Spine Buddy
Testing Proposal

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back strain gang

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In the US, as in much of the world, the backpack has become a staple of student living and an icon of the labor of learning. But romanticizations aside, backpacking to class can be an arduous, strenuous process, with heavy bags and titanic text books inducing kyphotic postures and back strain that can precipitate longer lasting and occasionally chronic, back pain.

back strain gang

For adolescents, carrying 10% of body weight or more can create kyphotic postures in the cervical spine and increase pressure on the spinal column. Several studies have found that ~50% of adolescents experience discomfort with backpack use. Since one of spine buddy's targeted applications is back-pack use, we decided to conduct an analysis of how spine buddy affects the posture of the college student demographic.

Study 1: Posture Analysis

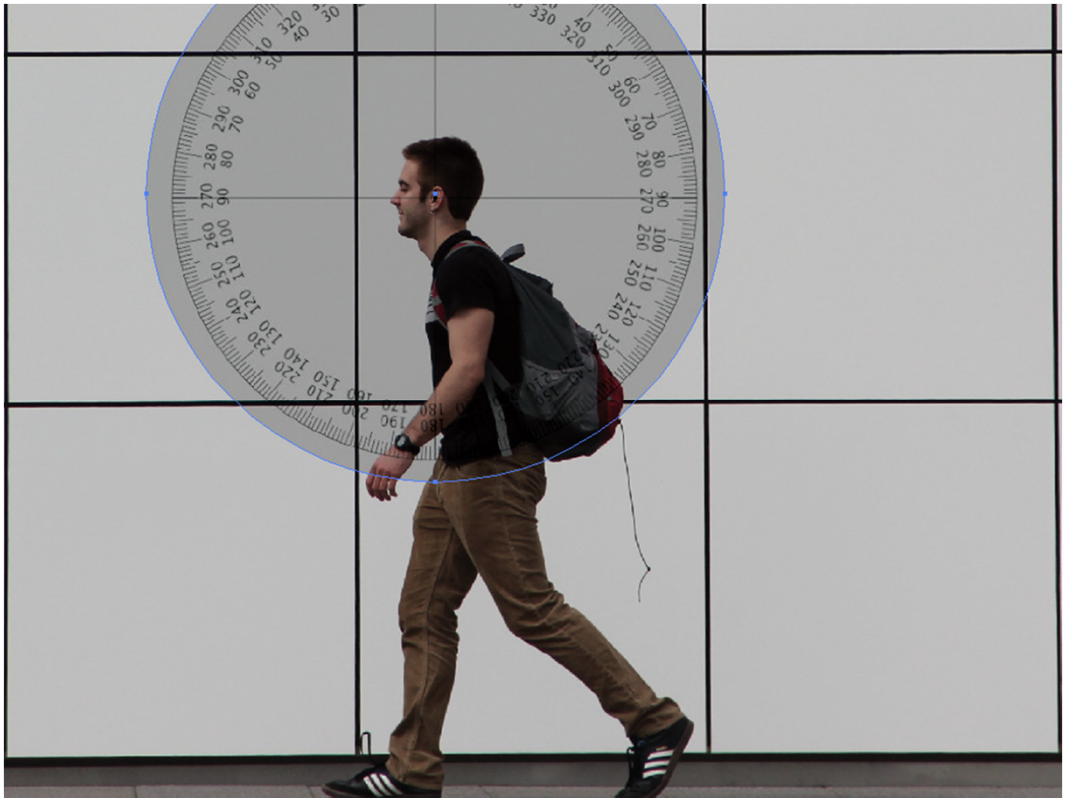
- N=4 College Students
- Weight = 20 lbs
- Cornell Convenience Sample

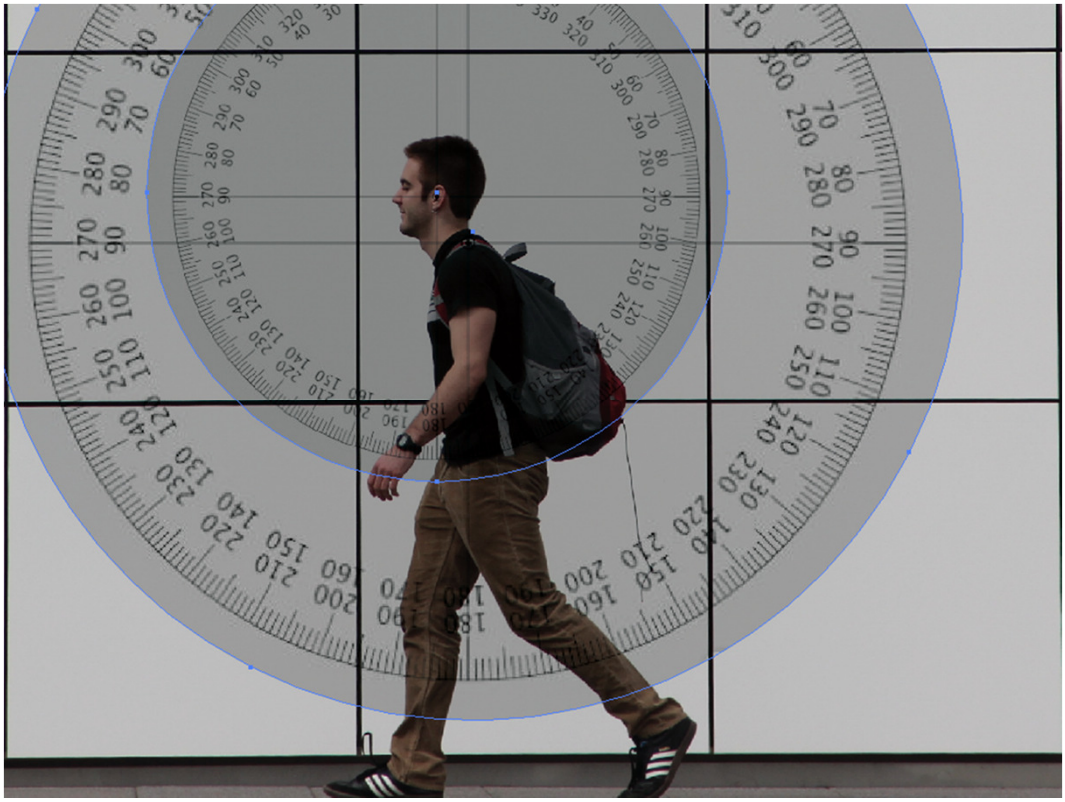
- Within subjects + between subjects design
- **scenario 1** backpack **scenario 2** 3" Spine Buddy **scenario 3** 5" Spine Buddy

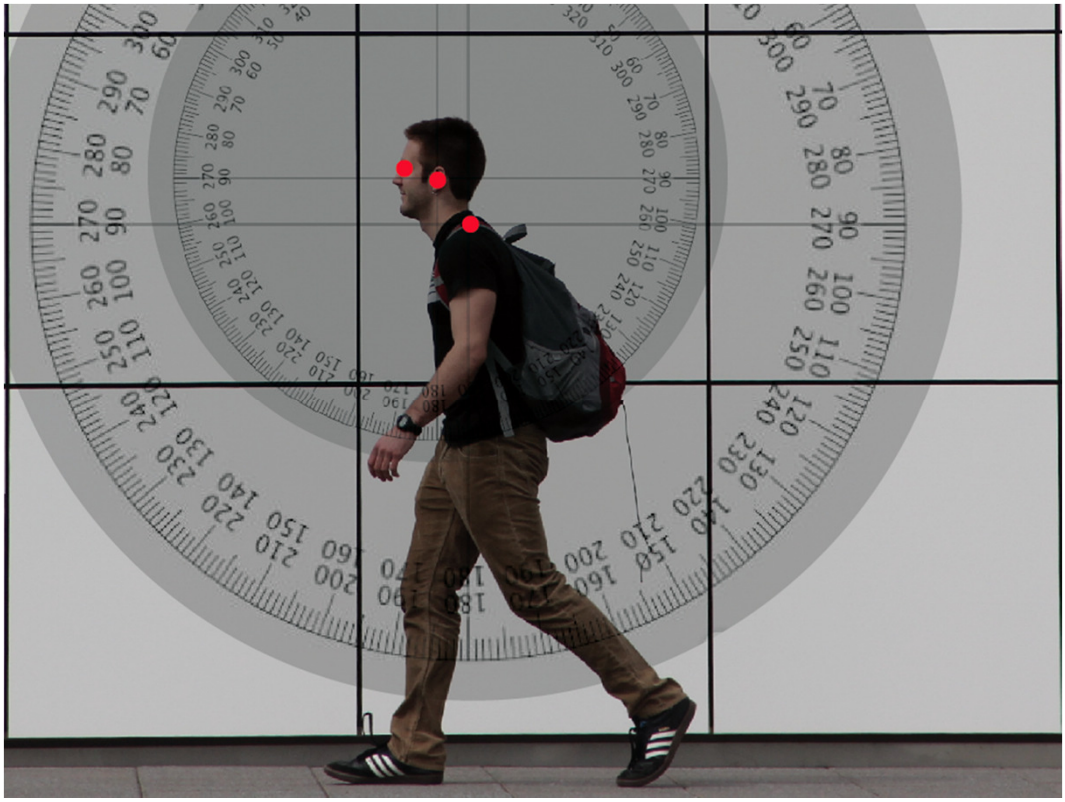
We decided to conduct a photographic posture analysis observing the postural effects on college students wearing both the spine buddy and a backpack.

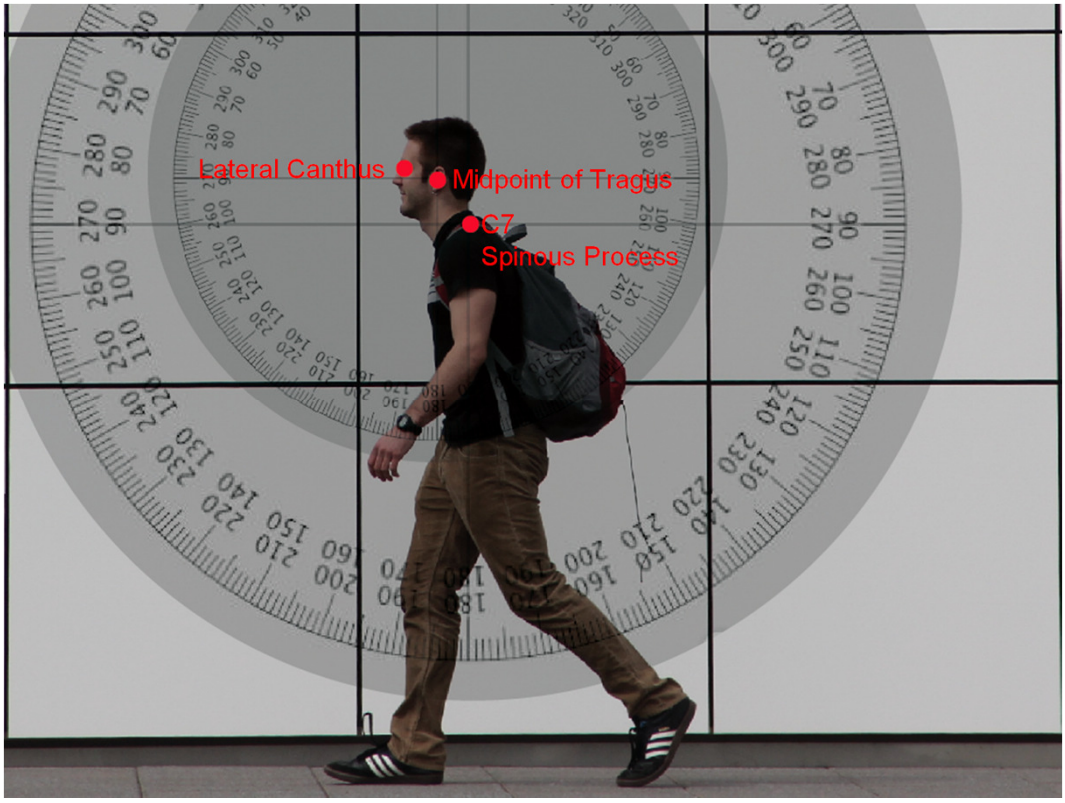
A single backpack weighing 20 pounds was assigned to a convenience sample of four different Cornell students

To conduct the postural analysis a telephoto camera was used to prevent distortion and compress a subject so that morphological landmarks could be readily determined to calculate posture angles

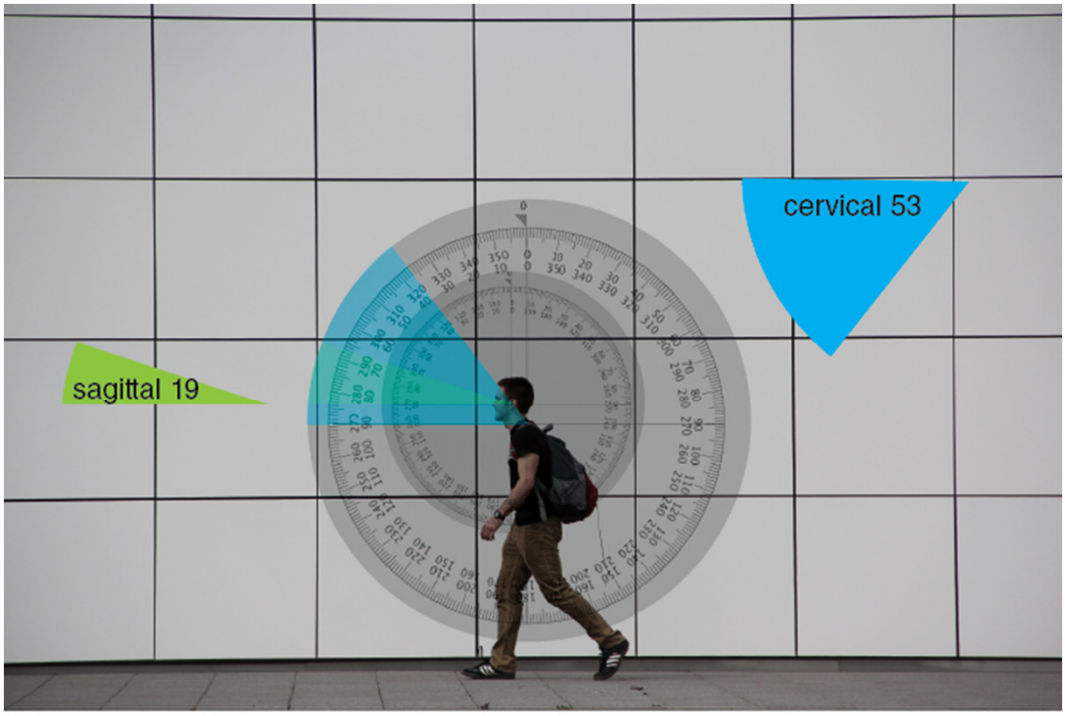




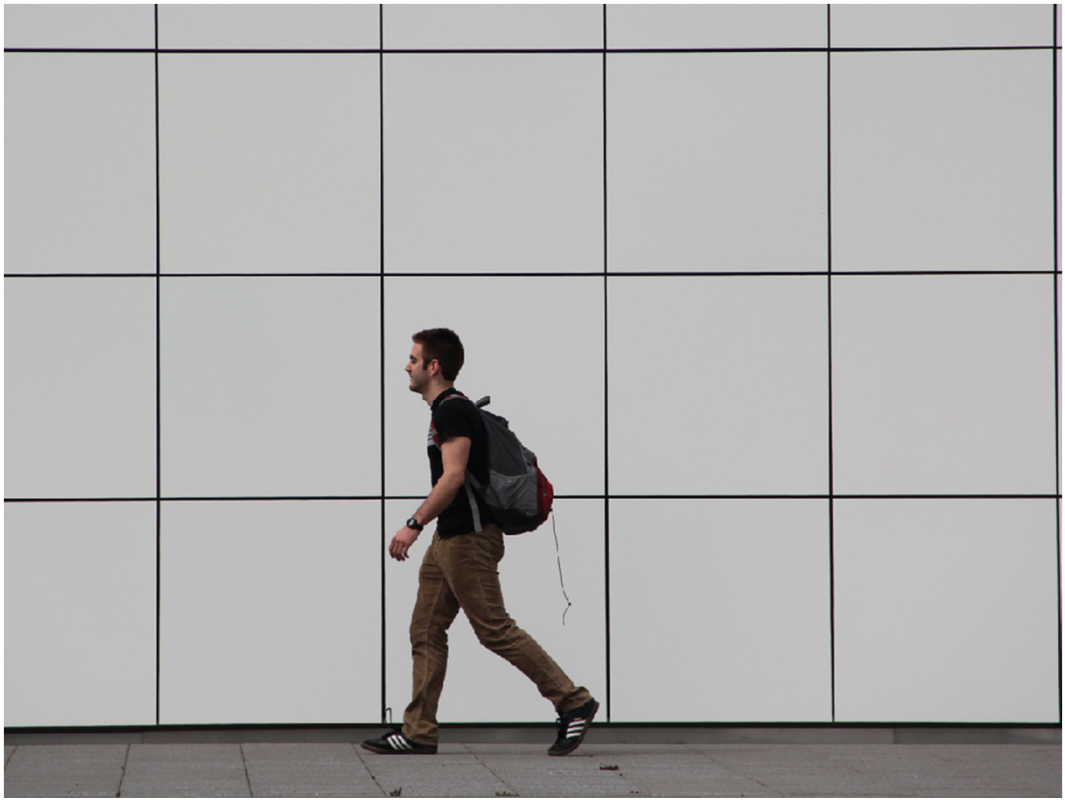


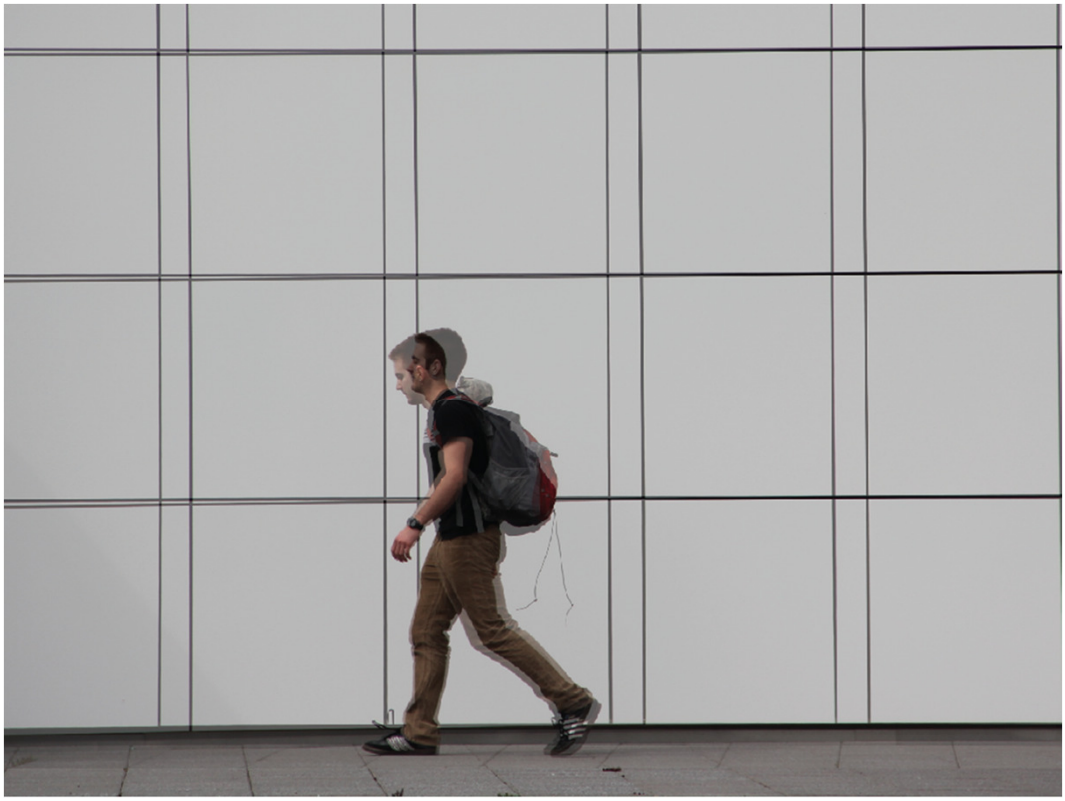


Three landmarks were selected, Cervical Spine Vertebrae #7, the midpoint of the Tragus and the Lateral Canthus

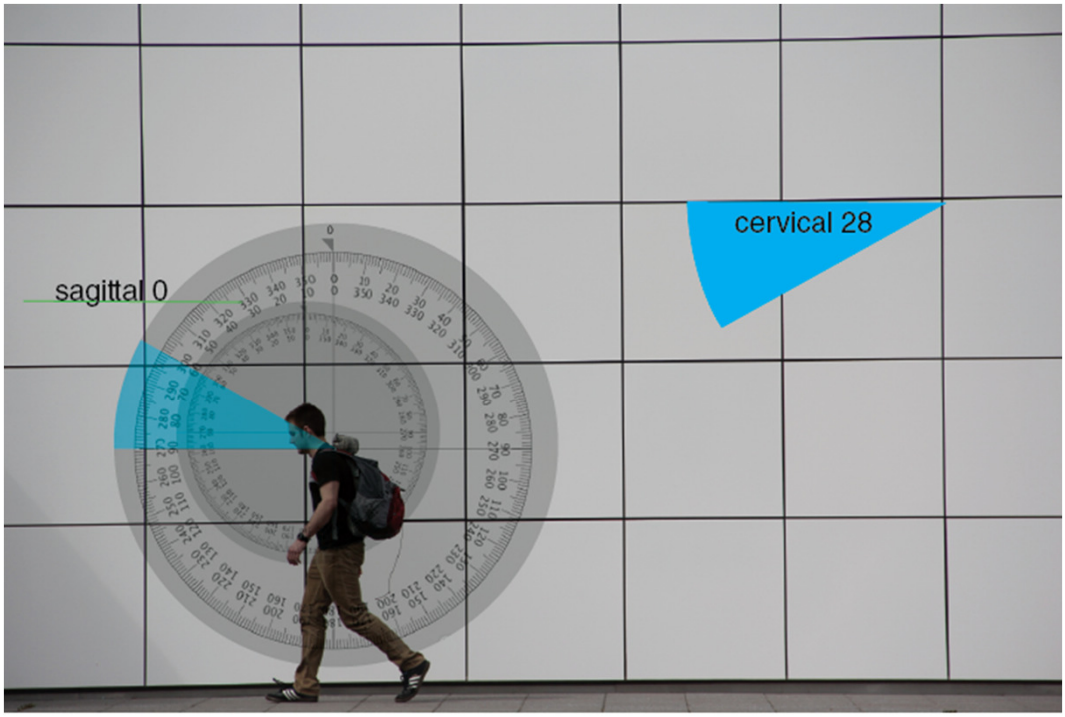


Male student with backpack.

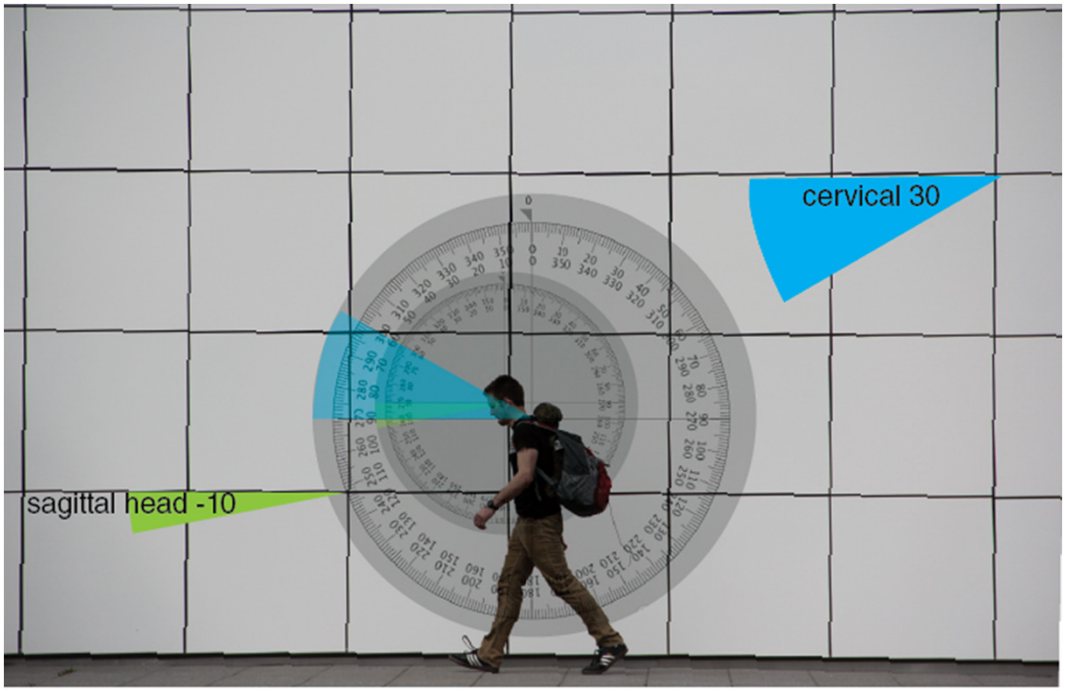




This overlay shows the relative change in posture that the single male subject experienced when wearing the spine buddy (increased neck flexion) as compared to his posture when wearing the backpack

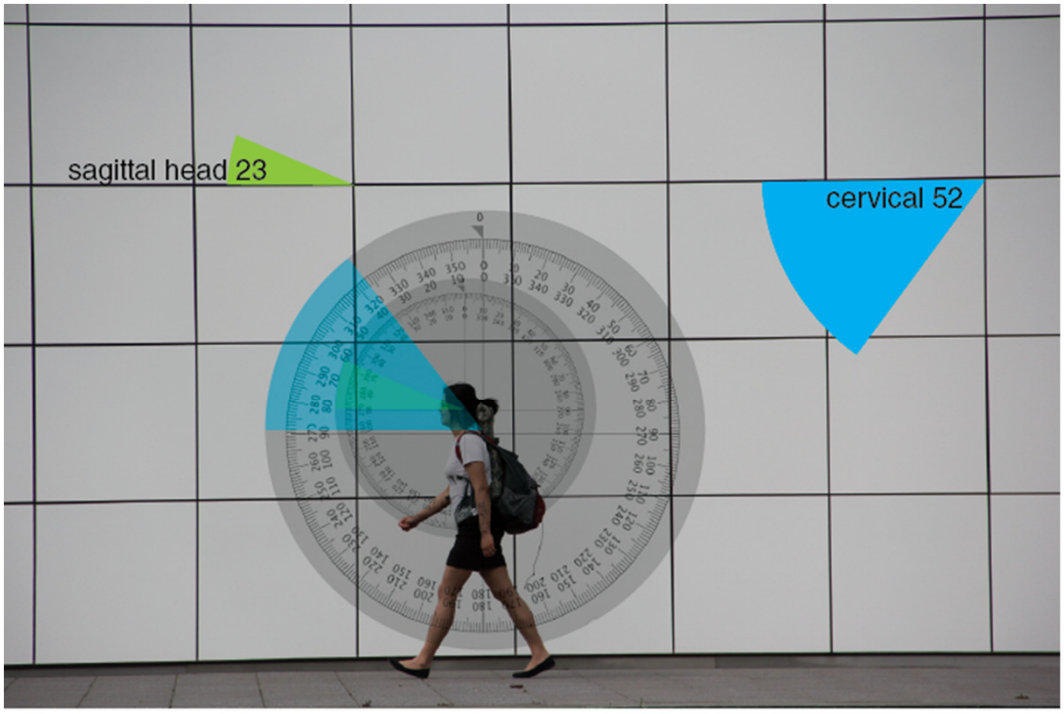


Male student with 3" spine buddy

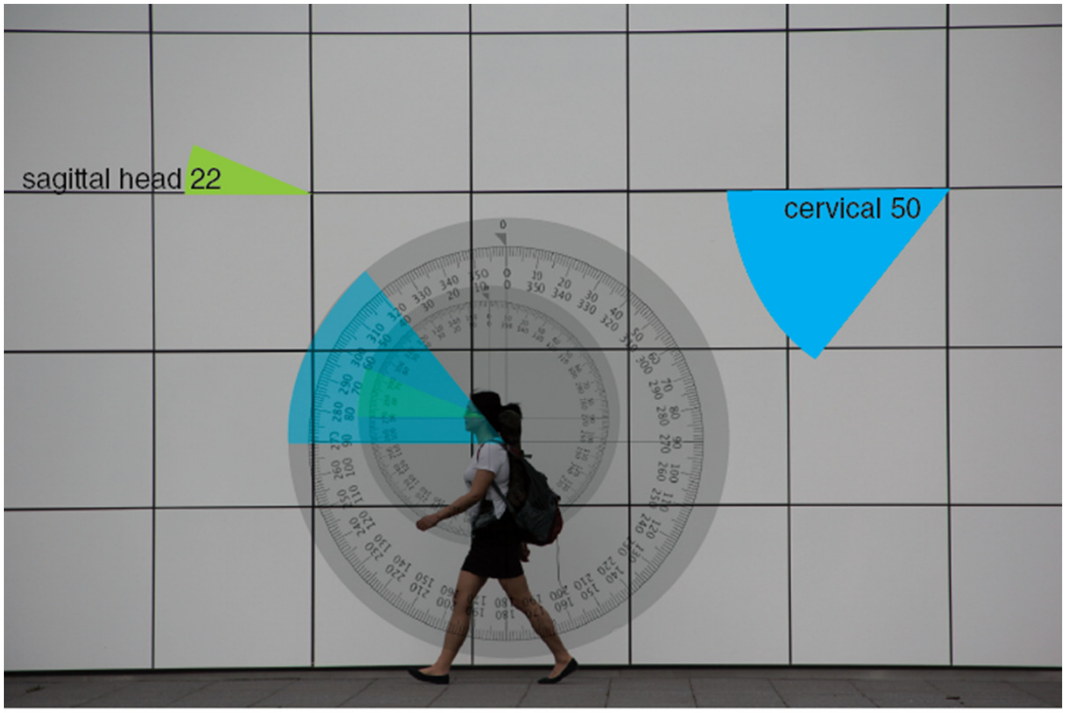


Male student with 5" spine buddy

Female student #1 w/ backpack



Female student #1 w/ backpack + 3" diameter spinebuddy

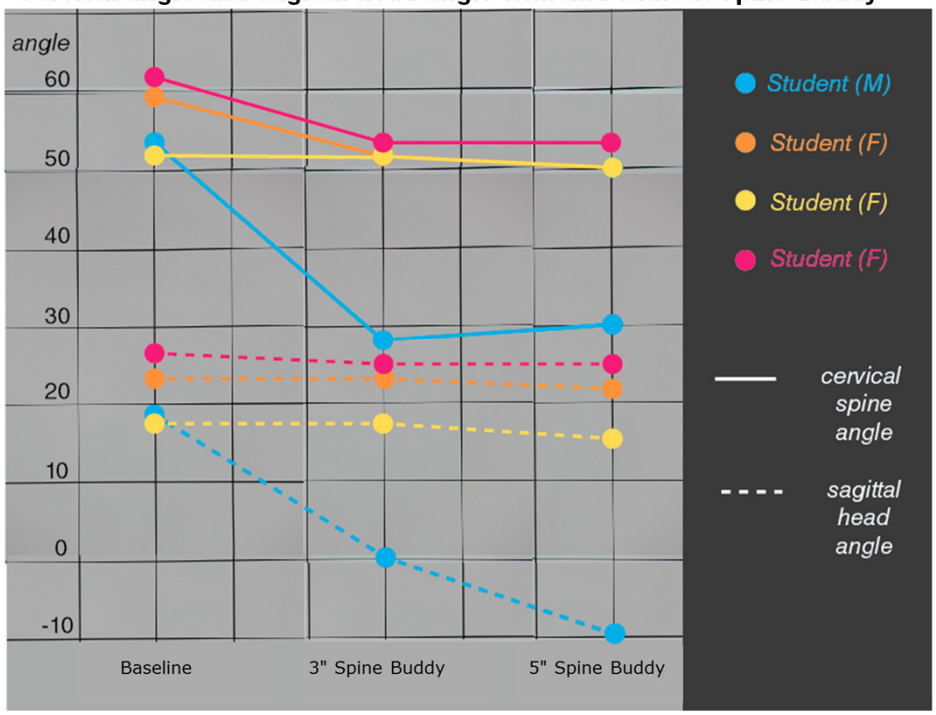


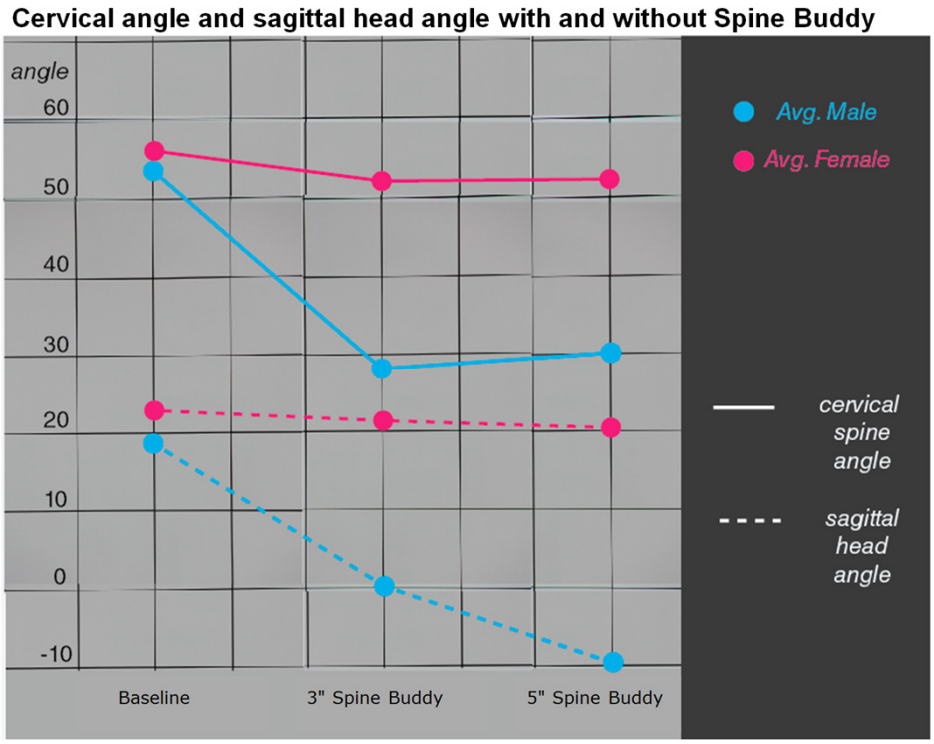
female student #1 with backpack + 5" diameter spine buddy

Female student #2 w/ 3" spinebuddy

Female student #3 w/ 3" diameter spine buddy

Cervical angle and sagittal head angle with and without Spine Buddy





For all subjects both cervical spine angle and sagittal head angle decreased with both of the spine buddy versions, although they decreased more for both females and males with the 6" spine buddy.

The spine buddy padding increases the distance of the backpack from the body thereby increasing the moment placed on the trunk. This appears to induce a kyphotic posture in the male subject as well as increased downward neck tilt. This posture can potentiate back pain originating at the cervical spine.

gender differences with spine buddy
can be addressed with future research

It is important to note however that there was a distinct gender difference in the magnitude to which the spine buddy affected posture. Both the 3" and 6" spine buddy had a more prominent kyphotic impact on the male subject's posture, while the female's posture was influenced only marginally by the spine buddy.

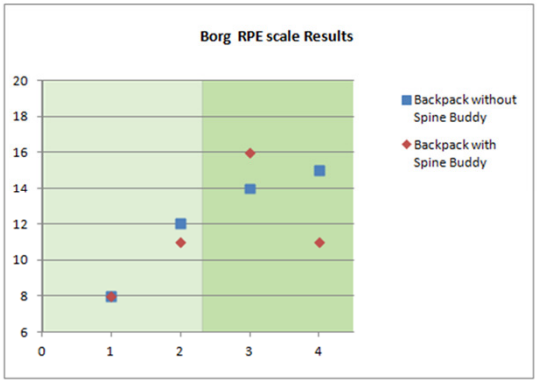
Study 2 - Perceived Exertion

- Control (backpack only) vs. Treatment (w/Spine Buddy)
- 3" diameter (20 lbs.) vs. 5" diameter (25 lbs.)
- 3 min. at 3.0 speed, 3 min. break between trials
- Survey pre and post test

  - Participant 1 (3" diameter): [Control] - rest - [Treatment]
  - Participant 2 (3" diameter) [Treatment] - rest - [Control]
  - Participant 3 (5" diameter): [Control] - rest - [Treatment]
  - Participant 4 (5" diameter): [Treatment] - rest - [Control]

To reduce the factors which might impact the experiment results, we counterbalanced the procedures, use the same treadmill, same backpack, walked at the same speed for same length of time. To mimic the daily experience in using backpacks, we used the walking speed instead of running. The feedback are collected as subjective evaluation, include borg RPE scale, and we used open questions to let the participant reflect their thoughts. According to the spinebuddy instruction, the 3" spinbuddy is for backpack <=20lb, and the 5" is for backpack > 20lb. So we used the 20lb and 25lb as experiment settings.

Study 2: Borg RPE Scale Results



6 No exertion at all
7
Extremely light (7.5)
8
9 Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion

The Borg rating of perceived exertion measures the intensity level of a physical activity. Perceived exertion is a psychophysical construct that is based on the physical sensations a user experiences during an activity as influenced by increased breathing rate, sweating and muscle fatigue. The ordinal rating scale allows for inter-subject comparisons.
We asked the participants to report their borg RPE scale after using the backpack w and w/o spinebuddy. This chart show their data. The light green area contains the data of the two participants used 20lb backpack and 3" diameter spinebuddy. The darker green area contains that of the two participants used 25lb backpack and 5" diameter spinbuddy. Subject 1 is a male, aubjects 2,3 and 4 are females. The blue rectangles shows their borg RPE scale after using backpack only, and the red diamonds shows their borg RPE scale after using backpack with instructed spinebuddies.
2 of 4 reported the spingbuddy reduced their perceived exertion, one reported no change, and one reported some increase in perceived exertion when using spinebuddy.

Study 2: Survey Results

2 of 4 report that Spine Buddy reduce the perceived exertion of wearing backpack by:

- padding
- redistribute the weight of backpack

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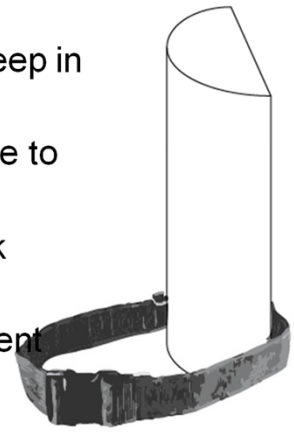
2 of 4 report that Spine Buddy makes them more uncomfortable by:

- changed their posture
- too bulky so the shoulder straps were digging into the shoulders

Their detailed comments shows how the spinebuddy impacted their perceived exertion or experience in using backpack. The 2 reported spinebuddy reduced their perceived exertion described that it worked like a pad between them and their backpacks, redistribued the weight of the backpack that balanced the pressure on their back. The two reported that spinebuddy didn't change their perceived exertion, or increased it, described that the spingbuddy changed their posture toward an discomfortable direction. One reported that when she used the spinebuddy, she tried to tighten the shoulder straps so as to benefit from its effect on her back. She felt it stretched her spine especially the lower back, but increased the pressure at the shoulders through the straps.

Design Recommendations

- Add waist strap to prevent rising spine buddy + keep it close to spine
- Or buckle strap around backpack to keep in place
- Cut in half to reduce bulkiness (flat side to backpack)
- Remove horizontal component at neck (becomes upside down T)
- Introduce a shoulder cushion component
- Work with backpack manufacturers to implement Spine Buddy in design



Study 1 + 2 results provide preliminary basis for improvement in civilian + hiking backpack contexts:
- Waist strap would maximize the stretching effect on the spine and fixed in the right place in relation to the spine
- Strap around backpack would keep it from sliding up and down, since civilian backpacks and hiking packs do not have frames that the military spine buddy has
- Changing the cylindrical shape to half cylinder provides stability, so the backpack does not roll from side to side, and reduces the distance between the spine and the backpack
- The upper neck support is unnecessary because it changes the neck and back posture (inducing kyphosis) and is not supported by the civilian backpack structure
- The Spine Buddy may provide temporary comfort to the spine but creates a tradeoff, where the distance between the spine and backpack makes the backpack straps cut into the shoulder; A shoulder cushion would minimize this potential tradeoff
- Eventually working in conjunction with backpack manufacturers to integrate the Spine Buddy would eliminate these various instability factors and provide the correct Spine Buddy size fit for the user if the backpack fits as well

Military Context

- Foot March
  - Heavy Rucksack (up to 30-40% of body weight; min. 40 lbs)
  - Long distances (varies between 3-18 miles)
  - Standard speed: 4km/h; pace of 15-20 min. per mile
- Goal
  - Time
  - Performance (follow-

After pilot-testing the SpineBuddies on student backpacks (convenience sampling), additional testing based on the original purpose for military applications should be considered. The SpineBuddy would be most commonly used during foot (ruck) marches.

Future Research Proposal

Experimental Study w/Control

- Representative sample
  - Military with at least 1-yr Ruck March experience
  - Within-Subjects Design (Repeated Measures)
    - Control: 40-lb Rucksack only
    - Treatment: 40-lb Rucksack with SpineBuddy
- Test Conditions
  - First session: 15-min. on treadmill (speed of 3.0)
  - 2-min. break (change treatment)
  - Second session: 15-min. on treadmill (speed of 3.0)
  - Counter-balance treatment order
- Measurements
  - Questionnaire + Level of Exertion + Posture Analysis

From an understanding of the military context (foot/ruck march activity, rucksack weight, etc.) we propose an experimental study (similar to the pilot tests) with a representative sample.
Variations of this study (e.g. different rucksack weights, treadmill incline, etc.) are possible if necessary.

Future Research Proposal

Field Study

- Representative sample
  - Military with at least 1-yr Ruck March experience
  - Randomize treatment among sample
- Test Conditions
  - Typical Ruck Day March (training practice)
- Measurements
  - Questionnaire + Level of Exertion + Posture Analysis
  - Performance (compare with sample's records)

Improvements made based on the findings of the experimental study can be then implemented in a field study.
Performance measures can be added to better understand the outcome.

Military Applications

Possible Concerns

- Lower hip portion of the spine buddy may conflict with kidney padding already present on rucksacks

As part of our research, we solicited the opinions of several ROTC cadets and officers, to get a sense of their experience with rucksacks, and some of the typical use cases. This and the following slides highlight some of their chief concerns.

Military Applications

- Increases distance between ruck and soldier, particularly in conjunction with body armor
- Increases the moment around the soldiers' hips, further modifying posture

Military Applications

- May interfere with the more dynamic movements required for combat situations