

Research

Ice Pack-Cooled Ergonomic Chair Support Impact on Spine Pain and Flexion-Relaxation Phenomenon: A Pilot Study

John Ward, DC, MA, MS^{1*}, Jesse Coats, DC, BS, DAAPM, CCSP²

Address: ^{1*}Associate Professor/Research Fellow, Department of Physiology and Chemistry, Texas Chiropractic College, Pasadenda, TX, USA, ²Professor, Department of Clinical Specialties, Texas Chiropractic College, Pasadena, TX, USA.

E-mail: John Ward, DC, MA, MS – jward@txchiro.edu

*Corresponding author

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Abstract

Objective: The study purpose was to assess the impact of the ice pack-cooled Spine Buddy LT1 H/C chair support on relieving spine pain and modifying muscle activity patterns during a functional task.

Methods: Thirty-two college students (age 27.8 + 6.4 y, height 1.72 + 0.11 m, body mass 83.2 + 21.0 kg, hours seated that day 5.9 + 1.6 hr: mean + SD) completed a Nordic Musculoskeletal Questionnaire (NMQ) instrument and a Flexion-Relaxation Phenomenon (FRP) test before and after sitting for 12 minutes in a standard office chair outfitted with a Spine Buddy LT1 H/C support containing 2 ice packs. The FRP test was conducted using 2 surface EMG sensors bilaterally to measure the electrical activity of the lower erector spinae muscles. A paired samples t-test was used to measure within-group changes for NMQ for 3 spine regions and FRP for the 4 phases of the test.

Results: Neck-related NMQ scores decreased 0.38 pts ($t(31) = 3.00$, $p = 0.005$, $d = 0.35$) and lower back-related NMQ scores decreased 0.81 pts ($t(31) = 4.76$, $p = 0.000$, $d = 0.63$) after the use of the support pad. In addition, the extension and flexion phases of the FRP post-test demonstrated that participants were approaching a more pain-free lower back muscle activation profile.

Conclusions: Preliminarily, the addition of an ice pack-cooled chair support product to an office chair was associated with decreased neck and low back pain/discomfort, as well as modestly normalized FRP test results short-term.

Introduction

Neck pain and low back pain are common medical complaints¹⁻³ that cost the US healthcare system billions of dollars annually.⁴⁻⁵ Globally, the 1 year incidence of neck pain is between 10.4% - 21.3%, with neck pain more commonly affecting office workers and females in general.¹ Low back pain is the second most common cause for physician visits.¹ It also is a frequent cause of absenteeism (absent from work)⁵⁻⁹ and presenteeism (present at work, but with impaired performance).¹⁰⁻¹³ Safe methods to reduce neck and low back pain during the workday are needed to help employees with pain that are attempting to work.

The Spine Buddy LT1 H/C ergonomic chair support is marketed as a product that can decrease neck and low back pain.¹⁴ Although the manufacturer has engaged in research on some of their products,¹⁵⁻¹⁸ literature and website searches revealed that the Spine Buddy LT1 H/C, the company's newest product, has not been extensively tested. The anterior surface of the product is an ergonomic memory foam cushion, while the posterior surface is modified to vertically hold two large cold or hot packs (the H stands for hot and C for cold). Consumers can use either side to fit their needs.

Cryotherapy is a well-established form of care to decrease musculoskeletal pain¹⁹⁻²⁷ and it is a common treatment for patients with neck or low back pain.²⁸⁻³¹ Cryotherapy can induce vasoconstriction to decrease swelling,¹⁹ lower localized pro-inflammatory cytokines (histamine, kinins, and prostaglandins),²⁰ decrease sensory nerve conduction,²¹ diminish spasms,²²⁻²³ and utilize the gate theory of pain control to lower pain perception by acting as a counter-irritant.³²⁻³³

The purpose of this study was to investigate the ability of the ice pack-cooled Spine Buddy chair support pad at lowering spine-related pain and influencing muscle activity patterns during a functional task. The researchers' hypothesis was that the ice-pack cooled pad would lower spine pain based on survey data and that muscle activity patterns would normalize more during a functional task.

Methods

This research experiment was reviewed and approved by the Texas Chiropractic College Institutional Review Board for human subjects in accordance with the Declaration of Helsinki. This trial was registered with the University hospital Medical Information Network Clinical Trials Registry (UMIN-CTR), trial number: UMIN 000021095 (Reg# R000024335).

Study Design, Rationale, and Setting

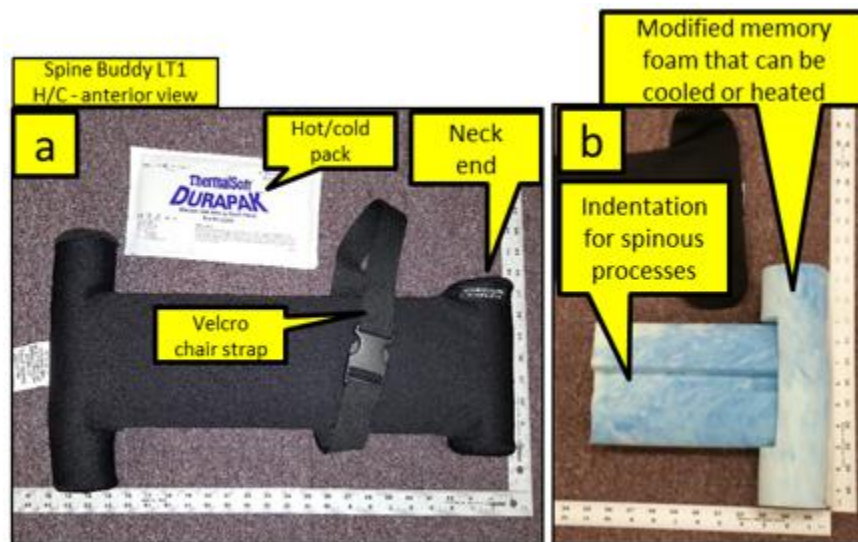
This was a single-arm controlled trial measuring the immediate impact of the Spine Buddy LT1 H/C when loaded with 2 ice packs on neck and back pain (**Fig. 1-2**). Thirty-two participants completed a baseline Nordic Musculoskeletal Questionnaire (NMQ),³⁴⁻³⁶ which is used to measure regional body pain/discomfort. After this they engaged in a Flexion-Relaxation Phenomenon test (**Fig. 3**).³⁷⁻³⁸ This test involved standing participants attempting to flex their torso forward at their hips to reach as far down as they could and then return back upright (similar to a standing toe-touch activity). The intent of performing this objective test was to see if muscle activity patterns were becoming more normalized during the post-assessment in response to the intervention. Next they sat in a chair for 12 minutes against a Spine Buddy LT1 H/C ergonomic chair support pad with 2 ice packs inside. Twelve minutes was

arbitrarily chosen because that is a similar time frame as some passive therapeutic modalities that are used in a chiropractic doctor's office. Afterward, participants completed another NMQ, FRP test, and wrote down how many hours they sat in a chair that day. Participants only attended 1 study session.

Figure 1. Spine Buddy LT1 H/C with ice packs. Masking tape was used to mark the specific location on the floor for the chair wheels to ensure similar placement between participants. The photograph shows the posterior aspect of the support pad that houses 2 large Velcro pouches for cold packs. The anterior aspect of the pad has a contoured memory foam pad designed to accommodate the spinous processes of the vertebral column.



Figure 2. Close up of the (a) Spine Buddy LT1 H/C product and ThermalSoft ice pack/hot pack, (b) removable composite memory foam cushion with blue gel crystals from the Spine Buddy.



This experiment occurred in a research lab with the ambient room temperature set to 74°F. Researchers intentionally avoided playing music in the lab background during the study. This was done to reduce the possibility that the calming effect of some forms of music could act as a covariate for perception of pain.³⁹

Participant recruitment

Study participants were recruited between November 2015 and January 2016 on a college campus. This population was targeted because students often sit for long periods of time⁴⁰ and thus represent a demographic pertinent to this research. Prior to enrollment, study applicants were screened to determine whether they met the inclusion and exclusion criteria (Fig. 4). They were provided with a copy of the informed consent and inclusion/exclusion criteria in several classes a few weeks in advance of the study. The sample included participants with at least one regional location of spine pain/discomfort out of the three regions focused on with the survey (cervical, thoracic, lumbar).

Figure 4. Study inclusion and exclusion criteria.

Inclusion criteria were:
1) college students 18-65 years of age
2) provide written informed consent
3) between 5'5" and 6'
Study participants with any of the following were excluded from the study:
1) diagnosis of any blood vessel or neurological disorder that would result in a decreased ability to perceive pain
2) sweaty or damp clothing worn by participants
3) wearing a sports bra or similar minimalist clothing that would put most of their back directly in contact with the cooled Spine Buddy product

All study applicants provided written informed consent prior to participation. This research project utilized a convenience sample of 32 study participants and did not follow an *a priori* power analysis. Participants were blinded to the manufacturer's claims for the product being tested (that the product was purported to lower spine pain), but they were able to observe the product as they sat down.

Product's attributes

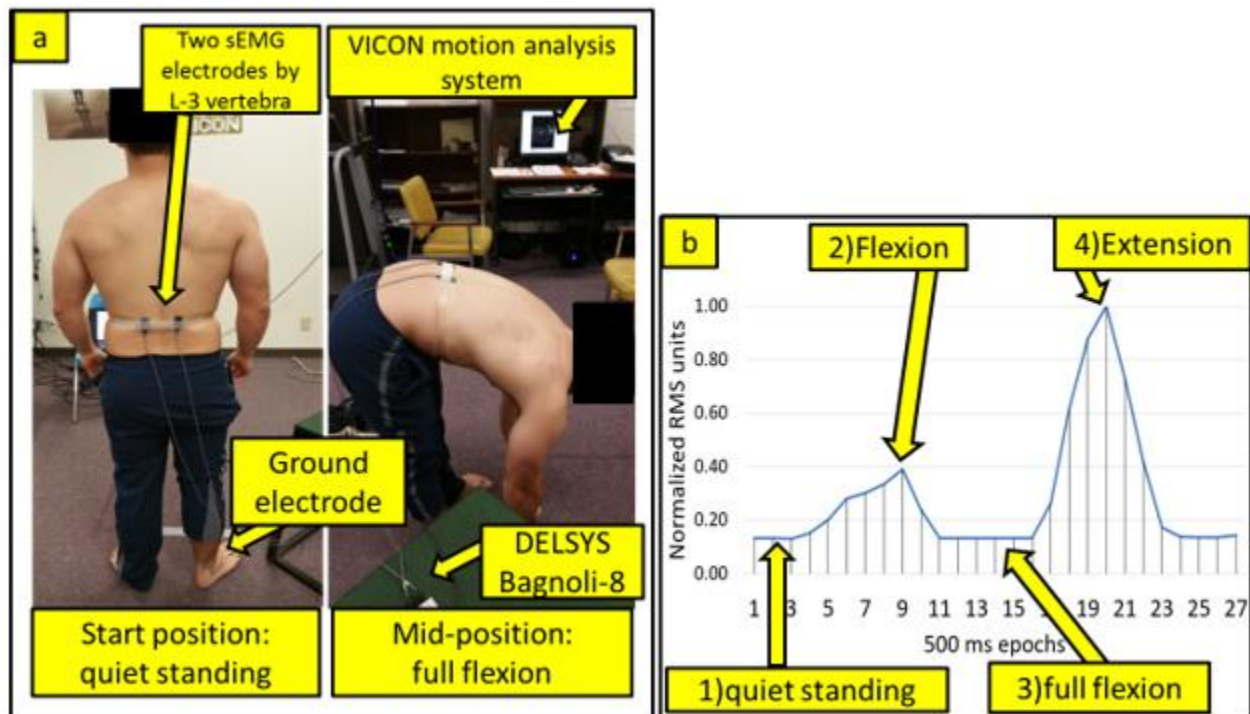
The Spine Buddy LT1 H/C memory foam support pad (Spine Buddy, Humble, TX, USA) has a soft core with rounded horizontal enlargements at the lower back and neck regions to help conform to the lordotic curves of the spine. The pad is approximately 540 mm long x 280 mm wide x 80 mm thick. The product has a Velcro strap that is used to affix it to chairs. The support pad has Velcro pouches on the posterior surface to accommodate 2 large gel packs that can be heated or cooled. For the cold pad analysis, the ThermalSoft (Mettler Electronics Corp., Anaheim, CA, USA) gel ice packs were kept in a portable Emerson CR500 freezer (Emerson Radio Corp, China) overnight. Multiple sets of ice packs were used in this study to ensure that each participant utilized a pack straight from the freezer.

Assessments and chair properties

The NMQ instrument is used to rate pain or discomfort in 12 bodily regions (eye, neck, shoulder, upper back, elbow, lower back, arm, wrist/hand, thigh, knee, calf, and feet/ankle) on a 5-point scale. On the scale "1" represents extremely comfortable and "5" represents extremely uncomfortable.³⁴⁻³⁶ Although data was collected on all 12 regions, the focus of the study was limited to the neck, upper back, and lower back. Researchers intentionally did not reduce the 12 questions to 3 questions in an attempt to make it less likely that participants would remember the exact numbers they filled out at baseline testing.

The Flexion-Relaxation Phenomenon (FRP) test (**Fig. 3**) is commonly used in low back pain research to assess the functional electrical activity of the lower back muscles.⁴¹⁻⁴³ Typically, as individuals eccentrically descend and concentrically ascend the electrical activity in their erector spinae muscles increases. Patients with significant spine pain demonstrate an aberrant FRP pattern or a generalized increase in muscle activity throughout the task (i.e., muscle guarding).⁴⁴ Participants were instructed to take approximately 3 seconds to bring their torso to a fully flexed position and to take another 3 seconds to return to an upright position. They were instructed to avoid touching their toes if they were flexible, and instead to bend at their waist as far as they could for the full flexion phase of the FRP test.

Figure 3. Illustration of the Flexion-Relaxation Phenomenon test. (a) Participant engaged in a standing toe-touch test to measure the Flexion-Relaxation Phenomenon (FRP) using surface EMG (sEMG), and (b) a sample graph showing each of the 4 phases of the FRP test summarized in 500 ms RMS epochs. Data was recorded for approximately 15 seconds per participant as they slowly moved through each of the 4 positions of the FRP test.



Surface EMG data was monitored using a Bagnoli 8 (Delsys, Natick, MA, USA) unit and was recorded through a VICON motion analysis system (Vicon, Centennial, CO, USA). Data were recorded at 1,000 Hz and processed with a Butterworth filter. The ground electrode was placed on the right lateral malleolus. Root Mean Square (RMS) analysis was utilized to smooth data using 500 ms epochs as shown in Fig. 3b. Final data were normalized in relation to highest RMS value per phase out of the 4 FRP phases (baseline to post-test, per participant) as was done by Harvey *et al.*⁴⁵

The chair used in this study was a black leather office executive chair with armrests (Office Star Products, China). Participants were not allowed to adjust the chair height and were instructed not to move or swivel the chair. The chair height was set at 18" from the inferior plastic shell of the underside of the seat to the floor. Duct tape was used to mark the exact location of each of the chair's wheels on

the floor, in order to keep its position in the room similar for all study participants. Participants were instructed to remove any thick sweaters, coats, or similar items, as these would block the impact of the cold Spine Buddy pad. Similarly, they were told that they could not wear a sports bra, cut-off shirt, or similar attire that would place the skin of their back directly against the product. They were asked to keep both feet on the floor, and were allowed to read during the 12-minute cooling period.

Statistical analysis

The data were exported from VICON as .csv files and initially organized and processed in Excel (Microsoft, Redmond WA, USA). The data were then placed in SPSS version 20.0 (IBM, Armonk, NY, USA) for analysis. Results are reported as mean \pm standard deviation (SD) unless otherwise specified.

A paired samples *t*-test was used to measure within-group changes over time for each of the 3 spine-related NMQ traits and the 4 phases of the FRP test. An alpha level of $p \leq 0.05$ was considered statistically significant for all tests. Cohen's *d* was determined for all statistically significant interactions as recommended by Field for paired samples *t*-tests to avoid overestimation of effect size.⁴⁶

Results

Attributes of participants were: age 27.8 ± 6.4 y, height 1.72 ± 0.11 m, and body mass 83.2 ± 21.0 kg (mean \pm SD). No study applicants violated the inclusion/exclusion criteria for this experiment.

As shown in **Table 1**, the NMQ scores for the neck region decreased 0.38 pts ($t(31) = 3.00, p = 0.005$) which represented a small effect size ($d = 0.35$). The NMQ scores for the lower back decreased 0.81 pts ($t(31) = 4.76, p = 0.000$) which represented a medium effect size ($d = 0.63$). The effect on pain/discomfort in the thoracic spine area was not statistically significant ($p=0.056$).

Table 1. Baseline and post-test results for the Nordic Musculoskeletal Questionnaire pain/discomfort (1-5) scale for the 32 study participants. Diff= baseline minus post-test value; L 95% CI = lower 95% confidence interval, U 95% CI = upper 95% confidence interval.

	Baseline	Post-test	Diff	L 95% CI	U 95% CI	<i>t</i> -test
Neck pain	2.0 ± 1.1	1.6 ± 0.9	0.38	0.12	0.63	*0.005
Upper back pain	1.9 ± 1.1	1.5 ± 0.8	0.38	-0.01	0.76	0.056
Lower back pain	2.4 ± 1.3	1.6 ± 0.9	0.81	0.46	1.16	*0.000

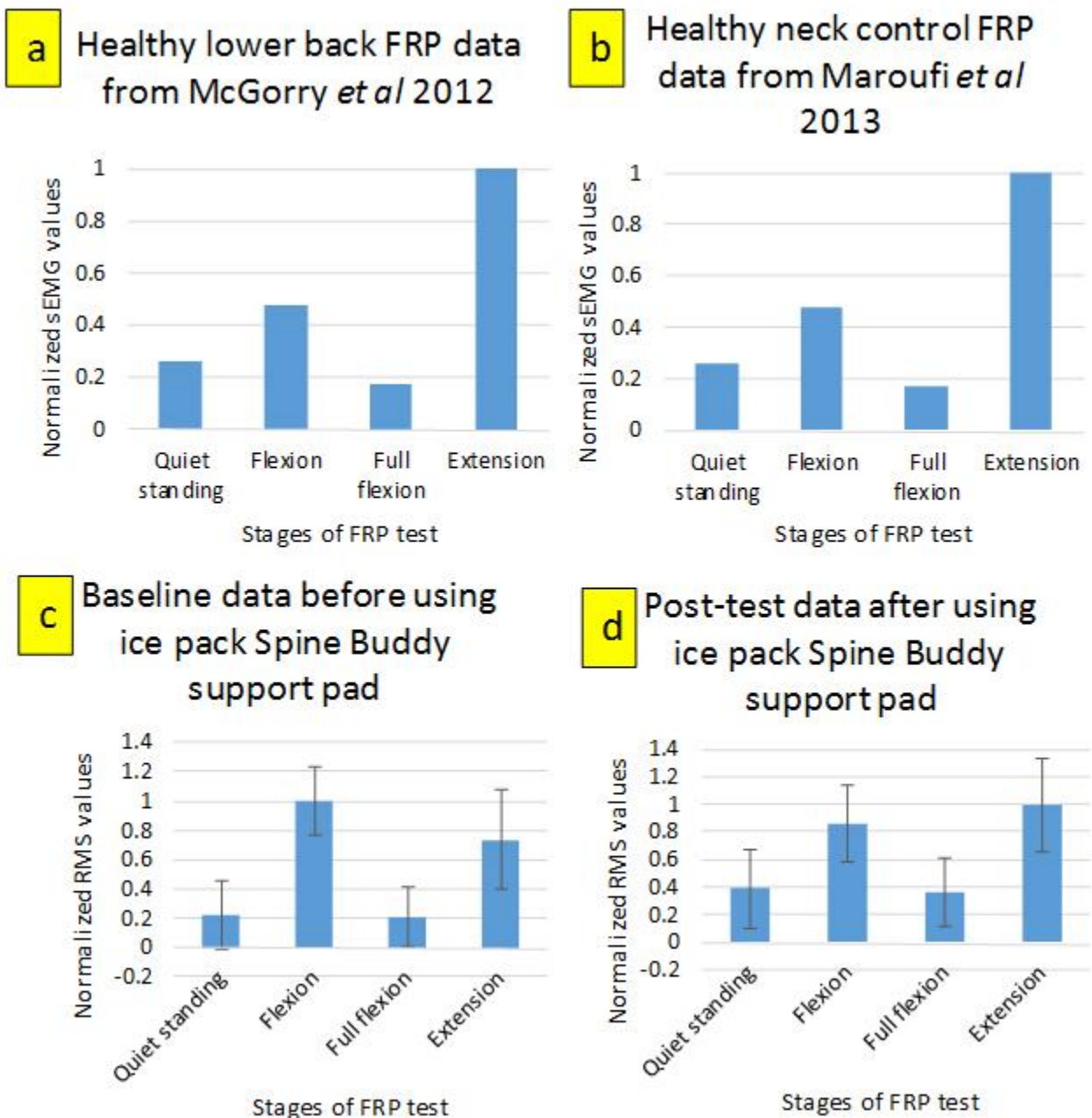
Data listed as mean \pm SD.

*= statistically significant.

After using the product, the back flexion and extension muscle activity profiles of study participants approached those of a person not reporting any back pain (**Fig. 5**). Quiet standing FRP phase RMS sEMG values did not reach a statistically significant level ($p = 0.144$). Flexion FRP phase RMS sEMG values

decreased 0.239 Volts ($t(31) = 3.995, p = 0.000$), which represented a medium to large effect size ($d = 0.71$). Full flexion FRP phase RMS sEMG values decreased 0.026 Volts ($t(31) = 2.109, p = 0.043$), which represented a small effect size ($d = 0.33$). Lastly, extension FRP phase RMS sEMG values decreased 0.098 Volts ($t(31) = 3.041, p = 0.005$), which represented a small effect size ($d = 0.37$). Cryotherapy is known to suppress nerve conduction velocity²¹ and is likely responsible for the overall reductions in 3 phases of the FRP test.

Figure 5. Comparison of healthy control spine FRP data as normalized sEMG values (a, b) versus the impact of the ice pack version of the Spine Buddy on FRP as normalized RMS sEMG values (c, d) for perspective. Included error bar data represents SD for Spine Buddy group. Error bar data was not available for McGorry *et al* 2012 or Maroufi *et al* 2013.^{44,62}



Discussion

Computer users and other individuals who sit at a desk for long periods of time are predisposed to the development of neck pain,⁴⁷⁻⁴⁸ trapezius strain,⁴⁷⁻⁴⁸ back pain,⁴⁹⁻⁵¹ and other regional musculoskeletal injuries. Some common risk factors for the development of these injuries are female gender, long work hours, repetitive motions, and sustained awkward desk postures.⁵²⁻⁵⁴ Various interventions have been shown to reduce these types of desk-related injuries, including adjustable office chairs,⁵²⁻⁵³ adjustable monitors,⁵³⁻⁵⁴ ergonomic training,⁵⁵⁻⁵⁷ regular work breaks,⁵⁸ and lumbar supports.⁵⁹⁻⁶⁰

The closest studies that are similar to this project have involved lumbar supports. Roelofs *et al* investigated variables that might predict adherence to the use of lumbar supports.⁵⁹ They pointed out that if participants are not regularly using the supports then they will not benefit from them.⁵⁹ The strongest predictor they found for use was positive attitude toward using a lumbar support, which explained 41% of the variance ($B=1.31$, $p<0.001$) in their model. Self-efficacy ($B=0.22$, $p=0.026$) and social support ($B=0.39$, $p=0.083$) both played a minor role in adherence.⁵⁹

Grondin *et al* measured the impact of a lumbar support on seated comfort and lumbar posture.⁶⁰ They found that a lumbar support resulted in participants moving in their chair less often, as a measure of center of pressure discomfort ($p=0.017$). Additionally, seated lumbar flattening was found to decrease when a lumbar support was used ($p=0.006$).⁶⁰

Makhsous *et al* analyzed the impact of an adjustable ischial and lumbar support on occupational low back pain.⁶¹ The addition of a support resulted in anterior displacement of the seated center of force and the peak pressure ($p<0.001$), such that participants placed more pressure against the back of the seat ($p<0.01$).⁶¹ As a result, less direct force was being exerted on the lower back in an axial direction. Due to this displacement, muscle activity in the lumbar spine decreased significantly. They theorized that this would benefit patients with low back pain when sitting. Makhsous *et al* used participants in their study with a higher amount of pain/symptoms as measured by the Oswestry Low Back Pain Disability Questionnaire and Roland-Morris Low Back Pain Disability Questionnaire than in the present study, which may be associated with the larger effect size they observed.⁶¹

This preliminary research found that the use of a cooled chair support may be associated with reduced neck and low back pain/discomfort. Additionally, participant FRP assessments marginally approached asymptomatic levels on the flexion and extension phases of the test as shown in Figure 5a-b. The Spine Buddy LT1 H/C is unique in that one side of the product can house ice packs and provide palliative care for spine-related pain.¹⁹⁻²⁷ An earlier version of this product consisted of only an ergonomic memory foam pad for support (with no ice or hot pack option), and our lab found no impact on participant spine pain/discomfort during testing (unpublished data). A subsequent product version included a memory foam support pad with blue gel crystals internally which could be heated or cooled. That product ultimately was not able to sustain temperatures as cold as an ice-pack or as hot as a hydrocollator pack. Again, no statistically significant benefit was found for spine pain/discomfort in this second experiment on this product line.¹⁸

In the present study, researchers tested the 3rd model in this product line. This version used a memory foam support pad containing gel crystals and 2 large external pouches on the posterior surface of the

product. The anterior surface of the chair support consisted of an ergonomic memory foam pad designed to “cup” the spine. The posterior surface of the chair support had pouches for 2 large cold or hot packs with the intent of providing pain relief from either cryotherapy or thermotherapy. The product is reversible, giving consumers the choice of using it for support or temperature-related pain relief. Researchers conducted a 3rd and 4th study on this product line. On one study, researchers placed the product with ice packs facing the chair and the memory foam ergonomic side facing the participant. The logic was that the cold from the ice packs would laterally cool the back from the sides of the pad while the memory foam ergonomic side touching the participant’s spine would provide comfort. No statistically significant benefit of the product was shown in this study (unpublished data). This was followed up in another study where the product was turned around to have the ice packs directly face the spine of participants (experimental group #1). Researchers additionally compared this to the hot pack version of the product (experimental group #2), a competitor’s non-thermal chair support (SitSmart Relief, as control group #1), and a chair-only group (control group #2). The greatest benefit was seen when using the LT1 H\C with ice packs, which was the impetus for this present 5th study on this product line. The results of the present study suggest that neck and back pain/discomfort may be decreased with this product short-term. Based on this lab’s previous experiments, likely the benefit of the current product appears to be due to the inclusion of the ice packs, to provide cryotherapy. Utilizing the anterior side of the support pad by a consumer would be more of a comfort decision.

After the study was completed, researchers performed a post-hoc power analysis using G*Power version 3.1.9.2 (Universität Kiel, Germany) to determine the study’s power.⁶³⁻⁶⁴ Utilizing the NMQ lower back data to post-hoc analyze differences between two dependent means (matched pairs), utilizing two tails, an effect size of 0.63, alpha error probability of 0.05, and total sample size of 32 the power of the study was 0.932. Using the equivalent data for the neck pain NMQ results the power to detect change in the neck region was 0.483.

Some future directions of research that may stem from this study are: 1)determine how long participants can safely use the product (i.e. should there be a 20-minute safety limit due to using ice packs), 2)measure how the support product impacts participants when used on and off throughout a full day at work, and 3)determine if this product can be of some use to special populations (i.e. to reduce pressure ulcers in bed-rest nursing home patients).

Limitations

This study did not include a placebo or control, and participants were aware of the experimental condition (i.e. the cold packs inserted into the pockets of the support pad). It may be argued that the findings of this study would be stronger if the Spine Buddy were compared to another product or to a placebo. Based on previous studies of this product it appears that most of the benefits in this current study are from the incorporation of ice packs into the product. Cryotherapy is well-known to provide short-term pain relief through several physiologic mechanisms.

Another limitation is that this study utilized a heterogeneous sample which included participants with and without significant spine-related musculoskeletal pain/discomfort. Had this study only included participants with pain levels above a set cut-off of spine-related pain/discomfort a more significant response might have been observed.

Researchers additionally did not restrict healthcare that participants may have received earlier in the

day (i.e. they could have received spinal manipulation in the morning for low back pain, but engaged in this study in the late afternoon). Theoretically this could have dampened any potential impact of an intervention in this study because it would have lowered baseline pain to some degree. Likely this was not a significant factor for students in this study since most of them were in class throughout the day and the study generally occurred after their last class for that day.

Additionally, more baseline participant data could have been recorded. For example, participants could have filled out a survey to categorize their duration of spine pain, provide background medical information, and record other variables.

Conclusion

These preliminary results suggest that the addition of an ice-pack cooled Spine Buddy LT1 H/C ergonomic support pad to an office chair may result in a decrease in neck and low back pain/discomfort. A statistically significant improvement in thoracic pain/discomfort was not seen. This product appeared to help normalize the flexion and extension phases of the FRP post-test. The product did not normalize the quiet standing phase of the FRP post-test in relation to healthy participant normative data.

Cryotherapy is a common passive modality that can be used to provide short-term symptomatic relief to spine-related musculoskeletal pain. The incorporation of ice packs into the design of this product may have contributed to its ability to decrease spine-related pain transiently in this pilot study.

Funding sources and conflicts of interest

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