Force required to roll an office chair and the effect on human behavior.

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WMergo
Work Matters I Ergonomics

Background

Office ergonomists look at two types of movement:

1. Those that cause awkward postures.
2. Those that promote mini-breaks (visual or movement breaks).

Awkward postures can stress the spine and cause muscle fatigue or pain when repeated

consistently and over time. Awkward postures can lead to Muscloskeletal Disorders (MSDs) such as strains and sprains. When you are in an awkward posture, muscles operate less efficiently and you expend more force to complete the task (Reference 11). Awkward postures lead to faster muscle fatigue, leading to increased soreness and likelihood for injury.

So, what does that actually mean? Well, it basically means that using awkward postures such as bending sideways and bending forward puts you at greater risk for neck and low back pain that increases throughout the work day.

Mini-movement breaks allow muscles that have been static (not moving) to move and those muscles that are tense to relax, they allow blood to flow more freely in the legs, they are generally considered to be under 30-60 seconds in length. While micro breaks (mini-breaks) are a promising and simple strategy, just advising your clients on their potential benefits likely won't have any effect. This is because studies have shown that workers provided with education and advice only, did not take sufficiently frequent breaks to change discomfort levels (Reference 14, 15, 16).

So, what does this mean in general terms? Moving your body during the workday however small, such as moving your chair with your feet, increases blood circulation to organs including your brain for better function. Your feet muscles also act as a "blood pump" to increase oxygen delivery to muscles and organs while also allowing toxins and inflammation to be removed via your lymphatic system.

So, what if human behavior on different flooring surfaces naturally caused mini-breaks to occur? Are mini-breaks enough to combat the effects of prolonged sitting? That remains to be seen by more research, however given the following research, any movement breaks are preferable to none, especially when they are naturally caused and not needing reminders. A recent meta-analysis estimated a whopping 34% increase in mortality risk for adults who sit 10 hours per day (Reference 17). Studies have also shown sedentary time may be associated with increased cardiovascular and all-cause mortality, and an increased risk of type two diabetes (Reference 18).

Let's talk about flooring…. Flooring in an office space has been virtually overlooked as a component for ergonomics assessments or improvement. However, it seems that what your chair rolls on could be just as important as the chair itself, or is it? The present study is an initial step toward understanding the use of an office chair with different flooring - specifically the implications of how much force it takes to move a chair on different flooring **and** if the force to move the chair affects the amount of awkward postures versus mini-breaks observed.

Office chairs became a "hot" item during the COVID pandemic. Many people working from home quickly realized the virtue of a great chair versus a dining room chair. **What** the office chair is surrounded **by** is just as important - does the desk height fit the office chair, can you reach your keyboard and mouse easily? And, often overlooked, can you use your office chair in the way that it's meant? The wheels are made for easy movement to roll and put things away - to utilize the space you have easily, the swivel is made so that you can easily reach items you don't keep in immediate reach on your desktop. But are these functions being used to their capability? And, ultimately could the chair functions be utilized to provide more visual and mini-movement breaks if on the proper flooring?

A literature revealed that ergonomic interventions often include the work surface and chair adjustments, however no studies were found on the effects of the flooring and use of chair functions. Few journal articles exist on the possible benefits of changing the office environment to increase steps during the work day (Reference 1). However none of these studies mentioned the type of flooring in the office or looked at whether using the rolling function of the office chair could provide movement that counteracted the effects of prolonged sitting or the effect of small visual breaks from the Video Display Terminal (commonly know as the computer monitor).

Ergonomically speaking the office chair was created to maintain a comfortable posture during a work day. However, as people get more sedentary and spend more and more time at their computers - the office chair is one mode that can provide 30-60 second mini-breaks to use legs for movement and break from staring at a screen, reading, and typing. But, how much is

the office chair really being used for these mini-breaks? One research study found, “Office workers spend many hours sitting, thus efforts to increase movement through changes of posture (sit to stand) or moving while sitting have been proposed as ways to mitigate the negative effects of prolonged sitting” (Reference 2).

A few anecdotes were found on the benefits of a chair mat versus carpet such as, “Chair mats also make it much easier to move within your workspace—it takes 80% less effort to roll your chair on a mat than on carpet. And rolling your chair around on carpet all day can cause back pain and leg strain. Not to mention the static electricity carpet generates. An anti-static chair mat prevents static from reaching your computer or other electronic equipment, where it could cause you to lose data, or could damage your equipment” (Reference 3). However, no references were cited as to the origin of this data.

Ergonomist utilize both administrative controls (changing the way people work through coaching to form different habits) and engineering controls (changing something in the environment to cause a change in the way people work). Administrative controls are the least preferred strategy because they require a change in habits, which for most humans is difficult. Engineering controls cause a change without requiring a change in human habits and are therefore the preferred strategy for ergonomists.

Does rolling an office chair provide mini-breaks that are signifiant to mitigate the negative side effects of prolonged sitting and staring at a computer monitor? And, could increased ease of rolling an office chair have an effect on work space tidiness and organization?

During COVID the world also developed an obsession with organizing. Organizing requires **space** and utilizing an entire office space whether it’s a home office, cubicle or executive office. But, how easy is it to access that space depending on the flooring you have?

When it comes to office space, and especially, your immediate desktop area, studies have shown that a tidy workspace aids in focus. Simply put, “When our space is a mess, so are we.” “Our physical environments significantly influence our cognition, emotions, and behavior, affecting our decision-making and relationships with others” (Reference 4).

“Cluttered spaces can have negative effects on our stress and anxiety levels, as well as our ability to focus, our eating choices, and even our sleep” (Reference 5). A cluttered desk could even ruin your chance at promotion as evidenced by one study and, “Around half of those with everything neat and tidy feel more in control, more productive and generally happier” (Reference 6, 7, 8). This study does not address whether the amount of force to move an office chair results in tidier office spaces - but it would be an interesting study!

Funding

This research was fully funded by Vitrazza®. The funder provided support in the form of payment for study design and execution for authors (KM), but did not have any additional role in the study design, data collection and analysis, or preparation of the manuscript.

*WM ergo, Work Matters I Ergonomics became an affiliate of Vitrazza® after the completion of study design, data collection, and study write-up.

Purpose

The purpose of this pilot study was to determine the amount of force required to roll an office chair on different flooring surfaces. Secondly, human behaviors such as movement in an office chair and awkward postures were recorded in an attempt to determine if there was a correlation between force required to roll an office chair and human behaviors.

Materials

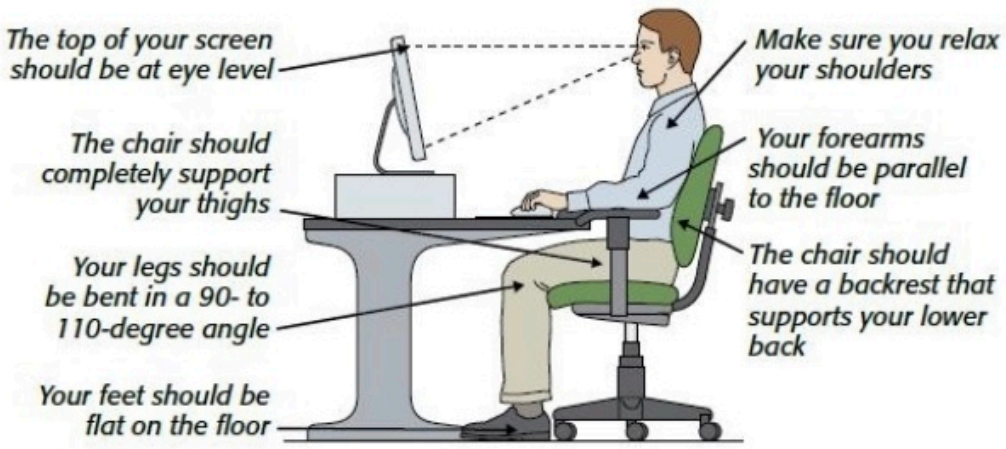
ME-500 push pull force gauge
Office chair - adjustable height
Work space (desk) - fixed height
Vitrazza® glass chair mat 45”x53”
Medium pile rug
Carpet tiles, low pile
Plastic chair mat 45”x53” for use with low pile carpet
Vinyl chair mat 45”x53” for use with medium pile carpet
Laptop computer
External keyboard
External mouse
Paper
Recycle bin
Document holder
Script
Consent form

Participants volunteered for study participating and were recruited through Craft Coworking and WM ergo Work Matters I Ergonomics.

Keywords - defined

- ***Mini-breaks*** - For the purpose of this study mini-breaks were defined as any movement of the chair more than 3 inches from starting position and any swivel of the chair greater than 45 degrees (both requiring participant to use feet to move chair) - both judged by observation.
- Mini-movement breaks allow muscles that have been static (not moving) to move and those muscles that are tense to relax, they allow blood to flow more freely in the legs (increasing removal of toxins and inflammation through our lymphatic system and ensuring nutrients and oxygen are delivered to muscles and organs for proper function). Mini-movement breaks are generally considered to be under 30-60 seconds in length. Static postures, even if ergonomic, are still a risk factor if over-used. Our body requires movement and variety, which is why the best approach is to use a variety of ergonomic postures in rotation, breaking up long periods of static working… Changing postures between sitting and standing is not sufficient for any worker – the working environment must still offer ways of varying their postures and incorporating movement into their daily working routines (Reference 19).

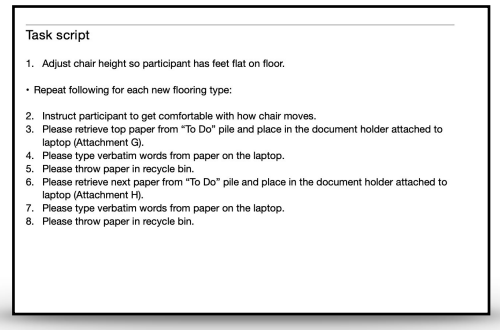
- ***Awkward posture*** - For the purpose of this study an awkward posture was defined as any trunk position that differed from the neutral starting sitting position including trunk side bend and trunk flexion more than 45 degrees - both judged by observation.
- Awkward posture refers to positions of the body that deviate significantly from the neutral position while performing work activities. When you are in an awkward posture, muscles operate less efficiently and you expend more force to complete the task (Reference 11). Poor or awkward postures put unnecessary strain on the musculoskeletal system and, over time, can cause the deterioration of muscle fibres and joints. For example, **the risk of neck pain increases** when the neck is rotated more than 45 degrees for more than 25% of the working day (Reference 19).



(Reference 9).

Human Behaviors:

1. Participants were recruited through Craft Coworking, Golden, Colorado and social media via Craft Coworking and WM ergo Work Matters I Ergonomics. See Attachment J.
2. Participants signed a consent to participate in the study and a photograph release, Attachment C.
3. Demographic information was collected in a simple chart format, Attachment D.
4. Standard office furniture supplied by Craft Coworking was utilized including a work surface and chair. Laptop, external keyboard, external mouse, recycle bin, rug, plastic chair mat, vinyl chair mat were supplied by WM ergo.
5. Glass chair mats were supplied by Vitrazza®.
6. Dimensions were replicated to estimate a typical office cubicle of 6'x8' to 10'x12' from the Colorado Office of the State Architect using the "Assigned Workstation, Dedicated or Shared" standard (Reference 10 and Attachment K).
7. Participants were seated in office chair. Office chair height was adjusted so that feet were flat on floor and participants could comfortably reach keyboard and mouse.
8. Participants were instructed to get comfortable with how the chair moved.
9. Participants were assessed using the same "Task Script" to be performed in a controlled office environment.



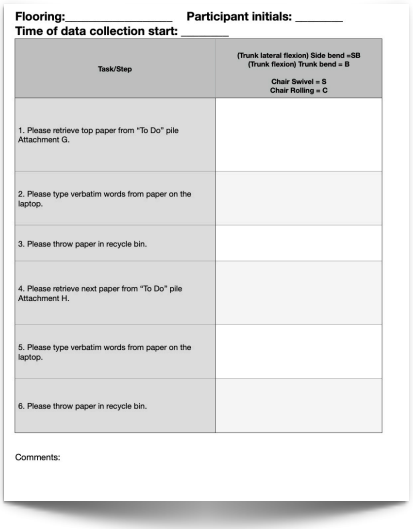
Task script

1. Adjust chair height so participant has feet flat on floor.

• Repeat following for each new flooring type:

2. Instruct participant to get comfortable with how chair moves.
3. Please retrieve top paper from "To Do" pile and place in the document holder attached to laptop (Attachment G).
4. Please type verbatim words from paper on the laptop.
5. Please throw paper in recycle bin.
6. Please retrieve next paper from "To Do" pile and place in the document holder attached to laptop (Attachment H).
7. Please type verbatim words from paper on the laptop.
8. Please throw paper in recycle bin.

10. Two "stations" were used:
    1. Medium pile rug, medium pile rug+vinyl chair mat, medium pile rug+Vitrazza® glass chair mat
    2. Carpet tiles, carpet tiles+plastic chair mat, carpet tiles+Vitrazza® glass chair mat
11. Tasks were performed on flooring consisting of:
    1. Medium pile rug
    2. Medium pile rug with a tabbed 45"x53" vinyl chair mat (Reference 12)
    3. Medium pile rug with a Vitrazza® 45"x53" glass chair mat
    4. Carpet tiles, low pile
    5. Carpet tiles, low pile with a 45"x53" plastic chair mat (Reference 13)
    6. Carpet tiles, low pile with a Vitrazza® 45"x53" glass chair mat
12. Observational data collected using abbreviations to designate types of movements observed during tasks.
13. Participants were paid $50 compensation for time.



Flooring:_____ Participant initials: _____
Time of data collection start: _____

Task/Step	(Trunk lateral flexion) Side bend =SB (Trunk flexion) Trunk bend = B Chair Swivel = S Chair Rolling = C
1. Please retrieve top paper from "To Do" pile Attachment G.	
2. Please type verbatim words from paper on the laptop.	
3. Please throw paper in recycle bin.	
4. Please retrieve next paper from "To Do" pile Attachment H.	
5. Please type verbatim words from paper on the laptop.	
6. Please throw paper in recycle bin.	

Comments:

Observational data collection sheet

Force:

1. Force was measured after Human Behavior data collection.
2. A Mark-10 ME-500 digital ergonomic force gauge with looped strap and hook was used to collect data measurements.
3. Flooring types measured:
    1. Low pile carpet tiles
    2. Plastic chair mat over carpet tiles
    3. Vitrazza® glass chair mat over carpet tiles
    4. Medium pile rug
    5. Vinyl chair mat over medium pile rug
    6. Vitrazza® glass chair mat over medium pile rug
4. Force measurements (in foot pounds) were recorded 3 times for each surface (with 0 pounds added to the chair and with 100 pounds added to the chair in the form of hand-weights) and an average of measurements was reported. Records were taken for 1 foot of movement across each flooring type of the peak foot pound value recorded and averaged. Chair was pulled forward by KM using equipment described above

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Results

Participants used a variety of methods to complete each task including a mix of awkward postures and mini-movement breaks. Results were tallied for all methods each participant used to accomplish the task.

During the data collection three opportunities for movement were presented to participants through the task script.

Eight participants were recruited for the study and participated in data collection. Four men and four women volunteered for the study age range 60-26 years old. Approximate height ranged from 5 feet 4 inches to 6 feet 2 inches and approximate weight ranged from 150-195 pounds, while approximate arm length ranged from 26 inches to 32 inches.

Foot Pound Force:

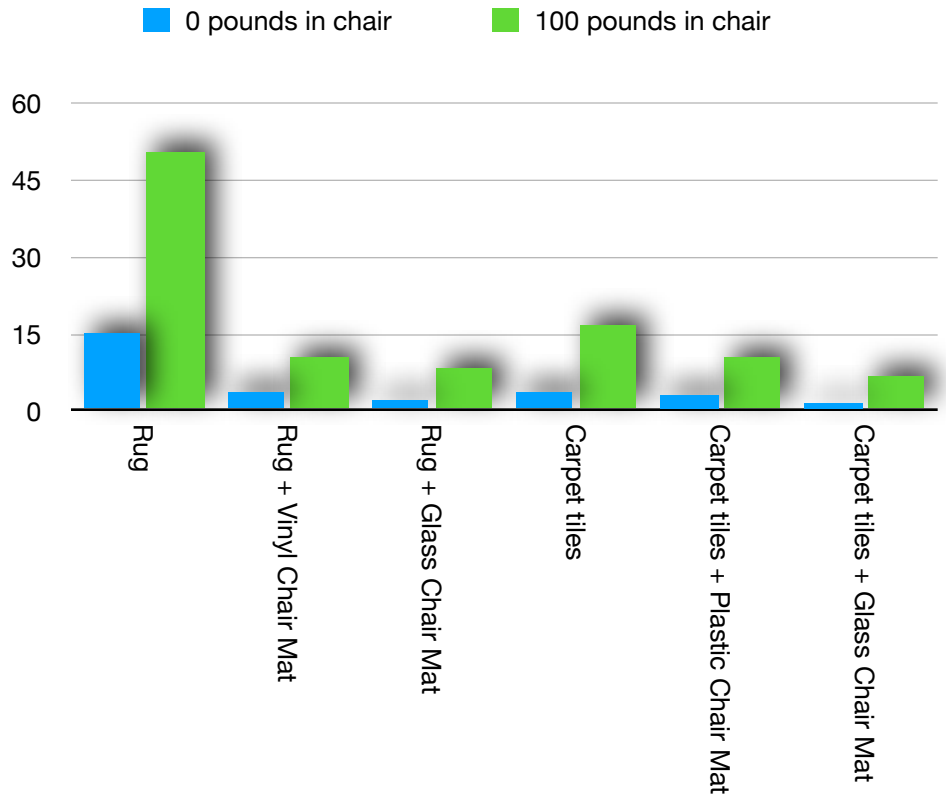
Foot pounds were used via a force gauge to determine how much pull force was necessary to move an office chair both with 0 pounds added to the chair and with 100 pounds in hand weights added to the chair.

Foot Pound Averages

	Rug	Rug + Vinyl Chair Mat	Rug + Glass Chair Mat	Carpet Tiles	Carpet Tiles + Plastic Chair Mat	Carpet Tiles + Glass Chair Mat
0 pounds in chair	14.9	3.77	2.17*	3.67	3.27	1.57*
100 pounds in chair	50.37	10.53	8.5*	16.47	10.5	6.95*

*The foot pound force difference in the Vitrazza® Glass Chair Mat + Rug versus the Vitrazza® Glass Chair Mat + Carpet Tiles is an anomaly that is not able to be explained in this research since the Glass Chair Mats used were identical. Hypothesis possible to explain the difference in foot pound force - 1. difference in static created by the rug versus the carpet tiles 2. slope of the floor between two stations that resulted in different foot pound measurements. However, since two different foot pound forces were collected in data collection the data comparisons were maintained via which workstation they were collected.

The least amount of force necessary to move the chair was obtained by carpet tiles + Vitrazza® glass chair mat with 0 pounds in the chair. The most amount of force necessary to move the chair was obtained by a medium pile rug with 1000 pounds added to the chair.

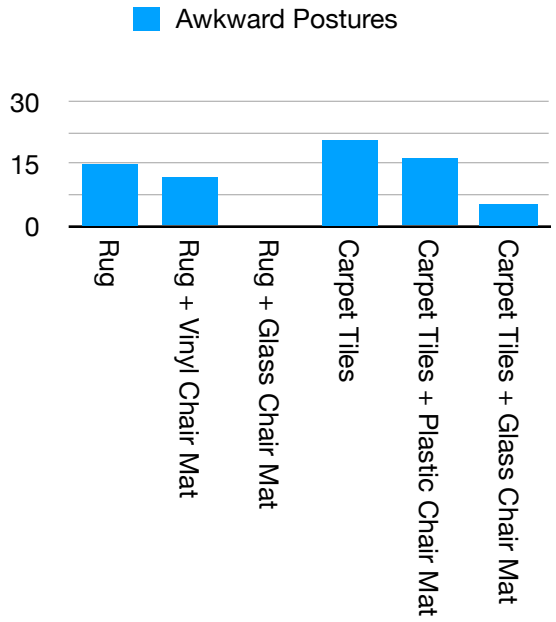


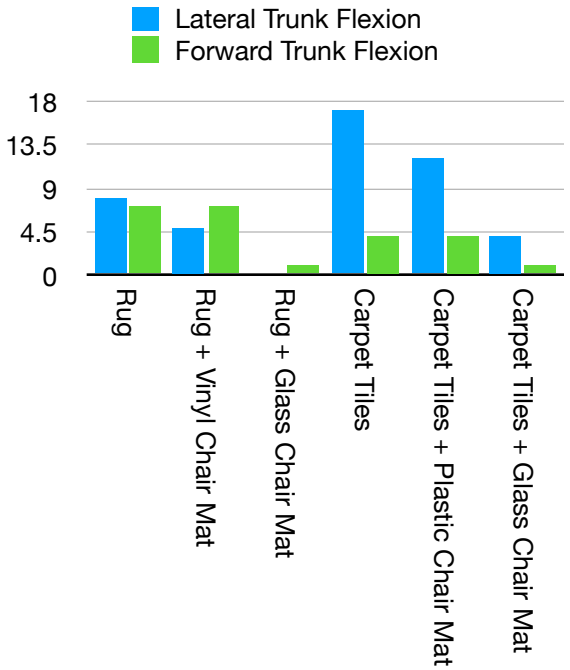
Frequency of awkward postures and mini-movements:

Frequency of Movement

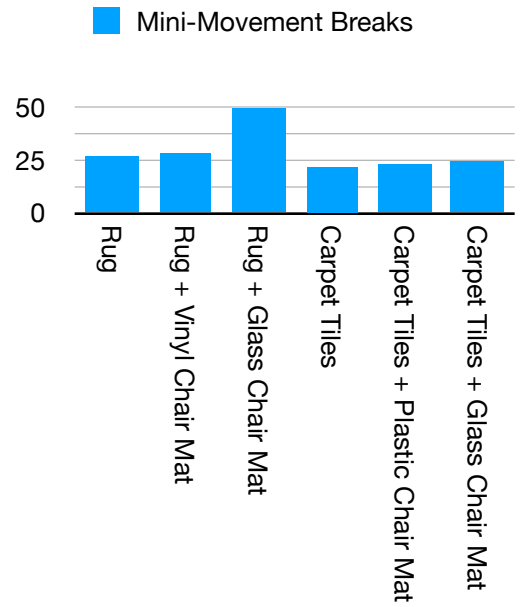
	Rug	Rug + Vinyl Chair Mat	Rug + Glass Chair Mat	Carpet Tiles	Carpet Tiles + Plastic Chair Mat	Carpet Tiles + Glass Chair Mat
Lateral Trunk Flexion	8	5	0	17	12	4
Forward Trunk Flexion	7	7	1	4	4	1
Swivel	16	15	23	9	9	10
Roll	3	13	26	12	14	14

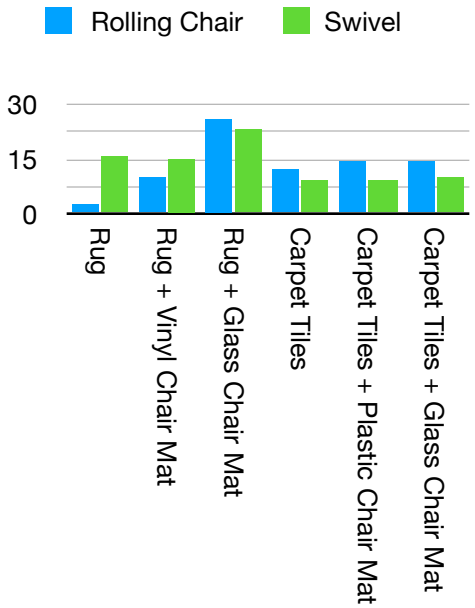
Awkward postures were calculated in two ways - first by adding lateral trunk flexion and forward trunk flexion greater than 45 degrees together and secondly by looking at lateral trunk flexion and forward trunk flexion separately. Fewer awkward postures were recorded on the flooring surfaces that required less foot pounds to move the chair both for lateral trunk flexion and forward trunk flexion.





Mini-movement breaks were calculated in two ways - looking first at both swivel and rolling combined and secondly looking at swivel and rolling separately. More mini-movement breaks were recorded on the flooring surfaces that required less foot pounds to move the chair.





Percent change

Percent change was used to determine increase and decrease in awkward postures, mini-movements and foot pound force. The percent change calculation used was: $\%\ \text{change} = 100 \times \frac{(\text{final} - \text{initial})}{|\text{initial}|}$. This calculation was chosen for its ability to look at not only percentage but directional percentage (ie. increase or decrease).

Foot pound force comparisons (100 pounds in chair):

Versus:	Vitrazza® Glass Chair Mat decreased foot pound force required to move chair with 100 pounds by:
Rug	83%
Rug + Vinyl Chair Mat	19%

Versus:	Vitrazza® Glass Chair Mat decreased foot pound force required to move chair with 100 pounds by:
Carpet Tiles	58%
Carpet Tiles + Plastic Chair Mat	34%

Looking specifically at change in both awkward postures and mini-movements the following calculations were obtained using a “percent change” calculation showing percent reduction of awkward postures and percentage increase in mini-movements:

Reduction in awkward postures:

- The Vitrazza® Glass Chair Mat was compared to all other options in reduction of awkward postures:

Versus:	Vitrazza® Glass Chair Mat decreased awkward postures by:
Rug	93%
Rug + Vinyl Chair Mat	92%

Versus:	Vitrazza® Glass Chair Mat decreased awkward postures by:
Carpet Tiles (low pile)	76%
Carpet Tiles (low pile) + Plastic Chair Mat	69%

Increase in mini-movement breaks:

- The Vitrazza® Glass Chair Mat was compared to all other options in increasing mini-movement breaks:

Versus:	Vitrazza® Glass Chair Mat increased mini-movement breaks by:
Rug	61%
Rug + Vinyl Chair Mat	43%

Versus:	Vitrazza® Glass Chair Mat increased mini-movement breaks by:
Carpet Tiles (low pile)	13%
Carpet Tiles (low pile) + Plastic Chair Mat	4%

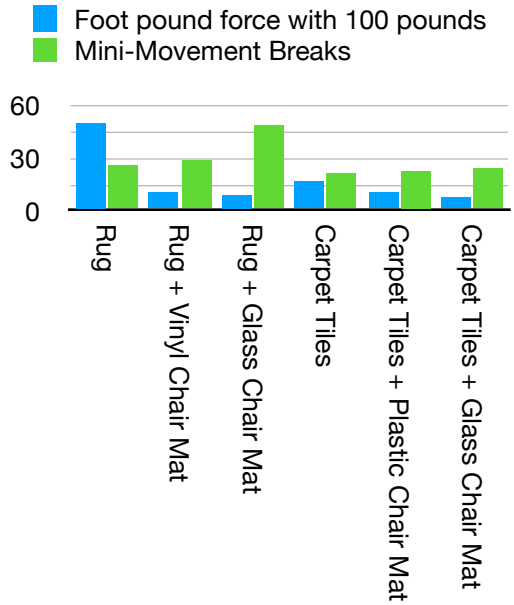
Conclusion

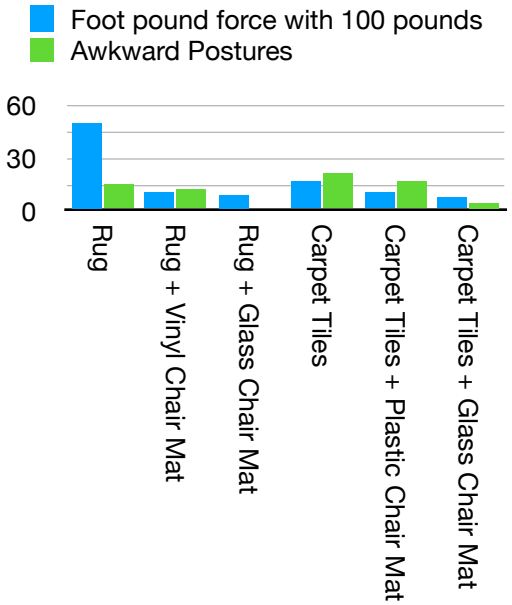
Participants used a variety of combined movements to accomplish the tasks from the script. Overall, when the foot pound force required to move the chair went up - so did the use of awkward postures by the participants and the participants moved the chair through swiveling or rolling less. Conversely, when the foot pound force required to move the chair went down participants were more likely to use their feet to move the chair by either swiveling or rolling or both and less likely to use an awkward posture.

These participants had no coaching how to use the chair. The participants were not coached on the benefits of moving the chair or the risk of using awkward postures.

The foot pound force required to move an office chair appears to be correlated with how many awkward postures a person uses and also inversely correlated with how many mini-movement breaks a person utilizes. For example, 34% decrease in foot pound force to move an office chair on a Vitrazza® glass chair mat versus a plastic chair mat over carpet tiles resulted in a 69% decrease in awkward postures.

As you can see from the charts below as foot pound force to move a chair with 100 pounds goes down the mini-movement breaks go up. Conversely, when the foot pound force goes down the awkward postures go down.





Simply put:

- **more** foot pounds required to move a chair = **more** awkward postures and **fewer** mini-movement breaks
- **less** foot pounds required to move a chair = **fewer** awkward postures and **more** mini-movement breaks

The increased mini-movement breaks on flooring requiring less foot pound force to move (ie. Vitrazza® Glass Chair Mat) could translate into a healthier work environment by naturally encouraging increased blood flow to organs and muscles via foot movement, incorporating more movement naturally, without the worker requiring reminders or coaching to move. In addition, the decrease in awkward postures, when less foot pound force was required to move the chair, could translate into a reduction of repeated awkward postures that can lead to MSDs contributing to neck and low back pain.

Changing the flooring surface in an office space is an engineering control (not requiring a change in habits), demonstrated by this pilot study to have a natural effect in changing behaviors. By using flooring that requires less foot pound force for movement (i.e. Vitrazza® Glass Chair Mat) both mini-movement breaks and fewer awkward postures are naturally achieved. The aspiration is that flooring as an engineering control would also result in less neck and back pain as the result of a person using fewer awkward postures and increased movement. Of course more research would need to be conducted to correlate neck and back pain, increased blood flow, and increased lymphatic efficiency to use of an office chair and flooring type.

From this pilot study it's clear that human behaviors were changed by simply changing flooring surfaces. Those requiring less foot pounds of force to move resulted in more natural opportunities for movement and fewer awkward postures.

When looking at the flooring that resulted in the greatest reduction in awkward movement **plus** the greatest increase in mini-movement breaks, the the Vitrazza® Glass Chair Mat provided more benefit in reducing "bad" awkward postures and increasing "good" mini-movement breaks versus the other flooring choices. All other flooring choices resulted in more "bad" postures and fewer "good" movements than the Vitrazza® Glass Chair Mat.

Ergonomist should consider assessing flooring in any office space just as we assess the fit of a task chair or the position of computer monitors. Flooring should be added as a consistent potential change to increase movement and decrease awkward postures. Choosing a flooring that requires less foot pounds of force to move a chair seemed to be correlated to both reducing awkward postures and increasing mini-movement breaks.

By coaching clients to place items such as printers, trash and recycle bins, documents, stapler, and other frequently used work tools in locations that would require rolling or swiveling, more movement could naturally be added into any office space, as long as the client ***has*** flooring that promotes mini-movement breaks and not awkward postures.

This pilot study demonstrates that there is likely a correlation between office flooring and human behaviors even with no coaching for benefits and risks of certain movements. More research needs to be conducted to further investigate the effects of office flooring on human behavior and the risks and benefits of different movements while seated in an office chair.

Attachment C

We, are asking you to participate in a research study titled “Force required to roll an office chair and the effect on human behavior.” We will describe this study to you and answer any of your questions. This study is being led by Kelly Meetz, MSPT, CEAS I WM ergo.

What the study is about
The purpose of this research is to determine the amount of force required to roll an office chair on different flooring surfaces. Secondly, human behaviors such as movement in an office chair and awkward postures were recorded in an attempt to determine if there was a correlation between force required to roll an office chair and human behaviors.

What we will ask you to do
We will ask you to follow simple directions and complete tasks in a mock office space on different types of flooring to record specific observed behaviors.

Risks and discomforts
We do not anticipate any risks from participating in this research.

Benefits
No direct benefits are perceived from participating in this study.

Compensation for participation
$50 cash per participant who completes the full study.

Photograph consent

- Photographs will assist the researcher to document certain postures and movement and may be used in a submission of a white paper to an academic journal or for marketing materials.
- **All faces will be blacked out of photographs**
- Photographs may be included in publications in the future

- I do not want to have photographs.
- I am willing to have photographs.

Signed: _____
Date: _____

Privacy/Confidentiality/Data Security

- Data collected from this study will be maintained securely for at least 7 years
- No personal identification information will be collected or used during this study or if study is included in a publication

Taking part is voluntary

Participant involvement is voluntary, the participant may refuse to participate before the study begins, discontinue at any time, or skip any questions/procedures that may make him/her feel uncomfortable, with no penalty to him/her, and no effect on the compensation earned before withdrawing, or their academic standing, record, or relationship with the university or other organization or service that may be involved with the research.

If you have questions

The main researcher conducting this study is Kelly Meetz, MSPT, CEAS I. Please ask any questions you have now. If you have questions later, you may contact Kelly Meetz at kelly@wmergo.com or at 303.777.4511.

Statement of Consent

I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Your Signature: _____

Date: _____

Your Name (printed): _____

Signature of person obtaining consent: _____
Printed name of person obtaining consent: _____
Date: _____

This consent form will be kept by the researcher for 7 years beyond the end of the study.

Attachment D

Demographics of person

Participant Initials	Age	Approximate height	Approximate weight	Male or Female	Arm length of right arm

Attachement F

I acknowledge that I received $50 as payment for participation in the study “Force required to roll office chair and the effect on human behavior.”

_____

Signature Date

Twinkle twinkle little star,

How I wonder what you are?

Up above the world so high,

Like a diamond in the sky!

Twinkle twinkle little star,

How I wonder what you are?

Colorado Rocky Mountain high,

I've seen it rainin' fire in the sky,

The shadow from the starlight is softer than a lullaby,

Rocky Mountain high, Colorado,

Rocky Mountain high, high in Colorado!

Attachment J

VOLUNTEERS NEEDED

PLEASE PARTICIPATE!

Work Matters I Ergonomics (WM ergo) is conducting a study of office flooring and the effects on human behaviors.

$50

COMPENSATION FOR ALL PARTICIPANTS

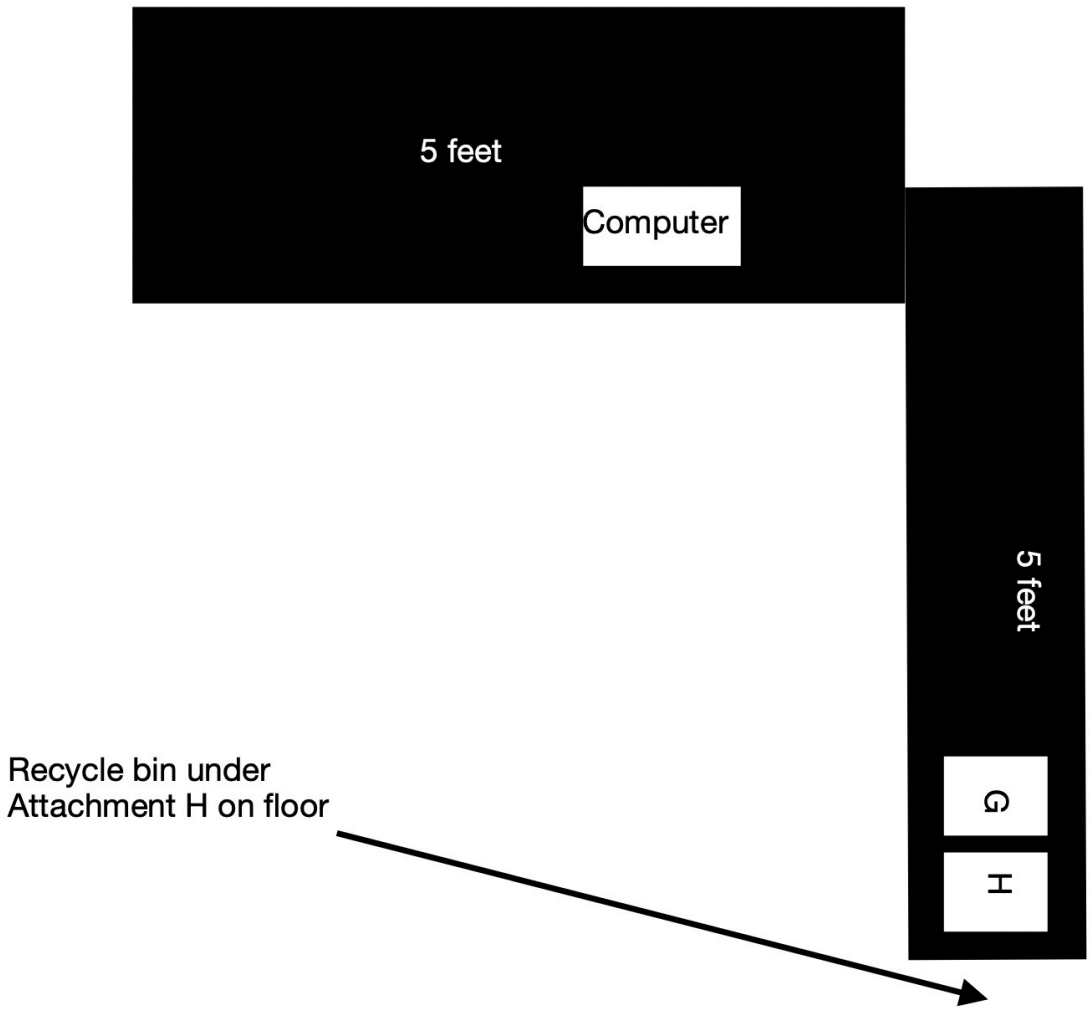
Data collection will take place on *July 14, 2022* at Craft Coworking.

Participation will require approximately 30-45 minutes per participant.

PARTICIPANTS WILL BE CONTACTED TO SCHEDULE SPECIFIC TIME SLOT

KELLY@WMERGO.COM

Attachment K



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