Research

Anterior-to-posterior Protective Capabilities of the Spine Buddy® Jockey Vest Support Pad

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Abstract

Background: The Spine Buddy® jockey vest support pad was developed to be added underneath an existing jockey vest, against the spine, to protect the torso of jockeys from being trampled by horses.

Purpose: The purpose of this study was to determine the force absorptive properties of the additional pad added to a jockey vest through two experiments: a simulated model and a human model.

Methods: The simulated model experiment involved dropping a 90-pound horse hoof simulator onto a force plate from a height of 12 inches under three different conditions at 10 repetitions per condition: 1) bare force plate, 2) anterior aspect of a standard jockey vest, and 3) posterior aspect of a jockey vest with the addition of the Spine Buddy® support pad. The human experiment involved dropping a significantly lighter and safer load, a 1.5-pound weight, onto the sternum of 14 male study participants laying supine on a force plate from a height of 24 inches. This occurred under the following conditions: 1) jockey vest with Spine Buddy® support pad, 2) jockey vest alone, and 3) no jockey vest. Outcome measures during all six conditions were peak force.

Results: For the simulated experiment the additional support pad reduced peak force 28.1% more than with the jockey vest alone (p=0.010). In the human experiment the additional support pad reduced peak force 6.4% more than the jockey vest alone (p=0.380).

Conclusion: Preliminarily, the results of this study demonstrate that the addition of an extra cushioned support pad to a jockey vest can add to the protective capabilities of the vest in an anterior-to-posterior direction.
Introduction

Professional horse racing can broadly be divided into two major categories: flat racing and jump racing (obstacle racing).\(^1\)\(^-\)\(^3\) Most competitors in these sports are male with a smaller build.\(^3\)\(^-\)\(^4\) They are proportionately strong, have quick reaction time, and are flexible.\(^5\)\(^-\)\(^7\) Despite the athletes being fit, competitive horse racing can be a dangerous sport. Research suggests serious injuries occur approximately once per every 350 hours of riding.\(^8\)

Horse jockeys periodically suffer soft tissue injuries which may be caused by falling off of their horse and/or being struck.\(^1,3,5,9\)\(^-\)\(^17\) The more experienced competitive jockeys are, the less likely they are to fall from their horse.\(^9,17\)\(^-\)\(^18\) This is partly due to experience and also due to competitive jockeys riding well-trained horses compared to novices.\(^9\)

In their sport, jockeys periodically suffer soft tissue injuries, fractures, and concussions.\(^1,15\) Soft tissue injuries are the most common type of injury sustained by jockeys.\(^1,9,19\) These include muscle contusions, ligament sprains, and muscle strains. Fractures represent the second most common type of injury suffered by these athletes.\(^9\) The bones that are fractured most often are the clavicle and those of the upper extremity, associated with fall injuries.\(^9,20\) The third most common injury seen with horse riding is concussion.\(^9\)

Jockeys are typically required to wear protective fastened helmets\(^1,9,19\)\(^-\)\(^20\) and some form of body protector (e.g., a padded jockey vest).\(^1,9,12,20\) Although they are required to wear these forms of protective equipment, their ability to prevent significant injuries has been poorly studied in research. Limited research exists analyzing jockey helmet safety,\(^16\) but almost no research exists on the safety of jockey vests. Despite this lack of research, the padded jockey vests are designed to primarily protect the jockey from thorax soft tissue injuries and rib fractures.\(^1,15\)

Chest injuries account for approximately 25-54% of all patient injuries following equestrian accidents.\(^16,18\) Jockey vests are designed to protect the general chest region, but they are not designed to protect the spinal column from compressive injuries.\(^1,3,21\) Studies suggest that 7-17% of jockey injuries are spinal injuries.\(^22\)\(^-\)\(^25\) Sometimes these injuries result in spinal fractures and surgery is required.\(^21\)\(^-\)\(^24\) Injuries to the spine primarily affect the thoracic and lumbar spine over the cervical spine.\(^15\) Analysis of the protective capabilities of jockey equipment, particularly torso protective equipment, represents a gap in research literature that should be addressed to optimally protect these athletes.\(^3,26\)

Methods

This study was reviewed and approved by the Texas Chiropractic College Institutional Review Board for human subjects in accordance with the Declaration of Helsinki. All subjects were provided a written and oral explanation of the study procedures prior to participation. Informed consent was provided by all participants prior to engaging in the study. This trial was registered with the University hospital Medical Information Network Clinical Trials Registry (UMIN-CTR), trial number: UMIN000015063.
Study Design and Setting

This study was carried out in two phases. Phase one involved dropping a 90-pound horse hoof simulator 10 times onto a force plate from a height of 12 inches under the 3 following conditions: 1) on the bare force plate, 2) anterior aspect of a standard jockey vest only, and 3) poster aspect of a standard jockey vest with the additional Spine Buddy® support pad added. Average peak force amongst the 10 drops per condition was measured in Newtons. Phase two of this study utilized 14 male participants (age = 26.7 ± 5.4 yr, height= 1.71 ± 0.09 m, body mass = 75.8 ± 21.3 kg: mean ± SD) that placed their torso supine on a force plate. Each participant had a 1.5-pound weight dropped over their mid-sternum from a height of 24 inches, one time, for each of the following three conditions: 1) jockey vest with the Spine Buddy® support pad added underneath, 2) jockey vest only, and 3) no jockey vest. Similarly, peak force was measured under each of the three conditions, per participant.

Horse hoof simulator and testing protocol

The horse hoof simulator (shown in Figures 1-2) was made of PVC plumbing pipe with screw caps placed on all three ends. Two of the caps were sealed with industrial strength glue. Sand was poured and packed through the opening of the third cap before it was sealed. The simulator was maximally filled with sand to arbitrarily weigh 90 pounds total. The intent was to generate a horse hoof simulator that was heavy, but still could be manipulated repeatedly by strong graduate students. A metal Queens Plate Wedge XT size 7 racing horseshoe was drilled into the bottom of the horse hoof simulator with 6 screws. The simulator was designed to have two long PVC pipe support arms on top that research assistants could grasp to more easily manipulate the weight.
Figure 1. (a) Image of the 90-pound PVC pipe horse hoof simulator and (b) image of the inferior base of the horse hoof simulator.

Simulator arms marked by arrows to illustrate where graduate assistants grasped the horse hoof model for control.

Figure 2 illustrates the horse hoof simulator under each of the three tested conditions. A ruler was placed adjacent to the simulator, connected to a metal stationary platform. One graduate student lifted the simulator by its arms, while the second graduate student grasped the lower sides of the simulator and provided the fine-tuning of the proper height of the horseshoe base before each drop. Research assistants attempted to drop the simulator on the center of the force plate during each release. The simulator was dropped 10 times in a row during each of the three tested conditions. There was approximately a 5-second rest period between each of the 10 successive drops. The two male graduate assistants vocally synchronized their release of the simulator. The height drop of 12 inches was chosen because dropping the simulator, focally, from a height greater than that with 90-pounds would have exceeded the maximum force registering capabilities of the force plate that was utilized. A 40 cm x 60 cm Bertec 4060-NC force plate (Bertec Corp., Columbus, OH, USA) was used in this study to measure force in Newtons in the vertical plane. Prior to use, the force plate was zeroed and gain was set to 1. Data was recorded at 1,000 Hz and processed through Vicon software (Vicon, Centennial, CO, USA). Force plate data was then exported to Excel as .csv files for further analysis of peak force profile line graphs.
**Figure 2.** Illustration of the 90-pound horse hoof simulator under the three tested conditions: (a) bare force plate, (b) anterior aspect of a standard jockey vest, and (c) posterior aspect of a jockey vest with the addition of the Spine Buddy® support pad.

![Figure 2](image)

**Table 1.** Comparison of force that was exerted using the horse hoof simulator under each of the three tested conditions with the force plate gain set at 1. Lower numbers indicate greater force attenuation.

<table>
<thead>
<tr>
<th></th>
<th>Bare force plate</th>
<th>Posterior jockey vest with support pad</th>
<th>Anterior jockey vest</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newtons of vertical force</td>
<td>$719.8 \pm 104.5$</td>
<td>$425.9 \pm 85.4$</td>
<td>$628.1 \pm 88.1$</td>
<td></td>
</tr>
<tr>
<td>% decrease in force beyond $719.8$ N bare force plate alone condition</td>
<td>$40.8%$</td>
<td>$12.7%$</td>
<td>$28.1%$</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Comparison of force that was exerted with the human model using 14 male participants under each of the three following conditions with the force plate gain set at 50. Lower numbers indicate greater force attenuation.

<table>
<thead>
<tr>
<th>Newtons of vertical force</th>
<th>Jockey vest with support pad</th>
<th>Jockey vest</th>
<th>No jockey vest</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>811.5 ± 106.4</td>
<td>875.2 ± 129.3</td>
<td>988.7 ± 71.4</td>
<td></td>
</tr>
<tr>
<td>% decrease in force beyond 988.7 N no jockey vest condition</td>
<td>17.9%</td>
<td>11.5%</td>
<td></td>
<td>6.4%</td>
</tr>
</tbody>
</table>

Data listed as mean ± SD unless listed as a percentage. Percent decrease determined using mean n value for jockey vest with support pad or jockey vest alone

**Human testing protocol**

Inclusion criteria were:

- 1) the participant was male
- 2) the participant had a Body Mass Index (BMI) under 30
- 3) the participant was between the ages of 18-45 years
- 4) the participant provided his informed written consent

Exclusion criteria were:

- 1) diagnosis of any cardiovascular, respiratory, neurological, or muscular disorder
- 2) presence of pain in the torso or any musculoskeletal injury affecting the torso that the participant would rate greater than a 3, on a 0 to 10 Numeric Rating Scale (NRS)

A convenience sample of 14 male student participants was utilized for phase two of this research study. They were asked to lie supine under each of the 3 tested conditions with their torso centered on a force plate (as shown in Figure 3). A 1.5- pound fully-inflated basketball was dropped onto participants’ chest from a height of 24 inches, once per test condition.
Figure 3. Illustration of the human model tested under three different study conditions on supine male participants: (a) jockey vest with the Spine Buddy® support pad internally underneath, (b) jockey vest only, and (c) no protective jockey vest.

A basketball was chosen, as opposed to a small solid weighted object, because it would more likely cause less harm to participants focally due to its large shape with dispersed mass. The height of the ball drop and the number of drop repetitions per test condition were set as limits by the college’s IRB to avoid causing undue harm to student volunteers, while still providing researchers with information on the force absorbing properties of the additional support pad.

The three following conditions were tested in order: 1) wearing a standard jockey vest with the Spine Buddy® support pad, 2) wearing only the jockey vest, and 3) wearing no jockey vest. During the study all participants wore a t-shirt over their upper torso. No sweaters or other thicker apparel was allowed. Three sizes of jockey vests were utilized: medium, large, and extra-large. The jockey vests were made by Phoenix (Phoenix Performance Products Inc., ON, Canada) and weighed 1-3 pounds, dependent on size. Prior to dropping the basketball, participants were instructed to close their eyes and hold their breath for approximately 10 seconds. They were asked to close their eyes to prevent any anticipatory motions. Participants were instructed to hold their breath to keep their torso braced as similarly as possible during each of the three test conditions.

The principal investigator at the lab computer signaled a research assistant to drop the ball. This occurred within 10 seconds of the participant being asked to hold their breath and close their eyes. A secondary research assistant helped to ensure the ball was 24 inches from the surface of the participant’s chest. They also acted to block the ball from traveling toward the research participant’s head after it initially struck the participant’s sternum. The assistant dropping the ball attempted to drop it centrally on the body of the sternum during each test. The gain of the force plate was increased to 50, to account for the cushioning effect of the human ribcage. Data was again recorded at 1,000 Hz through the Vicon computer software system. Only vertical force was measured. Peak force per condition was measured in Newtons.
Protective pad properties

The Spine Buddy® supportive pad (Figure 4), named “Spine Buddy® for athletes,” utilized in this study was made by the International Neck & Back Cushion Enterprises company (Humble, TX, USA). The support pad was composed of a woven Nylon cover with an internal 1340 polyurethane cushioned foam core. The foam had the following attributes as determined by the ASTM D-3574 test method perform by Microcell (Hyannis, MA, USA), the plant that physically makes the product: 1.30 ± 0.1 lbs/cu ft density, 12 min lbs/inch tensile strength, 1.5 min lbs/sq inch tear strength, and 160% elongation. The dimensions of the support pad were 21 inches long, 11 inches wide and 1.5 inches thick. The support pad weighed approximately 0.8 pounds. The cushioned pad had a Velcro strap to connect it internally to an existing jockey vest.

Figure 4. (a) Illustration of the inside view of a standard padded jockey vest on the left and the Spine Buddy® support pad on the right, and (b) an image showing the Spine Buddy® support pad connected to the jockey vest with its Velcro strap.

Statistical Analysis

Data were analyzed in SPSS version 20.0 (IBM, Armonk, NY, USA). Results were reported as mean ± standard deviation (SD) unless otherwise specified. Between-groups peak force for the three tested conditions per study phase were compared using a one-way analysis of variance (ANOVA). The a level of $p < 0.05$ was considered statistically significant for between-group variable analysis. Levene’s test was used to observe homogeneity of variance and Welch’s $F$ was used in cases of homogeneity of variance violation. In the event of a significant $F$ ratio, a Bonferroni post-hoc analysis was performed.
Results

For the horse hoof simulation study, between-groups comparison indicated that the Spine Buddy® pad added to the jockey vest demonstrated the greatest force protective properties out of the three tested conditions. The posterior aspect of the jockey vest with the Spine Buddy® pad added was 28.1% more effective at reducing force than the anterior aspect of the vest alone. Post-hoc analysis indicated the following: the Spine Buddy® added to a jockey vest compared to the bare force plate resulted in a statistically significant difference in force attenuation (p=0.000). Similarly, the anterior aspect of the jockey vest alone compared to the bare force plate resulted in a statistically significant difference in force attenuation (p=0.033). Lastly, the comparison of the Spine Buddy® added to a jockey vest against the anterior aspect of the jockey vest alone condition resulted in a statistically significant difference in force attenuation (p=0.010).

In phase two of the study, the Spine Buddy® support pad was seen to be 6.4% more effective at absorbing anterior-to-posterior force than wearing a jockey vest alone, but this did not reach statistical significance. Post-hoc testing revealed that wearing the Spine Buddy® added to a jockey vest compared to wearing no protective equipment at all resulted in a statistically significant difference in force attenuation (p=0.000). Similarly, wearing a jockey vest alone compared to wearing no protective equipment at all resulted in a statistically significant difference in force attenuation (p=0.025). Lastly, the comparison of the Spine Buddy® added to a jockey vest against the jockey vest alone condition did not result in a statistically significant difference in terms of force attenuation (p=0.380).

Discussion

The purpose of this study was to determine the anterior-to-posterior force absorptive properties of adding an additional cushioned support pad to a standard jockey vest under two conditions: a simulation model and a human model. Both of these experiments demonstrated that the additional support pad did decrease the force that was transmitted to the force plate in an anterior-to-posterior direction more than the jockey vest alone. However, the human model failed to reach statistical significance between the participants wearing the support pad and jockey vest compared to the jockey vest alone. The reason for this failure is unclear. Perhaps the weight that was dropped on participants was too light to significantly challenge the force attenuating properties of the polyurethane Spine Buddy®. Interestingly, the horse hoof simulator model did result in a significant difference being shown for force attenuation when wearing the extra support pad compared to the anterior surface of the jockey vest alone. This likely was due to the cushioning properties of having an extra support pad that compresses, as opposed to not having an extra support pad.

There is a paucity of research on protective jockey equipment. Limited studies cite that protective jockey headgear reduces the incidence of skull fractures amongst jockeys after falls. Similar research has not been adequately performed on the capabilities of protective jockey vests to reduce torso injuries. Typically, jockey vests are slender padded protective vests that are designed to reduce soft tissue injuries. These vests have been shown to provide minimal protection for the spine. Due to the prevalence of spine injuries amongst jockeys, more research should be performed on designing optimal protective equipment for them.
Further study is warranted to determine if wearing the additional support pad negatively impacts jockey performance in any way. For example, if jockeys wore the additional support pad, which is about as thick as the back layer of a standard jockey vest, they likely would need to wear a larger vest to accommodate the additional pad. The data from this study preliminarily indicate that extra padding added to a jockey vest absorbs more force, anterior-to-posterior, but how much absorption is considered enough to adequately protect a jockey from harm remains an unanswered question.

Lastly, this study focused on horse hoof trampling injuries and did not focus exclusively on how the additional pad would impact torso-related fall injuries off of a horse. As a result, further study is warranted on how the addition of the protective pad would reduce torso trauma associated with falling from a horse.

**Limitations**

In this study, force was only analyzed anterior-to-posterior. Data supported that the additional support pad does help absorb more force in an anterior-to-posterior direction than a standard jockey vest. However, based on the physical location of the pad, it is unlikely that it would have any additional force absorptive properties if a jockey was trampled in a side-to-side manner.

The horse hoof simulator used in this study weighed 90-pounds. A typical race horse weighs approximately 450-500 kg (990-1,100 pounds), which is substantially more weight than the simulator that was used in this study. Thus, the results of this study are exploratory, at best.

During the simulation study, two graduate students released the simulator at the same time. Since a machine was not built to precisely regulate drops of the 90-pound simulator in a reliable manner, it is reasonable to suggest that the simulator may have marginally been released from slightly varying heights during each release due to human error (e.g., ± 0.5 inches within the target of a 12” release). Due to this fact, researchers attempted to take 10 data samples under each of the three tested conditions to develop a clearer average transmission of force.

Male students used in this research study had a larger build than typical horse jockeys. As a result, the protective property of the additional support pad on smaller build males is not clear. Testing the support pad with competitive jockeys would have been more ideal. However, given the budget for this study, and available participants in the convenience sample, researchers did not have access to actual jockeys.

The experiments conducted in this study were performed in a controlled lab environment. It is reasonable to suggest that when a jockey falls off a horse that a horse’s hoof will not perfectly strike their torso anterior-to-posterior. Thus further study is warranted to determine how angulated strikes would affect the force absorbing properties of the added pad.
Conclusions

Preliminary research demonstrates that the Spine Buddy® jockey vest support pad reduces anterior-to-posterior force transferred through a protective jockey vest. This was demonstrated in a simulated model and human model experiment. The extra support pad underneath a jockey vest was more protective with the heavier simulated model than the human model. Further studies are warranted to determine how this additional support pad impacts angular strikes to a jockey vest or protects against falls from horses.

Funding sources and potential conflicts of interest

This study was supported by a grant from the Spine Buddy® company.

References


