

# A Systematic Review of Prophylactic Braces in the Prevention of Knee Ligament Injuries in Collegiate Football Players

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**Objective:** To determine the relative risk reduction associated with prophylactic knee braces in the prevention of knee injuries in collegiate football players.

**Data Sources:** An exhaustive search for original research was performed using the PubMed, SportDiscus, and CINAHL databases from 1970 through November 2006, with the search terms *knee brace*, *knee braces*, *knee bracing and football*, *prophylactic brace*, and *prophylactic knee braces*.

**Study Selection:** Seven studies comparing knee injuries among braced and nonbraced collegiate football players were included. Study methods were assessed using the Physiotherapy Evidence Database (PEDro) scale. PEDro scores ranged from 2 to 5.

**Data Extraction:** The number of participants and frequency of knee injuries were used to calculate the relative risk reduction or increase.

**Data Synthesis:** We found a relative risk reduction for 3 studies with point estimates of 10% (36% to –26%), 58% (25% to 76%), and 56% (13% to 77%). Four studies demonstrated an increased risk of injury, with point estimates of 17% (19% to –71%), 49% (–31% to –69%), 114% (23% to –492%), and 42% (–18% to –70%).

**Conclusions:** Data from existing research are inconsistent. Based on a Strength of Recommendation Taxonomy level of evidence of 2 with a grade B recommendation, we cannot conclusively advocate or discourage the use of prophylactic knee braces in the prevention of knee injuries in collegiate football players.

**Key Words:** protective equipment, injury prevention

Knee injuries have been reported to be the most common of the severe lower extremity injuries suffered in American football.<sup>1–5</sup> More than 600 000 injuries are identified annually in all competitive levels of American football, of which 20% are related to the knee joint.<sup>6</sup> Only 4 of 5 professional football players sustaining a serious knee injury involving the anterior cruciate ligament return to competition.<sup>7</sup> A significant number of players returning to competition after knee injury are not able to perform at their preinjury level.<sup>4,7</sup> In general, knee injuries are estimated to cost almost \$1 billion per year, so the ability to characterize risk factors and develop prevention strategies has widespread health and fiscal importance.<sup>8</sup>

Controversy surrounds the effectiveness of prophylactic knee braces in preventing knee injuries. Prophylactic knee braces have been reported to decrease peak tension magnitudes and impulse responses on knee ligaments.<sup>9,10</sup> Other authors<sup>11–14</sup> noted limited or no differences in knee stability or absorption of impact from prophylactic knee braces compared with controls. The effect of prophylactic knee braces on anterior cruciate ligament injuries is also controversial.<sup>10,12,15</sup> Because of high costs and lack of evidence for brace efficacy, researchers have not advocated for the use of prophylactic knee bracing in football players.<sup>16</sup>

Recently, numbers-needed-to-treat (NNT) and relative risk reduction (RRR) analyses have been used to systematically assess the prophylactic effect of other knee injury prevention

strategies.<sup>17</sup> Our purpose was to systematically review the literature to evaluate the efficacy of prophylactic knee braces in preventing ligamentous knee injuries in collegiate football players. We assessed the methods of previously conducted clinical trials and performed NNT and RRR analyses to develop an evidence-based conclusion as to the use of prophylactic knee braces in collegiate football players.

## METHODS

### Search Strategies

An exhaustive search for pertinent articles was performed using the PubMed, SportDiscus, and CINAHL databases from 1970 through November 2006. Searches were performed with key words *knee brace*, *knee braces*, *knee bracing and football*, *prophylactic brace*, and *prophylactic knee braces*. Limits of language were set to include only English-language articles. Our initial search identified 725 articles. We further limited our search to studies involving collegiate football players and reporting incidence of ligamentous knee injuries, with and without knee braces as a dependent variable. We only included studies that provided participant eligibility criteria and, therefore, could be assessed using the Physiotherapy Evidence Database (PEDro) scale. Pertinent studies were cross-referenced to identify articles that met inclusion criteria but were not located during the original database search.

**Table 1. Details of Included Studies**

Study	PEDro Score/Summary of Missing Methodologic Components	Original Unit of Injury Exposure	Study Design	Population Studied/ Number of Participants	Positions Studied	Prophylactic Knee Braces Used	Injuries Included as the Dependent Variable	Injury Definition
Hewson et al, <sup>18</sup> 1986	4: No random allocation, no concealed allocation, no blinding	1 Practice or game per player	Chart review	NCAA Division I collegiate football players/450 total players	Offensive linemen, defensive linemen, linebackers, tight ends	Anderson Knee Stabilizer	ACL, MCL 1°-3° sprains; medial meniscus, ACL, MCL combination	Not addressed
Albright et al, <sup>19</sup> 1994	3: No random allocation, no concealed allocation, no blinding	1 Knee per season	Quasiexperimental	10 NCAA Division I collegiate football programs/987 total players	All positions	Any brace designed to protect against a lateral blow to the knee	MCL sprains	Determination of tissue damage by team physician
Sitler et al, <sup>20</sup> 1990	3: No concealed allocation, no blinding, no P values reported	1 Player per season	Randomized controlled trial	College-aged intramural cadets/1396 total players	All positions (8-man tackle football)	DonJoy Orthopaedics Protector Knee Guard (enforced lateral stability)	ACL, MCL 1°-3° sprains	Acute trauma to knee that resulted in inability to practice 1 day of football
Teitz et al, <sup>21</sup> 1987	3: No random allocation, no concealed allocation, no blinding, large dropout rate	1 Practice or game per knee	Ex post facto	75 NCAA Division I collegiate football programs/11752 total players	All positions	McDavid, Omni Anderson Knee Stabilizer, Don Joy, American Prostheses, others not specified	ACL, MCL sprains and meniscus	Not addressed
Rovere et al, <sup>22</sup> 1987	4: No random allocation, no concealed allocation, no blinding	1 Player per practice or game	Cohort study	NCAA Division I collegiate football program/ 368 total players	All positions	Anderson Knee Stabilizer	ACL, MCL 1°-3° sprains, LCL, and meniscus	Clinical examination by the senior author determining laxity and tenderness
Zemper, <sup>23</sup> 1990	3: No random allocation, no concealed allocation, no blinding; not all players in experimental group wore knee braces during all practices and games	1 Player taking part in 1 practice or game	Prospective cross-sectional studies	59 NCAA and National Association of Intercollegiate Athletics football teams/6229 total players	All positions	McDavid Knee Guard, Anderson Knee Stabilizer, DonJoy	ACL, MCL, meniscus	Not addressed
Hansen et al, <sup>24</sup> 1985	2: No random allocation, no concealed allocation, no blinding; not all players in experimental group wore knee braces during all practices and games; no measures of variability	1 Player per season	Retrospective chart review	NCAA Division I football players/477 total players	All positions	Anderson Knee Stabilizer	All knee injuries (not specified)	Not addressed

Abbreviations: NCAA, National Collegiate Athletic Association; ACL, anterior cruciate ligament; MCL, medial collateral ligament; LCL, lateral collateral ligament.

**Table 2. Numbers Needed to Treat and Relative Risk Reduction**

	Total Players		Normalized Injury Rate		Nonbraced Injuries		Normalized Nonbraced Injury Rate	Number Needed to Treat to Benefit (NNTB) or Number Needed to Treat to Harm (NNTH) (95% Confidence Interval)		Relative Risk Reduction (RRR) or Relative Risk Increase (RRI, %) (95% Confidence Interval, %)
	Braced	Nonbraced	Braced Injuries	Rate	Nonbraced Injuries	Injury Rate		NNTB	NNTH	
Albright et al, <sup>19</sup> 1994	978	987	54	0.1094	46	0.0932	NNTB 63 (NNTB 49 to ∞ to NNTH 19)	RRR 17 (19 to -71)		
Sitler et al, <sup>20</sup> 1990	691	705	20	0.0227	51	0.0535	NNTH 32 (NNTB 20 to 92)	RRR 58 (25 to 76)		
Hewson et al, <sup>18</sup> 1986	224	226	48	0.2143	54	0.2389	NNTH 42 (NNTB 19 to ∞ to NNTH 10)	RRR 10 (36 to -26)		
Flovere et al, <sup>22</sup> 1987	164	146	11	0.0732	5	0.0342	NNTH 26 (NNTB 86 to ∞ to NNTH 11)	RRR 114 (23 to -492)		
Teitz et al, <sup>21</sup> 1987	4686	7011	477	0.0954	499	0.0640	NNTH 32 (NNTB 24 to 46)	RRR 49 (-31 to -69)		
Zemper, <sup>23</sup> 1990	1744	4485	185	0.1061	336	0.0749	NNTH 32 (NNTB 22 to 63)	RRR 42 (-18 to -70)		
Hansen et al, <sup>24</sup> 1985	148	327	7	0.0472	35	0.107	NNTH 17 (NNTB 9 to 205)	RRR 56 (13 to 77)		

**Included Studies and Quality Assessment**

Seven studies<sup>18-24</sup> met the specified criteria and were independently rated by a panel of 3 evaluators, using the PEDro scale.<sup>25</sup> The details of these 7 studies are found in Table 1. One group<sup>19</sup> studied only knees that had not been previously injured. The rest of the authors<sup>18,20-24</sup> included both knees that had been previously injured and knees that had not been injured.

The PEDro scale, which awards 10 points for performing the study with the best methods and 0 for the worst, was used to assess the quality of each study. The 3 reviewers (1 male, 2 females, age = 23 ± 0 years) had previous experience with the PEDro scale. The reviewers first scored each of the selected studies individually, then as a group, and discussed the methodologic quality of each study before achieving a consensus on the final score. All identified studies scored relatively low on the PEDro scale. Due to the lack of differences in methodologic quality among studies, we included all the studies that could be assessed by the PEDro scale. One investigation could not be assessed by the PEDro scale and was excluded because eligibility criteria for the control group were not described.<sup>26</sup> Both braced and unbraced groups were included in each study we assessed.

Injury rates, NNT, and RRR were extrapolated from the sample size and injury data included in the 7 studies (Table 2).<sup>18-24</sup> A meta-analysis was not prudent for summarizing these data because outcomes, braces used, and injury inclusion criteria were different for all the studies.

**Normalization of Exposures and Analysis of Data**

Because exposures were different among all the studies, comparing analyses was difficult (Table 1). We normalized all exposures equal to 1 player per season. Injury definitions were different in all the studies and are summarized in Table 1. Normalized incidence rates were extrapolated and used to calculate RRR and NNT analyses (Table 2).

**Quality Assessment**

The mean PEDro score for methodologic quality for all the studies was 3.14 (range = 2 to 5, mode = 3, median = 3). The reason for points deductions in the PEDro score for each study are summarized in Table 1.

**Data Analysis**

After exposures were normalized, corresponding non-braced injury rate (NBIR) and braced injury rate (BIR) were collected, and RRR and NNT analyses were calculated for each study. The RRR was calculated using Equation 1. If a negative RRR was generated, a positive relative risk increase (RRI) was used to indicate an increase in relative risk. The NNT was calculated using Equation 2.<sup>27</sup> The NNT point estimates and confidence intervals that reflected a prophylactic effect of knee bracing were reported as numbers needed to treat to benefit (NNTB), whereas those depicting an increase in injury rate were reported as numbers needed to treat to harm (NNTH). The 95% confidence intervals were calculated and depicted using previously described methods.<sup>28</sup>

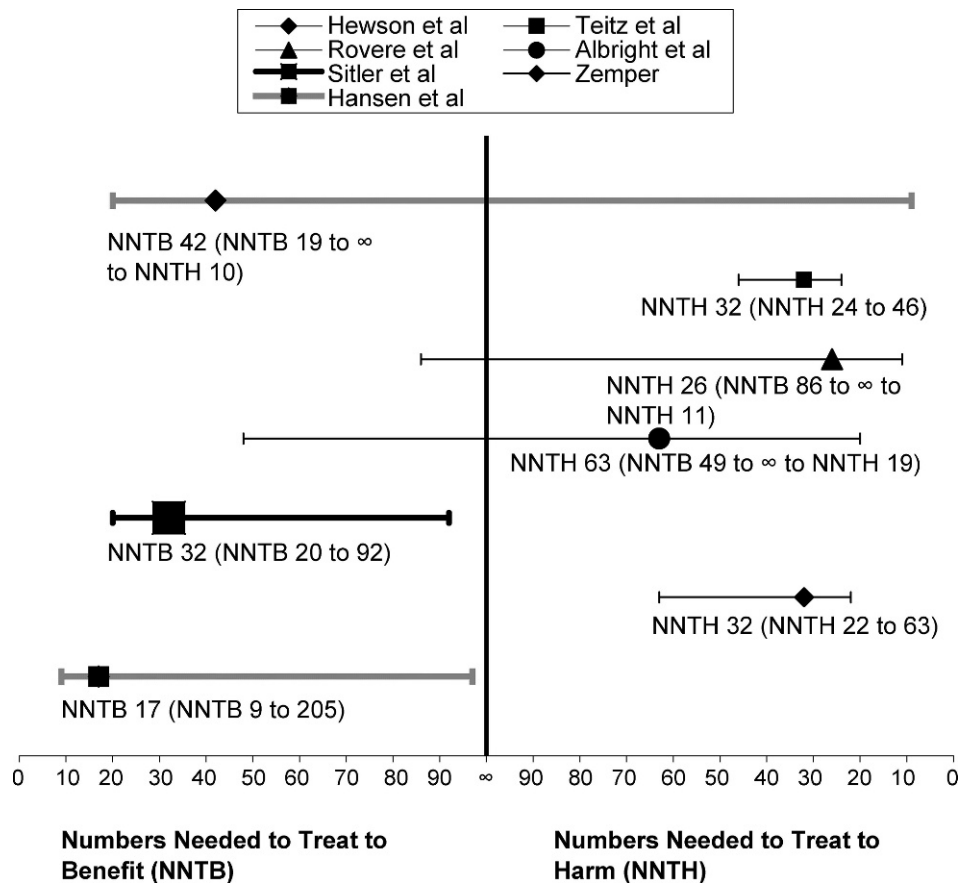


Figure 1. Numbers needed to treat to benefit or numbers needed to treat to harm for the 7 studies: Hewson et al,<sup>18</sup> Teitz et al,<sup>21</sup> Rovere et al,<sup>22</sup> Albright et al,<sup>19</sup> Sitler et al,<sup>20</sup> Zemper,<sup>23</sup> and Hansen et al.<sup>24</sup>

#### Equation 1: Relative Risk Reduction

$$\left(1 - \left(\frac{BIR}{NBIR}\right)\right) * 100 = RRR$$

#### Equation 2: Numbers Needed to Treat

$$\frac{1}{(NBIR)(RRR)} = NNT$$

## RESULTS

Point estimates and 95% confidence intervals have been reported numerically in Table 2 and graphically in Figures 1 and 2 for both RRR and NNT analyses. The RRR point estimates calculated for 3 studies (Hewson et al,<sup>18</sup> Sitler et al,<sup>20</sup> and Hansen et al<sup>24</sup>) indicated that prophylactic knee braces decreased the incidence of knee injury compared with the control groups (Figure 2). The RRI calculated for 4 studies (Albright et al,<sup>19</sup> Teitz et al,<sup>21</sup> Rovere et al,<sup>22</sup> and Zemper<sup>23</sup>) demonstrated more injuries per player in the group that wore prophylactic knee braces (Figure 2). Confidence intervals for the RRR in 3 of the studies (Hewson et al,<sup>18</sup> Albright et al,<sup>19</sup> and Rovere et al<sup>22</sup>) were very large and crossed zero, suggesting that a true prophylactic effect was unlikely (Figure 2).

The NNT analysis generated point measures in 3 studies (Hewson et al,<sup>18</sup> Sitler et al,<sup>20</sup> and Hansen et al<sup>24</sup>) depicting an NNTB for wearing prophylactic knee braces. In 4

studies (Albright et al,<sup>19</sup> Teitz et al,<sup>21</sup> Rovere et al,<sup>22</sup> and Zemper<sup>23</sup>), prophylactic knee braces had a harmful effect with NNTH. These NNTH point measures can be interpreted as the number of players needed to be braced to incur 1 knee injury. The effect of the intervention decreases as the number of participants needed to be braced moves closer to infinity, which is the point that represents the most ineffective intervention (Figure 1).<sup>28</sup> The most harmful prophylactic treatment is represented as an NNTH of 1 in Figure 1 and is understood to be an intervention that injures every treated individual. As the point measure moves closer to infinity on the negative side, the interventions are considered less harmful. The NNT confidence intervals for 4 studies (Hewson et al,<sup>18</sup> Rovere et al,<sup>22</sup> and Albright et al<sup>19</sup>) crossed infinity, making it impossible to determine the associated benefit or possible harm of the intervention.

## DISCUSSION

Point measures for the 3 studies showing an NNTB indicated that 42,<sup>18</sup> 32,<sup>20</sup> and 17<sup>24</sup> players, respectively, would need to be braced for 1 season to prevent 1 knee injury. The NNTB point estimates calculated in these 3 studies<sup>18,20,24</sup> are lower than those from recently recommended neuromuscular control training programs used to prevent noncontact anterior cruciate ligament injuries (89).<sup>17</sup> Unfortunately, the conclusions from these studies<sup>18,20,24</sup> were confounded by those from 4 other studies that demonstrated a harmful effect with prophylactic knee-

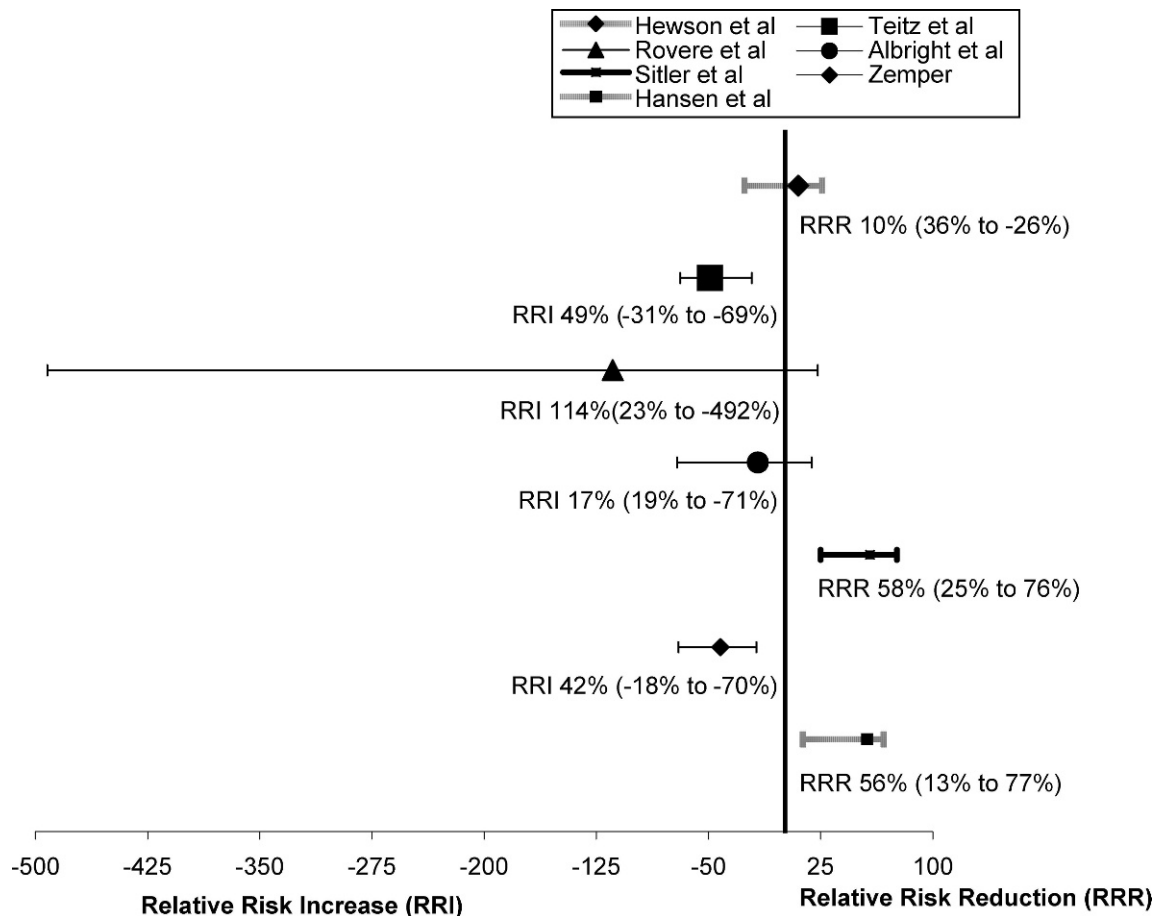


Figure 2. Relative risk increase or relative risk reduction demonstrated by the 7 studies: Hewson et al,<sup>18</sup> Teitz et al,<sup>21</sup> Rovere et al,<sup>22</sup> Albright et al,<sup>19</sup> Sitler et al,<sup>20</sup> Zemper,<sup>23</sup> and Hansen et al.<sup>24</sup>

bracing: point estimates indicated that if 63,<sup>19</sup> 32,<sup>21</sup> 26,<sup>22</sup> and 32<sup>23</sup> players were braced for 1 season, 1 knee injury would occur.

Therefore, due to the inconsistent findings within the literature, we deem the current evidence regarding the efficacy of prophylactic knee bracing in reducing knee injuries inconclusive. The available studies have severe methodologic flaws and many threats to internal and external validity. The Centre for Evidence-Based Medicine<sup>29</sup> has established guidelines for the levels of current evidence, which identify systematic reviews of high-quality randomized clinical trials as the highest level (1a) and expert opinion without critical appraisal as the lowest level (5). According to these guidelines, we awarded the current evidence a level of 4 and a grade of D (scale = A through D), which represents the troubling and inconsistent findings of the current research. The Strength of Recommendation Taxonomy<sup>30</sup> awards a high level of 1 to systematic reviews and meta-analyses that include high-quality clinical trials and a low level of 3 to expert opinion, extrapolations from bench research, and case series. We have awarded the current evidence a level of 2 and a grade of B (scale = A through C), again because of the poor quality of the available studies and the inconsistency of the findings.

Although the current literature is not of solid methodologic quality, we must assess the studies in a way that is fair

to the nature of the research. The mean PEDro score of the 7 included studies was 3.14 points of a possible 10. Because of the nature of prophylactic knee bracing, it is not possible to blind the participants or the athletic trainer to the intervention applied. Therefore, a PEDro score of 8 represents the best possible methods of a study of this nature. The studies with PEDro scores of 4 and 5 should be understood to have fulfilled 50% and more than 65%, respectively, of the feasible methodologic criteria.

In the best representation available within the literature, only 1 poorly conducted randomized controlled clinical trial showed prophylactic knee braces to have a beneficial effect in reducing knee injuries.<sup>20</sup> The trial was not performed on varsity collegiate athletes but an 8-man intramural tackle football program. This leads us to question the external validity of the study and how we can generalize the results to varsity collegiate athletes. No similarities were seen among studies regarding the brace used, the positions played, or the injuries reported.

These studies had many limitations. Only 1 group<sup>19</sup> excluded participants with previously injured knees. Knees that had been previously injured have been reported to be more susceptible to subsequent injury.<sup>31,32</sup> Only 1 group<sup>20</sup> stratified BIR and NBIR by incidence of previous knee injury. Sitler et al<sup>20</sup> reported higher injury rates per 1000 athlete-exposures in nonbraced players with no history (3.19) and a history of knee injury (4.39) compared with



braced players with no history (1.33) and a history of knee injury (2.40). Although very interesting, this information was not reported in a manner conducive for calculating NNT between groups with and without a prior history of knee injury.

Most of the studies were nonrandomized, meaning that athletes who had previous knee injuries may have been more likely to use prophylactic knee braces. If these athletes were injured, injury rates would increase in the intervention group. Including previously injured participants may offer an explanation as to why more injuries occurred in the braced group.

The braces used within the studies were different and, therefore, conclusions that we drew are not specific to one particular brace. Some authors<sup>19–21,24</sup> reported the use of more than 1 type of brace and included different ligamentous and meniscal injuries within their injury rates. It may not be prudent to include meniscal or anterior cruciate ligament injuries when assessing the efficacy of a brace designed to prevent collateral ligament knee injuries. Including these types of injuries may have inflated injury rates. Also, conclusions drawn from a generation of prophylactic braces used in the 1980s and early 1990s may not accurately represent currently used devices.

Normalizing exposures was critical to compare RRR and NNT values among studies. Normalizing exposure rates to 1 athlete per season provided us with a comprehensible unit of measure for comparing results among studies. However, normalizing exposure rates may have introduced some error because each athlete was only considered across 1 season. Athletes wearing only 1 knee brace and those who were braced but did not have a high number of exposures across the season could not be taken into account. Although this is a limitation, we felt that it was necessary to collectively draw conclusions from the included studies.

Even though many arguments discredit the conclusions drawn by each of the groups, we cannot ignore the possibility that prophylactic knee bracing may increase the risk of injury. Altered muscle activation has been reported in individuals wearing prophylactic knee braces and may be a factor in increased injury rates.<sup>33</sup> It would be interesting to know if the ankles were taped or braced at the time of knee injury. Future researchers should document the mechanism of the knee injury as well as whether the ankles were taped or braced in conjunction with prophylactic knee bracing.

## CONCLUSIONS

Based on a Strength of Recommendation Taxonomy<sup>30</sup> level of evidence of 2 with a grade of B, we cannot conclusively advocate or discourage the use of prophylactic knee braces in preventing knee ligament injuries in collegiate football players. Better-quality randomized controlled trials will allow us to accurately determine whether prophylactic knee bracing in collegiate football players is efficacious or harmful.

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