passages
  - Data Entry: Transfer of product, client, and company information into user interface
  - Reading Comprehension: Qualitative Reasoning section of the standardized Graduate Record Exam (GRE)
- Discomfort in 13 body regions
- **Sit-Stand every 3 minutes – 20 over 2 hours**





Agarwal S, Steinmaus C, Harris-Adamson C. Sit-stand workstations and impact on low back discomfort: a systematic review and meta-analysis. Ergonomics. 2018;61(4):538-52.

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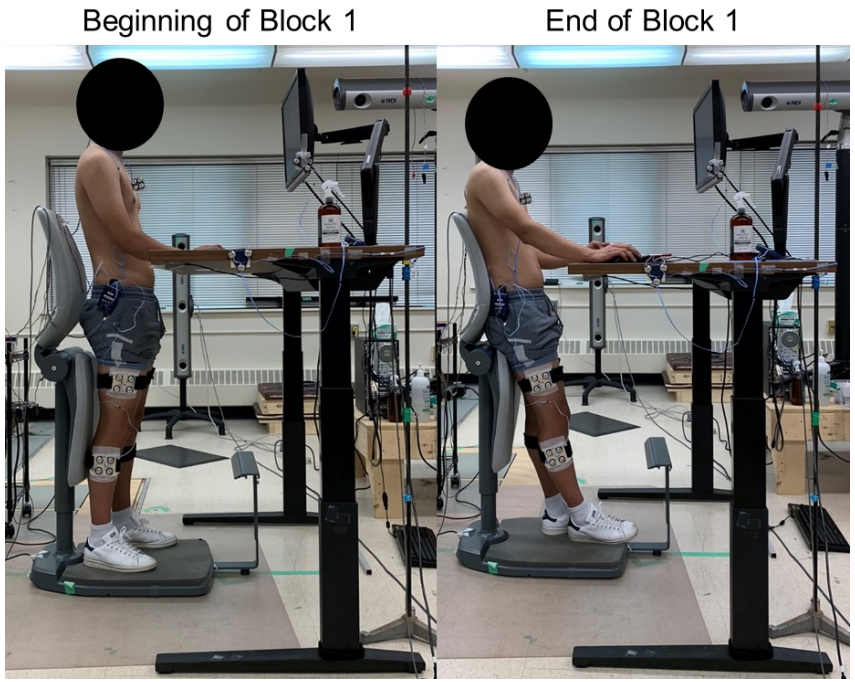
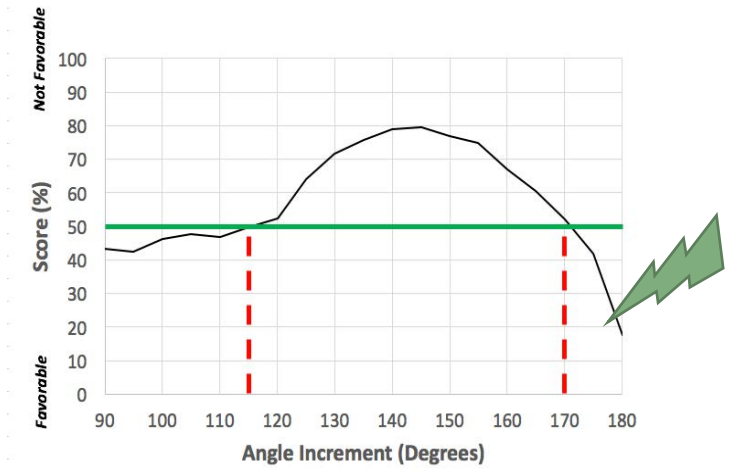
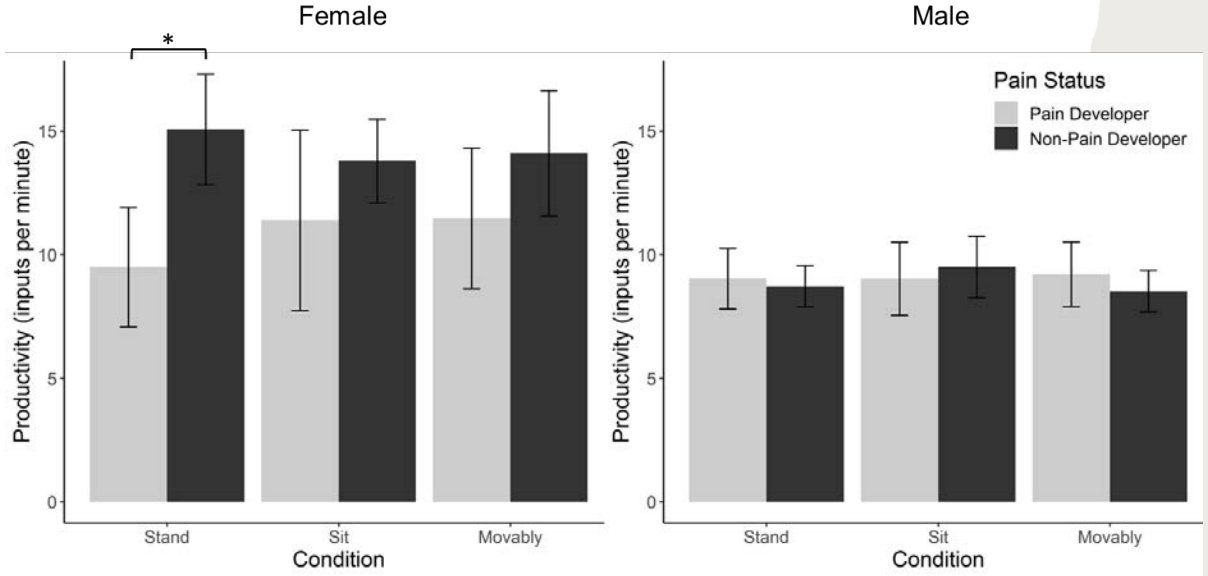
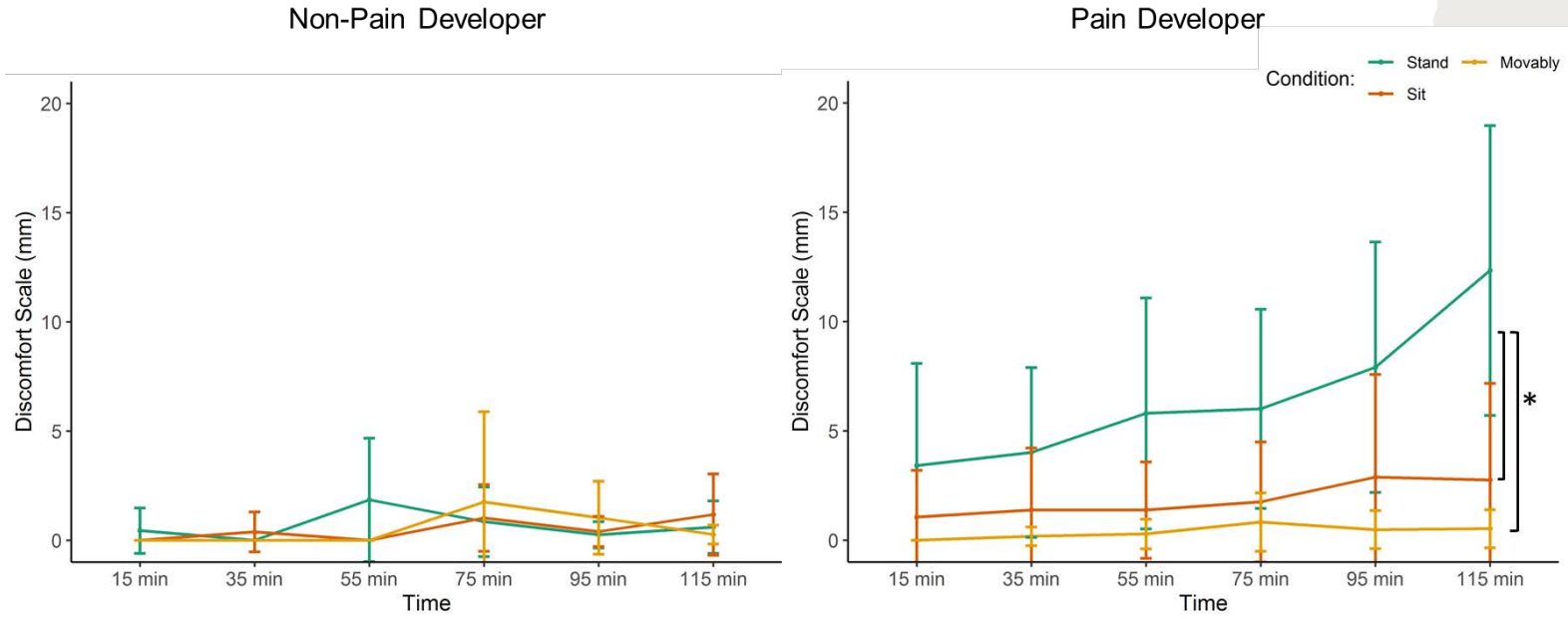
LEANING – THE NEW HYBRID?









TAKE HOME, TAKE OUT, TAKE AWAY

- Hybrid seating devices (i.e. open hip angle sitting):
  - Do not induce better low back postures
  - Are not a viable one-off workstation seating solution:
    i. create discomfort at the higher heights where postures differ from traditional sitting
    ii. may be suitable if they can accommodate traditional sitting (but may end up like unused HATs)
    iii. achievable postures below ~120 degrees do not alter lumbar posture – and still cause discomfort

- Sit to Stand rotations seem to be a more sound solution for
  - Health
  - Altering postures (i.e. good job rotation practice- gross postural change)

- "Leaning" available in some *large format* solutions
  - Provide a benefit in pain reduction
  - Create postures aligning with neutral zone measures
  - Can be cumbersome to enter and position
  - May not accommodate all desired postures (i.e. traditional sitting)
  - Impact on health outcomes associate with leaning are unknown (i.e. do they align with sitting and standing)

THANK YOU

- Quick Start Guideline: https://www.msdprevention.com/Quick-Start-Guideline-Office.htm

SITTING

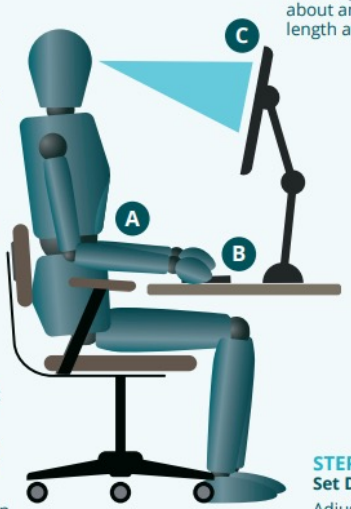
Introduce regular breaks and pauses into work. Stretching can help too.

STEP 5:
Set Monitor Height

The top of the computer screen should be at or below eye level and about an arm's length away.

STEP 1:
Set Chair Height

Knees and hips should be at 90° angles (thighs horizontal; lower legs vertical). Feet should be flat on the floor.



STEP 4:
Set Your Desk

Have your forearms approximately horizontal, with your wrists straight and not bent back.

The keyboard should be at about elbow level with the mouse close to the side of the keyboard to prevent side reaching.

STEP 2:
Set Chair Settings

Adjust backrest and seatpan such that the low back is well supported and there is no contact between the seat pan and back of the knees.

STEP 3:
Set Desk Height

Adjust desk height to be at or slightly below elbow height.

When Switching Between Sitting and Standing:

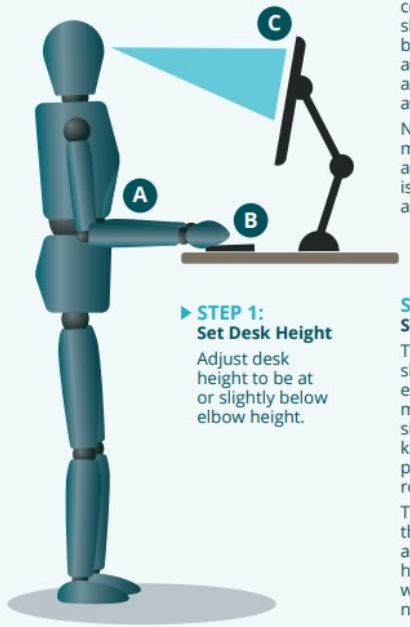
- **A** Set your desk height (ensure forearms are horizontal).
- **B** Make sure your keyboard is about elbow level and your mouse is close to the keyboard.
- **C** Ensure your monitor screen is at eye level. The location of the monitor changes between sitting and standing and needs to be adjusted. Keyboard and mouse placement may change too.

STANDING

STEP 3:
Set Monitor Height

The top of the computer screen should be at or below eye level and about an arm's length away.

Note: The monitor height above the desk is not the same as in sitting.



STEP 1:
Set Desk Height

Adjust desk height to be at or slightly below elbow height.

STEP 2:
Set Your Desk

The keyboard should be at about elbow level with the mouse close to the side of the keyboard to prevent side reaching.

The goal is to have the forearms approximately horizontal, with the wrists straight and not bent back.

POSTER 6: TRANSITIONING BETWEEN WORKING POSTURES

CRE-MSD
Centre of Research Expertise for the Prevention of Musculoskeletal Disorders

CHANGE IT UP: MOVE!

There is no single "correct" working position that fits everybody's work tasks and body and allows comfort for extended periods of time.

- There is no single "correct" position for office work.
- Working positions include reclining, leaning forward or standing.
- As long as the user can see, be supported, reach and work in comfort, a working posture is suitable.
- The working position needed for a particular task depends of factors such as the concentration or precision needed, the amount of movement needed and whether lifting or long reaches are required.
- Changing position regularly is critical to health and effectiveness.
- The working positions for a particular task depend on factors such as the concentration needed and whether long reaches are required.
  - **Sitting vs Standing:** Spending long periods of time continuously sitting OR standing is detrimental to health. Workers generally have more difficulties continuously standing than sitting at work.
  - **Sitting:** Best for tasks requiring high concentration, high precision or demanding visual requirements; little if any lifting or long reaches.
  - **Standing:** Best for tasks requiring a lot of movement and time spent away from the workstation or having long reaches or lifting, e.g., a postal clerk receiving parcels.
  - **Sit-Stand:** Best for tasks requiring high concentration, high precision or demanding visual requirements. A well-designed adjustable sit-stand desk allows change in working posture.
  - **Supported Standing:** Best when most tasks are suitable for standing but a worker would benefit from a short break from standing, e.g., a fold down stool for a supermarket cashier to "perch" on between customers.
  - **Sitting and Standing:** Best when workers need to be at eye level with a customer or client, when a variety of tasks are performed that require both sitting and standing positions, when a job involves movement to get to other equipment or when a worker lifts occasionally.

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ADDITIONAL UNANSWERED QUESTIONS FROM THE CHAT

- ***Do you think can measure the physiological consequences of these postures?***

  Absolutely! I think posture and muscle activity changes are physiologic consequences. If we are wondering about health impacts (like CVD and long term positive or negative outcomes) it would require some longitudinal data of users who have adopted a hybrid device and have used it for years. Given the newness of these devices and the small market share I would estimate it will take a while for this type of information to become available.

- ***Rather than siting upright with an increased hip angle, how about reclining with back support (backrest recline with forward sliding seat pan and flexible front seat edge) to allow for changes in posture…then standing? AND Would positioning the trunk in a (supported) reclined posture to open up the hip be beneficial (assuming keyboard/monitors positioned appropriately)? would the findings from the passive trunk/leg study help inform this question?***

  I know there are some workstaions that implement a solution like this as well as some gaming set ups. The practical issue here is about the need for either new worksurfaces or chairs with built in support for the computing peripherals. Currently, I think it may be a solution for individuals where it could solve a pain issue limiting work. I would also think about how the weight f the body is now acting on the spine differently than in an upright trunk posture (dominantly compression). As you recline more of the load becomes directed into shear and could result in flattening of the lumbar spine lordosis (known spine mechanical response), another thought would be that a reclined posture would also likely reduce dynamic micro-movements (like fidgets and shifts) as you would be working against gravity/pushed back into the reclined posture to be supported by the backrest (speculation – but sounds like a neat study!).

- ***Do you recommend anti fatigue mats when standing? Do they offer cushioning for the hips and pelvis?***

  Interestingly we have completed and published a study looking at this exact question. Here is a summary of the study:

  - Standing pain developers reported a subjective decrease in back pain.
  - There were no quantitative changes in posture of foot-floor interface measures that explained this change is pain (in other words these measure were no difference between standing on an AFM or without the mat).
  - There were some changes in movement (measured by increase centre of pressure excursion the number of body weight for both Pain developers and Non-Pain developers.
  - These findings suggest that AFMs may benefit individuals prone to developing standing-induced back pain, although largely due to subjective perception.

  Loading would not be changes at the hips and pelvis. Here is the reference for the full study if you are interested:

  Winberg, T.B., Glinka, M.N., Gallagher, K.M., Weaver, T.B., Laing, A.C., Callaghan, J.P. Anti-Fatigue mats can reduce low back discomfort in transient pain developers. *Applied Ergonomics* 100(103661): 1-7, 2022.