ECCENTRIC EXERCISES PREVENT HAMSTRING STRAINS IN ADULT MALE SOCCER PLAYERS: A CRITICALLY APPRAISED TOPIC

Shadle KB, Jacko AD, Rahman EK, Cacolice PA

Undergraduate student, Athletic Training; 2Adjunct Faculty, Department of Athletic Training, Duquesne University, Pittsburgh, PA

CLINICAL SCENARIO

Hamstring strains are a common sport-related injury which may limit athletic performance for an extended period of time. These injuries are especially common in the soccer setting. As such, it is important to determine an appropriate prevention program to minimize the risk of these injuries in soccer athletes.

Hamstring strains occur when external loads exceed the strength of the tissue. Development of eccentric muscle control has been shown to be an effective intervention to improve strength. Eccentric hamstrings training offers a practical and inexpensive strengthening method for field sport athletes. This form of strengthening may provide an effective and practical hamstring strain prevention strategy.

PURPOSE

To perform a critical appraisal of the literature to address the question: What is the effect of eccentric exercises on hamstring strain prevention in adult soccer players?

METHODS

Search Strategy

- PubMed
- Medline
- SPORT Discus
- Proquest Health Management
- PEDro Database

Additional resources obtained via review of reference lists and hand searches

Inclusion and Exclusion Criteria

- Inclusion
  - Studies investigating eccentric strengthening, exercises, and prevention for hamstring injuries.
  - Studies where hamstring injury incidence was reported.
  - Level 2 evidence or higher.
  - Limited to English language.
  - Limited to humans.
  - Limited to soccer athletes.

- Exclusion
  - Studies with mixed subject pool (male vs. females, adult and adolescent).

RESULTS

Four studies, with an evidence grade of 2 or higher, were located. A systematic review on eccentric strength training in the prevention of hamstring muscle strains was acquired but not utilized in this paper because the research sample was not limited to soccer players.

The following studies were identified as the “best” evidence and selected for inclusion in the critically appraised topic (CAT) project (Table 1). These studies were selected because they examined the effects of eccentric exercises on hamstring injury prevention or strengthening, and fit all the inclusion and exclusion criteria.

- Arnesson et al. (2001) Cohort Study
- Askeland et al. (2006) Cohort Study
- Mjølnes et al. (2004) Cohort Study
- Potestas et al. (2011) Cohort Randomized Controlled Trial

Significant reduction in hamstring strains with eccentric exercise only.2,3 Mjølnes et al.4 however, looked at multiple hamstring strengthening strategies. While hamstring incidence and severity were not measured in their study, the authors agree that eccentric exercise might be useful to prevent hamstring injuries and that an eccentric exercise program should be considered as a preventive measure. Askeland et al.5 looked at a concentric hamstring curl with a focus on the eccentric contraction. This study was the only study not to use the Nordic hamstrings training exercise for eccentrically strengthening the hamstrings. Yet, the results still showed that with eccentric strength training there was a decrease in hamstring injury incidence and severity. Mjølnes et al.6 looked at strength gains with eccentric versus concentric training. In their investigation, the authors noted a reduction in injuries in strength with eccentric exercises. Peterson et al.7 showed that eccentric training prevents hamstring injuries. The study used a control group that performed the team’s daily warm up while the intervention group added the Nordic hamstrings exercise. The intervention group had dramatically fewer injuries to the hamstring than the control group.

- The only negative effect from eccentric exercises was that the intervention group was delayed onset muscle soreness (DOMS). However, the overall outcomes suggested implementing eccentric exercise into a team’s warm up for the purpose of increasing eccentric hamstring strength and preventing hamstring injuries.

The present study's objectives were to review and critically appraise evidence on the effects of eccentric exercises in the prevention of hamstring strains in soccer athletes. The main goal was to determine the effectiveness of eccentric exercises in preventing hamstring strain injuries.

Table 1 - Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcome Measures</th>
<th>Male Findings</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnesson et al. (2001)</td>
<td>Male soccer teams from the Icelandic and Norwegian top leagues (n=15)</td>
<td>6 weeks of Nordic hamstring exercise (NHE) training (4 times per weak)</td>
<td>Number of hamstrings</td>
<td>No significant difference in incidence of hamstring strains between teams that followed the flexibility training, and those that did not (P&gt;0.05). Thigh flexor muscle strength (P&lt;0.05). None of the subjects experienced a hamstring strain injury.</td>
<td>Significant increase in strength and flexibility in the control group (NHE) compared to the control group (C) without training. The intervention group had a significantly lower number of hamstring strains than the control group (C). The study showed that eccentric training is effective in reducing hamstring strain injuries.</td>
</tr>
<tr>
<td>Askeland et al. (2006)</td>
<td>Male soccer teams from the top five Danish soccer divisions (n=50)</td>
<td>6 weeks of Nordic hamstring exercise (NHE) training (3 times per week)</td>
<td>Number of hamstrings</td>
<td>No significant difference in incidence of hamstring strains between teams that followed the flexibility training, and those that did not (P&gt;0.05).</td>
<td>Significant decrease in hamstring strain injuries in the intervention group (NHE) compared to the control group (C). The intervention group had a significantly lower number of hamstring strains than the control group (C). The study showed that eccentric training is effective in reducing hamstring strain injuries.</td>
</tr>
<tr>
<td>Mjølnes et al. (2004)</td>
<td>Male soccer teams from the Icelandic and Norwegian top leagues (n=50)</td>
<td>6 weeks of Nordic hamstring exercise (NHE) training (3 times per week)</td>
<td>Number of hamstrings</td>
<td>No significant difference in incidence of hamstring strains between teams that followed the flexibility training, and those that did not (P&gt;0.05).</td>
<td>Significant decrease in hamstring strain injuries in the intervention group (NHE) compared to the control group (C). The intervention group had a significantly lower number of hamstring strains than the control group (C). The study showed that eccentric training is effective in reducing hamstring strain injuries.</td>
</tr>
<tr>
<td>Potestas et al. (2011)</td>
<td>Male soccer teams from the Icelandic and Norwegian top leagues (n=50)</td>
<td>10 weeks of eccentric overloading (EO) training (3 times per week)</td>
<td>Number of hamstrings</td>
<td>No significant difference in incidence of hamstring strains between teams that followed the flexibility training, and those that did not (P&gt;0.05).</td>
<td>Significant decrease in hamstring strain injuries in the intervention group (EO) compared to the control group (C). The intervention group had a significantly lower number of hamstring strains than the control group (C). The study showed that eccentric training is effective in reducing hamstring strain injuries.</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSIONS

Our study examined the high-quality evidence available for one specific strategy to prevent hamstring strain injuries. All of the studies reviewed involved eccentric hamstrings training as an intervention. Their conclusions indicate that eccentric hamstring training programs are effective in reducing the risk of strains in adult male soccer players.

The eccentric training groups in all four selected studies demonstrated increased hamstring strength and/or decreased incidence of hamstring strains when compared to the other conditions. Three of the four studies showed a

significant reduction in hamstring strains with eccentric exercise only.2,3 Mjølnes et al.4 however, looked at multiple hamstring strengthening strategies. While hamstring incidence and severity were not measured in their study, the authors agree that eccentric exercise might be useful to prevent hamstring injuries and that an eccentric exercise program should be considered as a preventive measure. Askeland et al.5 looked at a concentric hamstring curl with a focus on the eccentric contraction. This study was the only study not to use the Nordic hamstrings training exercise for eccentrically strengthening the hamstrings. Yet, the results still showed that with eccentric strength training there was a decrease in hamstring injury incidence and severity. Mjølnes et al.6 looked at strength gains with eccentric versus concentric training. In their investigation, the authors noted a reduction in injuries in strength with eccentric exercises. Peterson et al.7 showed that eccentric training prevents hamstring injuries. The study used a control group that performed the team’s daily warm up while the intervention group added the Nordic hamstrings exercise. The intervention group had dramatically fewer injuries to the hamstring than the control group.

- The only negative effect from eccentric exercises was that the intervention group was delayed onset muscle soreness (DOMS). However, the overall outcomes suggested implementing eccentric exercise into a team’s warm up for the purpose of increasing eccentric hamstring strength and preventing hamstring injuries.

The present study's objectives were to review and critically appraise evidence on the effects of eccentric exercises in the prevention of hamstring strains in soccer athletes. The main goal was to determine the effectiveness of eccentric exercises in preventing hamstring strain injuries.

REFERENCES


Future research should investigate which eccentric exercises are the best for preventing hamstring injuries. The Nordic Hamstring exercise was the most commonly used in these studies, however other eccentric hamstring strengthening exercises existed. Further research should compare the Nordic hamstring exercise to other eccentric hamstring exercises. DOMS was the only complaint of the athletes in the studies. Research should be conducted to examine if DOMS can be avoided by altering the training volume, intensity or selection of activity.

When considering the strength of recommendation associated with this topic, our assessment revealed support for a level ‘A’ recommendation that eccentric exercises can prevent hamstring injuries in adult, male soccer players. Therefore, it is recommended that athletic trainers evaluate current practices as it relates to hamstring injury prevention and consider implementing eccentric exercise based prevention programs.

For an abstract of this poster, please visit iagu.edu/athletictraining
The effects of plyometric or ballistic resistance training on throwing velocity for baseball players

**Powell MD, Spicher AW, Woodring SC, CapoPie PA**

Undergraduate student, Athletic Training; Adjunct Faculty, Department of Athletic Training, Duquesne University, Pittsburgh, PA

**CLINICAL SCENARIO**

Baseball players of all levels commonly work to increase their throwing velocity as greater throwing velocity is linked to better success.1 Any throwing velocity limitation due to injury may cause an athlete to alter their throwing behaviors in an effort to improve their throwing velocity. In altering their throwing behaviors, re-injury may occur, further delaying a return to full participation. Thus, optimizing throwing velocity after injury should be a concern for athletic trainers and sports medicine professionals responsible for return to play decisions.

Improved upper extremity strength and power are thought to increase throwing velocity in the overhead athlete1,2 and have been studied with various training programs.1,3,4 Plyometric training has been primarily studied to improve upper extremity power output5,6, but might produce similar gains in the upper extremity. We hypothesized that an upper extremity plyometric training protocol can significantly increase a baseball player’s throwing velocity.

**PURPOSE**

The purpose of this Critically Appraised Topic (CAT) was to look at upper extremity plyometric or ballistic resistance training programs and the effects on throwing velocity in baseball players.

**METHODS**

Search Strategy

Terms Used to Guide Research

- PB baseball
- 6 plyometric OR ballistic resistance AND shoulder
- C plyometric training protocol AND control
- OB baseball throwing velocity
- (Baseball AND [plyometric OR ballistic AND (shoulder)] AND (velocity)

Sources of Evidence Searched

- PubMed
- Google Scholar
- PEDro Database
- Sport Discus
- ProQuest

- Additional articles were hand searched using reference lists in previously obtained articles.

Inclusion Criteria

- Limited to level 3 evidence or higher.
- Limited to last 10 years (2004-2014).
- Limited to English.
- Limited to Humans.
- Included resistance band training using stretching shortening cycle.

Exclusion Criteria

- Study sample older than college age.
- Mixed subject pool.
- Studies that utilized weight training unless in comparison to a plyometric group.
- Studies that examined or utilized throwing athletes from sports other than baseball.

**RESULTS**

Three relevant studies were located and categorized (Table 1). All three studies demonstrated an increase in throwing velocity after a plyometric or resistance band (using stretching shortening cycle) training protocol.

**DISCUSSION AND CONCLUSIONS**

The purpose of our CAT was to determine the effectiveness of plyometric or resistance training on throwing velocity in baseball players. Our original hypothesis was that a plyometric or ballistic resistance training program would increase throwing velocity.1,2 However, the studies cited above utilized slightly different training protocols. The outcomes of these studies would suggest that the implementation of plyometric training may be more important when attempting to increase throwing velocity than actually implementing a specific plyometric program.

**REFERENCES**


**METHODS**

**Search Strategy**

**Terms Used to Guide Research**

- PB baseball
- 6 plyometric OR ballistic resistance AND shoulder
- C plyometric training protocol AND control
- OB baseball throwing velocity
- (Baseball AND [plyometric OR ballistic AND (shoulder)] AND (velocity)

**Sources of Evidence Searched**

- PubMed
- Google Scholar
- PEDro Database
- Sport Discus
- ProQuest

- Additional articles were hand searched using reference lists in previously obtained articles.

**Inclusion Criteria**

- Limited to level 3 evidence or higher.
- Limited to last 10 years (2004-2014).
- Limited to English.
- Limited to Humans.
- Included resistance band training using stretching shortening cycle.

**Exclusion Criteria**

- Study sample older than college age.
- Mixed subject pool.
- Studies that utilized weight training unless in comparison to a plyometric group.
- Studies that examined or utilized throwing athletes from sports other than baseball.

**RESULTS**

Three relevant studies were located and categorized (Table 1). All three studies demonstrated an increase in throwing velocity after a plyometric or resistance band (using stretching shortening cycle) training protocol.

**DISCUSSION AND CONCLUSIONS**

The purpose of our CAT was to determine the effectiveness of plyometric or resistance training on throwing velocity in baseball players. Our original hypothesis was that a plyometric or ballistic resistance training program would increase throwing velocity.1,2 However, the studies cited above utilized slightly different training protocols. The outcomes of these studies would suggest that the implementation of plyometric training may be more important when attempting to increase throwing velocity than actually implementing a specific plyometric program.

**REFERENCES**


**METHODS**

**Search Strategy**

**Terms Used to Guide Research**

- PB baseball
- 6 plyometric OR ballistic resistance AND shoulder
- C plyometric training protocol AND control
- OB baseball throwing velocity
- (Baseball AND [plyometric OR ballistic AND (shoulder)] AND (velocity)

**Sources of Evidence Searched**

- PubMed
- Google Scholar
- PEDro Database
- Sport Discus
- ProQuest

- Additional articles were hand searched using reference lists in previously obtained articles.

**Inclusion Criteria**

- Limited to level 3 evidence or higher.
- Limited to last 10 years (2004-2014).
- Limited to English.
- Limited to Humans.
- Included resistance band training using stretching shortening cycle.

**Exclusion Criteria**

- Study sample older than college age.
- Mixed subject pool.
- Studies that utilized weight training unless in comparison to a plyometric group.
- Studies that examined or utilized throwing athletes from sports other than baseball.

**RESULTS**

Three relevant studies were located and categorized (Table 1). All three studies demonstrated an increase in throwing velocity after a plyometric or resistance band (using stretching shortening cycle) training protocol.

**DISCUSSION AND CONCLUSIONS**

The purpose of our CAT was to determine the effectiveness of plyometric or resistance training on throwing velocity in baseball players. Our original hypothesis was that a plyometric or ballistic resistance training program would increase throwing velocity.1,2 However, the studies cited above utilized slightly different training protocols. The outcomes of these studies would suggest that the implementation of plyometric training may be more important when attempting to increase throwing velocity than actually implementing a specific plyometric program.

**REFERENCES**

To resolve an orthopedic injury, immobilization of the injured limb is commonly required. Rapid loss of muscular strength and mass are common consequences of such immobilization. Additionally, the rate of strength return after immobilization is consistently reduced. In fact, for every six weeks of immobilization, it takes four months to return to pre-immobilization strength levels. Effective strategies to maintain muscle strength and mass during unilateral limb immobilization is therefore of considerable concern to athletes and trainees who are working with orthopedically injured patients.

Cross-training (CT) is a strategy that has been used to improve performance in an uninjured target limb through exercise of the contralateral, uninjured limb. For example, CE can be described as strengthening an uninjured lower limb muscle to compensate for strength loss in an injured right arm. Although the majority of CE research was generated more than 40 years ago, the utilization of CE in both healthy and injured individuals has recently been revisited in the literature. In fact, recent research has shown that CE can decrease the rate of strength loss due to immobilization. The purpose of this critical appraisal project was to assess recent, high quality investigations of CE effectiveness as a treatment for immobilization.

**RESULTS**

Two critical reviews were found in our search, and these articles helped us to discover more about the original 30 strongly right intervened 30 strongly right and having studied cross education on either uninjured and immobilized patients or uninjured and immobilized subjects.

**DISCUSSION AND CONCLUSIONS**

The three selected studies described samples that were exposed to the intervention and did not display a significant decrease in either strength or muscle girth following use of CE during immobilization. As such, we concluded that CE is an effective way to manage the strength loss that occurs during immobilization. In addition, the variety of subject demographics suggests that CE could be useful in different patient populations. All three of the articles in this CAT measured CE effects between the upper extremities. The CE investigations differ in the specific joint motions measured, and all three studies used volitional isometric or isometric strengthening programs to investigate the effect of CE, with each study noting beneficial results. Further, the results suggest volitional contractions with or without simple strengthening equipment will be effective to clinicians. Although a considerable volume of research exists, there remain several areas where future studies are indicated. The specific central nervous system pathway stimulated through CE is not clearly understood. Future research to fully understand the mechanisms that would allow clinicians to optimize CE program design and utilization. Clinicians would also benefit from research designed to determine if a difference exists between CE.

**METHODS**

To conduct a critical appraisal of the literature to address the focused research question: Does cross education training increase strength in a contralateral immobilized limb?

**CLINICAL SCENARIO**

To resolve an orthopedic injury, immobilization of the injured limb is commonly required. Rapid loss of muscular strength and mass are common consequences of such immobilization. Additionally, the rate of strength return after immobilization is consistently reduced. In fact, for every six weeks of immobilization, it takes four months to return to pre-immobilization strength levels. Effective strategies to maintain muscle strength and mass during unilateral limb immobilization is therefore of considerable concern to athletes and trainees who are working with orthopedically injured patients.

Cross-training (CT) is a strategy that has been used to improve performance in an uninjured target limb through exercise of the contralateral, uninjured limb. For example, CE can be described as strengthening an uninjured lower limb muscle to compensate for strength loss in an injured right arm. Although the majority of CE research was generated more than 40 years ago, the utilization of CE in both healthy and injured individuals has recently been revisited in the literature. In fact, recent research has shown that CE can decrease the rate of strength loss due to immobilization. The purpose of this critical appraisal project was to assess recent, high quality investigations of CE effectiveness as a treatment for immobilization.

**TABLE 1**

<table>
<thead>
<tr>
<th>Participant Characteristics</th>
<th>Outcome Measures</th>
<th>Level of Evidence: Validity Score</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thirty right-handed participants were assigned to three groups. One group (n=20) was a non-fractured control group (Cast). A third group (n=20) received treatment (control). All patients were right-handed.</td>
<td>Peak torque (dynamometer), electromyography (EMG), and muscle thickness (ultrasound) were assessed in both arms before and after the intervention.</td>
<td>1b; No PEDro Score available</td>
<td>Unilateral strength training can preserve strength and muscle mass in a previously healthy immobilized limb through the cross education effect.</td>
</tr>
<tr>
<td>Thirty-nine women aged 50 years and older with a unilateral distal radius fracture were selected.</td>
<td>Primary outcome was peak force (handgrip dynamometer). Secondary outcomes were range of motion (flexion/extension; supination/pronation) measured with a goniometer.</td>
<td>1b; PEDro Score 4/10</td>
<td>Strength training in the fractured limb via cross education in the early stages of rehabilitation.</td>
</tr>
<tr>
<td>Thirty healthy adult males with non-fractured forearm placed cast immobilization.</td>
<td>Grip strength, forearm circumference, dynamic handgrip endurance and muscle oxygenation response were measured before and after the 21-day immobilization period.</td>
<td>1b; No PEDro Score available</td>
<td>Low volume exercise training (approximately two minutes per training bout) is effective in restoring the handgrip strength for the uninjured hand.</td>
</tr>
</tbody>
</table>

**REFERENCES**


CROSS EDUCATION TRAINING IMPROVES MULTIPLE FUNCTIONAL MEASURES IN IMMATURE PATIENTS: A CRITICALLY AMMSALIZED APPRAISAL

Field CE, Burke CA, Fields HJ, Carocile PA

1Undergraduate student, Athletic Training; 2Adjacent Faculty, Department of Athletic Training, Duquesne University, Pittsburgh, PA

For an abstract of this poster, please visit duq.edu/athletictraining
The effectiveness of cold water immersion in reducing delayed onset muscle soreness in collegiate athletes

Greenwalter TJ, Kidder AJ, Seiner EB, Cacolice PA

Undergraduate student, Athletic Training; Adjunct Faculty, Department of Athletic Training, Duquesne University, Pittsburgh, PA

CLINICAL SCENARIO

Delayed onset muscle soreness (DOMS) is muscular pain that peaks between 24 and 72 hours after exercise, and is thought to occur from novel stress to the connective tissues. 1 DOMS is debilitating at onset and hinders performance. For centuries, muscle soreness has been treated using Cold Water Immersion (CWI) baths. 2 Although firmly entrenched in tradition, there is limited evidence in the literature to support treatment effectiveness in an athletic population. If effective, CWI baths would be a valuable asset for return to optimal athletic performance.

PURPOSE

To conduct a critical appraisal of the evidence to determine the effectiveness of CWI on reducing DOMS in an athletic population.

METHODS

Search Strategy
Terms Used to Guide Research
P - Athlete
1. Cold Water Immersion [Cold AND (immersion OR bath)]
C - No Treatment
O: Reduced Muscle Soreness [DOMS OR muscles soreness]
(Cold AND (immersion OR bath)) AND (DOMS OR muscle soreness)

Sources of Evidence searched
PubMed
PEDro database
SPORTDiscus
Eurosport Library
ProQuest
Additional sources obtained via hand search.

Inclusion and Exclusion Criteria
Inclusion
- Level 2 evidence or higher.
- Limited to English language.
- Limited to Humans.
- Limited to studies published in last seven years (2007-2014).
- Limited to athletes over 18 years old.
- Limited to randomized control trial study design.
- Mixed subject pool (adult and adolescent).
- Systematic Reviews

Exclusion
- Mixed subject pool (adult and adolescent).

RESULTS

Four relevant studies were located that met inclusion criteria and described the effects of CWI to treat diabetes or reduce DOMS. Additional articles were obtained but not included in this critical appraisal as they did not specifically address our research question. These four selected studies were identified as the “best” evidence and selected for inclusion in this critically appraised topic (Table 1).

DISCUSSION AND CONCLUSIONS

The primary aim of this study was to determine if significant evidence exists for the effects of CWI on the clinical outcome of DOMS. The four studies reviewed in this paper, three showed that CWI baths are effective in reducing DOMS.4-6 This finding would indicate not only a beneficial effect for athletes but also potential benefits for recreational athletes.

Upon closer examination, the four articles agree the effectiveness of CWI in reducing DOMS.4-6 Each examined only adult male athletes. The fourth study utilized a mixed sex subject pool.8 Use of a mixed sex subject pool could have resulted in different findings versus those that treat only male athletes. Additionally, the mixed sex pool consisted of an elevated female to male subject ratio. Any noted effect in this study could have been sex specific, or could be from differences in mean mass and BMI that often are seen between males and females. Additionally, this mixed sex subject study utilized healthy college individuals as opposed to athletes. Although this investigation provided the highest reported PEDro validity measure the difference in activity level of the subject selection could have also provided for the non-statistically significant finding. Further, it would not be unreasonable to think that athletes have different pain thresholds, or are more familiar with muscle soreness.

There were additional differences between the studies. One considerable study difference was the manner the investigators induced the muscle soreness. In three studies4,5,8 the subjects were put into rigorous team sport, collision activities to induce DOMS. The fourth study9 had the subjects perform eccentric exercises to induce DOMS. These two methods of induction utilized healthy college individuals as opposed to athletes, times, with duration varying from as little as six to as many as 20 minutes per session. Shorter treatment times may be insufficient to affect muscle soreness.9 Further, the subjects were not familiar with recreational activities (up to 7ºC) between the investigations. To date, the literature is inconclusive as it relates to the effect of temperature on optimum CWI bath treatments. As such, even small changes in temperature could affect measured outcomes, especially when compared with varying treatment durations. Future research should include randomized, controlled trial studies with samples of elite female or male athletes matched by body mass and BMI. Additionally, high quality studies to determine optimal CWI bath temperature and treatment durations in the male athletic population would improve treatment recommendations.

In conclusion, our results show strong support for the use of CWI in adult male athletes for reducing the effects of DOMS after activity.7,8,9 There was no evidence to suggest or refute the use of this treatment in female athletes based upon the available literature. Additionally, the use of CWI in prevention of DOMS in a health college population was not supported.

REFERENCES


Table 1 - Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Outcome Measures</th>
<th>Male Findings</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higgins et al (2013)</td>
<td>CWI</td>
<td>Muscle soreness, evident 2 h after recovery in collision exercise</td>
<td>Significant difference in muscle soreness (DOMS) between groups</td>
<td>It was measured at four times (immediately before performance testing, immediately after performance testing, 24 h later and 48 h later) in comparison to the control and HCWI treatments, CWI resulted in significantly lower (P &lt; 0.05) muscle soreness ratings. The only benefit of HCWI over control was a significant reduction in muscle soreness 24 h post-exercise. This study demonstrated that CWI following exhaustive team sport exercise offers greater recovery benefits than passive stretch, pain with maximal isometric contraction, as indicated by significant changes from baseline to 24 h in post-exercise strength, serum creatine kinase levels. The outcome measures were recorded before exercise, 2 h post-exercise and 24 h post-exercise. Rating of muscle soreness was significantly increased at all time points in all conditions compared with pre-exercise values (P &lt; 0.05). A recovery of muscle resulted in a significantly lower muscle soreness 24 h after recovery compared with the no cold bagging group (P &lt; 0.05). No significant difference was evident between the conditions at any other time point (P &gt; 0.05). Although the plasma effect is a possible explanation for the reduction in perceptions of muscle soreness, the CWI implemented in the study did not elicit improvements in acute recovery of muscle function after intense, collision-based exercise.</td>
</tr>
<tr>
<td>Higgins et al (2010)</td>
<td>CWI</td>
<td>Muscle soreness, evident 2 h after recovery in collision exercise</td>
<td>Significant difference in muscle soreness (DOMS) between groups</td>
<td>It was measured at four times (immediately before performance testing, immediately after performance testing, 24 h later and 48 h later) in comparison to the control and HCWI treatments, CWI resulted in significantly lower (P &lt; 0.05) muscle soreness ratings. The only benefit of HCWI over control was a significant reduction in muscle soreness 24 h post-exercise. This study demonstrated that CWI following exhaustive team sport exercise offers greater recovery benefits than passive stretch, pain with maximal isometric contraction, as indicated by significant changes from baseline to 24 h in post-exercise strength, serum creatine kinase levels. The outcome measures were recorded before exercise, 2 h post-exercise and 24 h post-exercise. Rating of muscle soreness was significantly increased at all time points in all conditions compared with pre-exercise values (P &lt; 0.05). A recovery of muscle resulted in a significantly lower muscle soreness 24 h after recovery compared with the no cold bagging group (P &lt; 0.05). No significant difference was evident between the conditions at any other time point (P &gt; 0.05). Although the plasma effect is a possible explanation for the reduction in perceptions of muscle soreness, the CWI implemented in the study did not elicit improvements in acute recovery of muscle function after intense, collision-based exercise.</td>
</tr>
<tr>
<td>Pointon et al (2012)</td>
<td>CWI</td>
<td>Muscle soreness, evident 2 h after recovery in collision exercise</td>
<td>Significant difference in muscle soreness (DOMS) between groups</td>
<td>It was measured at four times (immediately before performance testing, immediately after performance testing, 24 h later and 48 h later) in comparison to the control and HCWI treatments, CWI resulted in significantly lower (P &lt; 0.05) muscle soreness ratings. The only benefit of HCWI over control was a significant reduction in muscle soreness 24 h post-exercise. This study demonstrated that CWI following exhaustive team sport exercise offers greater recovery benefits than passive stretch, pain with maximal isometric contraction, as indicated by significant changes from baseline to 24 h in post-exercise strength, serum creatine kinase levels. The outcome measures were recorded before exercise, 2 h post-exercise and 24 h post-exercise. Rating of muscle soreness was significantly increased at all time points in all conditions compared with pre-exercise values (P &lt; 0.05). A recovery of muscle resulted in a significantly lower muscle soreness 24 h after recovery compared with the no cold bagging group (P &lt; 0.05). No significant difference was evident between the conditions at any other time point (P &gt; 0.05). Although the plasma effect is a possible explanation for the reduction in perceptions of muscle soreness, the CWI implemented in the study did not elicit improvements in acute recovery of muscle function after intense, collision-based exercise.</td>
</tr>
<tr>
<td>Sellwood et al (2007)</td>
<td>CWI</td>
<td>Muscle soreness, evident 2 h after recovery in collision exercise</td>
<td>Significant difference in muscle soreness (DOMS) between groups</td>
<td>It was measured at four times (immediately before performance testing, immediately after performance testing, 24 h later and 48 h later) in comparison to the control and HCWI treatments, CWI resulted in significantly lower (P &lt; 0.05) muscle soreness ratings. The only benefit of HCWI over control was a significant reduction in muscle soreness 24 h post-exercise. This study demonstrated that CWI following exhaustive team sport exercise offers greater recovery benefits than passive stretch, pain with maximal isometric contraction, as indicated by significant changes from baseline to 24 h in post-exercise strength, serum creatine kinase levels. The outcome measures were recorded before exercise, 2 h post-exercise and 24 h post-exercise. Rating of muscle soreness was significantly increased at all time points in all conditions compared with pre-exercise values (P &lt; 0.05). A recovery of muscle resulted in a significantly lower muscle soreness 24 h after recovery compared with the no cold bagging group (P &lt; 0.05). No significant difference was evident between the conditions at any other time point (P &gt; 0.05). Although the plasma effect is a possible explanation for the reduction in perceptions of muscle soreness, the CWI implemented in the study did not elicit improvements in acute recovery of muscle function after intense, collision-based exercise.</td>
</tr>
</tbody>
</table>

For an abstract of this paper, please visit duq.edu/athletictraining.
After the literature search, three relevant articles regarding the effect of TBIs on sleep patterns met our inclusion criteria (Table 1). All three articles clearly focused on the TBI’s in the military. A fourth article was identified, which was an extensive controlled study examining sleep patterns as a result of TBIs in both athletes and civilians; however, it did not involve military personnel.

Despite on-going research consensus, a consensus on the effect that TBIs have upon sleep patterns continues to be elusive. As such, implementation of comprehensive treatment strategies remains challenging. This is a concern for clinicians treating this population as TBIs are being estimated to occur in up to 13% of deployed military personnel. The purpose of this research was to develop a better understanding of the effects that TBIs have on sleep patterns in deployed military personnel.

There is strong evidence suggesting that TBIs negatively impact normal sleep patterns in military personnel. Sleep has traditionally played a role in the management of TBIs. However, military personnel may be at a recovery disadvantage when variable sleep patterns and conditions associated with active military duty are considered. As such, recovery from TBI may be negatively impacted resulting in the exacerbation of other physical, cognitive, emotional, and psychological impairments. Sleep behaviors and TBIs do share commonalities. Existing research indicates that multiple TBIs are associated with increased incidence of clinical insomnia and severity of sleep disturbance. Insomnia was the second most common sleep disorder and was associated with the presence of medical comorbidities. In comparison to those military patients with no history of TBI, approximately four times as many patients with a single TBI and 10 times as many patients with multiple TBIs exceeded the threshold for clinical insomnia. Similarly, in a study involving athletes, those experiencing multiple TBIs reported significantly poorer sleep quality than the non-injured control group on the Pittsburgh Sleep Quality Index. If sleep disturbances are left unaddressed, they may compromise the overall rehabilitation of an individual. Sleep problems can and will exacerbate other symptoms such as pain, cognitive deficits, fatigue, and irritability. Cognitive brain function may also be impaired by TBI’s and becomes more debilitating depending on the severity and frequency of the TBI. One study reported that insomnia, post-traumatic stress disorder (PTSD), and pain co-occurred in 51.8% of the veterans. Those veterans with multiple TBIs were found more likely to suffer from high levels of stress, anxiety, and feelings of hopelessness, all of which can significantly increase emotional or cognitive activity at bedtime and affect sleep quality. The sleep disturbances of insomnia can persist despite appropriate therapy for PTSD.

The purpose of this critically appraised topic (CAT) was to assess the effects of TBI on sleep patterns in military personnel.

### RESULTS

CONCLUSIONS

The INCIDENCE AND FREQUENCY OF TRAUMATIC BRAIN INJURIES AFFECTING SLEEP IN MILITARY PERSONNEL: A CRITICALLY APPRAISED TOPIC

**O’Brien D1, Klein K2, Wozniak N3, Caocilpe PA2**

1Undergraduate student, Athletic Training; 2Adjunct Faculty, Department of Athletic Training, Duquesne University, Pittsburgh, Pennsylvania

In an effort to address the lack of research on the effects of TBIs on sleep patterns in military personnel, three relevant articles were identified. These articles examined the incidence and frequency of sleep disturbance associated with TBIs, comparing military personnel to civilian populations. The results indicated that military personnel with TBIs reported higher levels of sleep disturbance compared to civilian populations. However, further research is needed to fully understand the impact of TBIs on sleep patterns in military personnel.

### METHODS

Search Strategy

**Primary** Patient/Client Group: military AND deployed personnel

**Inclusion** and Exclusion criteria

- Level 2 evidence or higher.
- Limited to English language.
- Limited to humans.
- Studies must be military personnel.
- Limited to the last 2 years (2013-2014).

**Exclusion**

- Females.
- Pre-existing sleep disorders.
- Studies involving mixed subject groups.

**Sources of evidence searched**

- PubMed/ Duquesne
- SportDiscus
- Google scholar
- CINAHL
- ProQuest
- PEDro database
- Cochran Library
- Additional resources obtained by hand search.

**Inclusion and Exclusion criteria**

- Level 2 evidence or higher.
- Limited to English language.
- Limited to humans.
- Studies must be military personnel.
- Limited to the last 2 years (2013-2014).

**Exclusion**

- Females.
- Pre-existing sleep disorders.
- Studies involving mixed subject groups.

**Participants**

- Active duty military personnel with a diagnosis of polysomnography at a major military medical treatment facility in the Pacific Northwest in 2010.

**Intervention**

- FCSI Rating for Sleep Disorders, Insomnia, PTSD, mild traumatic brain injury (mTBI), anxiety, pain syndromes, and depression.

**Outcome Measures**

- Primary sleep disturbance rendered by review of polysomnographic and medical record by a board certified sleep medicine physician. Demographic characteristics and conditions of posttraumatic stress disorder (PTSD), mild traumatic brain injury (mTBI), anxiety, depression, and pain syndromes determined by medical record review.

**Main Findings**

- Insomnia was more likely diagnosed in females than males. Those with insomnia were more often on medication. Military personnel with insomnia were more likely to have a diagnosis of anxiety (r = 0.33, P < 0.05), depression (r = 0.27, P = 0.03), PTSD (r = 0.27, P = 0.02), and trauma or more comorbid diagnoses (r = 0.48, P < 0.002).

**Level of Evidence; Validity**

- 2B; No PEDro Score available.

**Conclusions**

TBIs are prevalent sleep related illnesses, most of which are associated with sleep, PTSD and pain syndromes. This article also highlights the unique bridge between TBI, PTSD, insomnia symptoms and other medical comorbidities.

### DISCUSSION AND CONCLUSIONS

Despite on-going research consensus, a consensus on the effect that TBIs have upon sleep patterns continues to be elusive. As such, implementation of comprehensive treatment strategies remains challenging. This is a concern for clinicians treating this population as TBIs are being estimated to occur in up to 13% of deployed military personnel.

The purpose of this research was to develop a better understanding of the effects that TBIs have on sleep patterns in deployed military personnel.

There is strong evidence suggesting that TBIs negatively impact normal sleep patterns in military personnel. Sleep has traditionally played a role in the management of TBIs. However, military personnel may be at a recovery disadvantage when variable sleep patterns and conditions associated with active military duty are considered. As such, recovery from TBI may be negatively impacted resulting in the exacerbation of other physical, cognitive, emotional, and psychological impairments. Sleep behaviors and TBIs do share commonalities. Existing research indicates that multiple TBIs are associated with increased incidence of clinical insomnia and severity of sleep disturbance. Insomnia was the second most common sleep disorder and was associated with the presence of medical comorbidities. In comparison to those military patients with no history of TBI, approximately four times as many patients with a single TBI and 10 times as many patients with multiple TBIs exceeded the threshold for clinical insomnia. Similarly, in a study involving athletes, those experiencing multiple TBIs reported significantly poorer sleep quality than the non-injured control group on the Pittsburgh Sleep Quality Index. If sleep disturbances are left unaddressed, they may compromise the overall rehabilitation of an individual. Sleep problems can and will exacerbate other symptoms such as pain, cognitive deficits, fatigue, and irritability. Cognitive brain function may also be impaired by TBI’s and becomes more debilitating depending on the severity and frequency of the TBI. One study reported that insomnia, post-traumatic stress disorder (PTSD), and pain co-occurred in 51.8% of the veterans. Those veterans with multiple TBIs were found more likely to suffer from high levels of stress, anxiety, and feelings of hopelessness, all of which can significantly increase emotional or cognitive activity at bedtime and affect sleep quality. The sleep disturbances of insomnia can persist despite appropriate therapy for PTSD.

### REFERENCES

6. Veterans Health Administration. PTSD Checklist-Civilian (C- PTSD). Insomnia Severity Index, Brief Pain Inventory Short Form (BPI).

Future research should continue to evaluate military personnel throughout their deployments and assess various intervention strategies aimed at treating TBIs in the military setting. Additionally, investigators and clinicians should investigate improving methods for diagnosing TBIs in a military setting in order to enhance the management of these patients and prevent possible long-term disability. As with all CATs, these findings should be reviewed in two years to determine whether additional best evidence has been published that may change the treatment suggestions.