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Systematic Review

Preventive Effects of Knee Brace on Anterior Cruciate Ligament Injuries in Susceptible Individuals: A Systematic Review

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Abstract

Introduction: The results of various studies on the preventive effect of knee brace on anterior cruciate ligament (ACL) injuries in susceptible individuals vary; leading to doubts about their utilization for orthopedic specialists. The present study aimed to review the preventive effects of knee brace on ACL injuries in susceptible individuals.

Methods: This systematic review was performed using the keywords "Prophylactic Knee Brace, Neoprene Knee Sleeve, Knee Brace, ACL, Tear Risk Factors, and Biomechanical Factors" in online databases such as PubMed, Scopus, Springer, ProQuest, and the Google Scholar search engine. The I2 index was used to assess heterogeneity among studies.

Results: A total of eight high-quality articles were assessed all represented moderate heterogeneity (I2 index: 25%-75%). Only one study reported the ineffectiveness of knee brace in preventing ACL injuries, and the rest noticed positive effects.

Conclusion: The use of a prophylactic knee brace in individuals susceptible to ACL rupture can avoid sustaining pressure and possible damage to the knee and ACL

Keywords: Anterior Cruciate Ligament (ACL) Injury, Functional Knee Brace, Prevention.

Introduction

The knee joint is a significant part of the lower extremity kinetic chain, playing a pivotal role in weight-bearing and mobility [1-3]. Since it is located between the ends of the two long levers of the tibia and femur and lacks a stable bony configuration, the knee joint is vulnerable due to dealing with external forces [4-6]. ACL injury alone accounts for half of all knee injuries so that it can impose high treatment costs, including surgical and rehabilitation procedures [7, 8]. The treatment of ACL injury, surgical or rehabilitation, imposes a heavy economic cost on the individual and society [9-11]. In the United States, for example, more than 300,000 ACL injuries cases are reported annually, costing more than 6 billion US$. In addition to therapeutic costs, ACL tear causes a lower quality of life, lower quality of work, staying away from work and social environments, and devastating impacts on the whole ankle [12, 13].

The knee braces are used by athletes for the past 30 years to prevent ACL injury. However, they are recently prescribed for individuals prone to an ACL injury [14]. The outcomes of such bracings are investigated in various studies. However, the lack of a conclusion led to doubts about their usage for orthopedic specialists and surgeons [15].

These braces are categorized into three main groups include prophylactic, rehabilitation, and functional.

Knee braces are used to treat instability of knee joints due to ACL dysfunction, support for postoperative ACL graft augmentation, and avoid ligament damage during exercise [16].

Prophylactic braces are a type of knee brace often recommended for individuals with knee joint instability. Prophylactic knee braces are used both to prevent ligament injury and increase the stability of the knee joint in the ones with an ACL injury. Many researchers believe that bracing improves performance in individuals with knee injuries and attribute it to the reduction of the anterior-posterior translation and rotation displacement in the knee joint [17].

Many patients reported higher knee proprioception, greater security, and comfortability during intense physical activity using the braces. On the contrary, some studies showed the negative impact of bracing on knee function; however, some researchers emphasized the ineffectiveness of bracing on the performance of athletes [18].

Numerous studies addressing the risk factors for ACL tear show that more than 70% of injuries are due to non-contact mechanisms and only 30% contact ones [19]. Risk factors for non-contact ACL injury are classified into four main categories of anatomical, hormonal, environmental, and biomechanical. Since only biomechanical ones are changeable among the classified factors, many studies were designed and focused on them. Studies show that most non-contact ACL injuries occur when the knee is in the near-full extension state or a rapid deceleration in landing. It is also stated that among the external risk factors for an ACL rupture, the amount of flexion and valgus of the knee, rapid deceleration during landing, and the hamstring to quadriceps ratio are the most important ones. However, little research is performed on the effect of bracing on risk factors for an ACL rupture [20, 21].

Various studies have shown that knee braces can reduce the amount of external load on the knee as well as muscle contraction [14]; Also, the use of knee rehabilitation braces has been used to reduce the forces on this joint, and its effectiveness has been proven to reduce some risk factors of the knee joint, such as the proximity torque of the knee [22]. Knee braces are used as a procedure in patients who do not want or are unable to undergo surgery. However, its 100% effectiveness has not yet been proven, and some studies have shown that it cannot affect external forces on foot. On the other hand, the use of these braces in the long run, can weaken the knee joint [16, 23].

Given that the results of various studies on the preventive effect of knee brace on ACL injuries in susceptible individuals are not summarized thus far, orthopedic specialists doubt using knee braces. Hence, the present systematic review aimed at investigating the preventive effects of knee brace on ACL injuries in susceptible individuals.

Methods

The present systematic review of studies published from 01 January 2010 to 01 October 2020 aimed at investigating the preventive effects of knee brace on ACL injuries. The study steps were as follows: study design, data collection, summarizing articles, analysis, and interpretation of findings. The present study also adopted the preferred reporting items for systematic reviews and meta-analysis (PRISMA) [24].

Search and Data Collection Strategy

The electronic, English-language databases of Science Direct, Web of Science, PubMed, Scopus, Springer ProQuest, and the Google Scholar search engine, as well as printed and online texts, were searched by two researchers. The keywords, including Prophylactic Knee Brace, Neoprene Knee Sleeve, Knee Brace, ACL Tear Risk Factors, and Biomechanical Factors, were determined in a meeting with three knee surgeons familiar with the writing of systematic articles and then handed over to librarians. Inclusion criteria were a clinical trial, quasi-experimental, descriptive, and cohort studies, and their purpose is to investigate the effects of knee braces on knee function (laboratory - human-designed models and biological studies). Exclusion criteria included articles without full-text, published in non-English languages, failed to provide a valuable report, or those with inappropriate reporting, low quality, and lack of relevance to the study topic. First, two researchers independently searched the databases and texts using keywords, and the retrieved ones were placed at disposal of two faculty members qualified in meta-analysis and they reviewed the titles, keywords, and abstracts of the articles and selected the ones in line with the systematic review objectives. The lowest kappa coefficient for both researchers in the selection of articles was 70%. For articles not selected

by one of the researchers, the strategy of "simultaneous review by both researchers" was applied; in other words, the article was reviewed by both researchers in a meeting the final decision was made by consensus. Ultimately, articles with full texts were included in the study. Then, their references were also reviewed to find all the relevant articles, and the selected ones were finally reviewed and entered into the study.

Data collection form

First, the articles were studied thoroughly by two researchers qualified in systematic reviews. They also designed a data collection form including the name of the first author, the year of publication, country of origin, sample size, the study's main objectives, the inclusion and exclusion criteria, and the results. The form was completed by the researchers, and any controversies between them were resolved by consensus. If it failed to obtain a conclusive result, the problem was resolved with the help of a third party.

Data analysis

The I2 index was used to assess heterogeneity among studies, and in the case of heterogeneity, the random-effects model was utilized to synthesize the studies and perform a systematic review. Index I2 less than 25% was considered as low, 25%-75% as moderate, and more than 75% as high heterogeneity.

Results

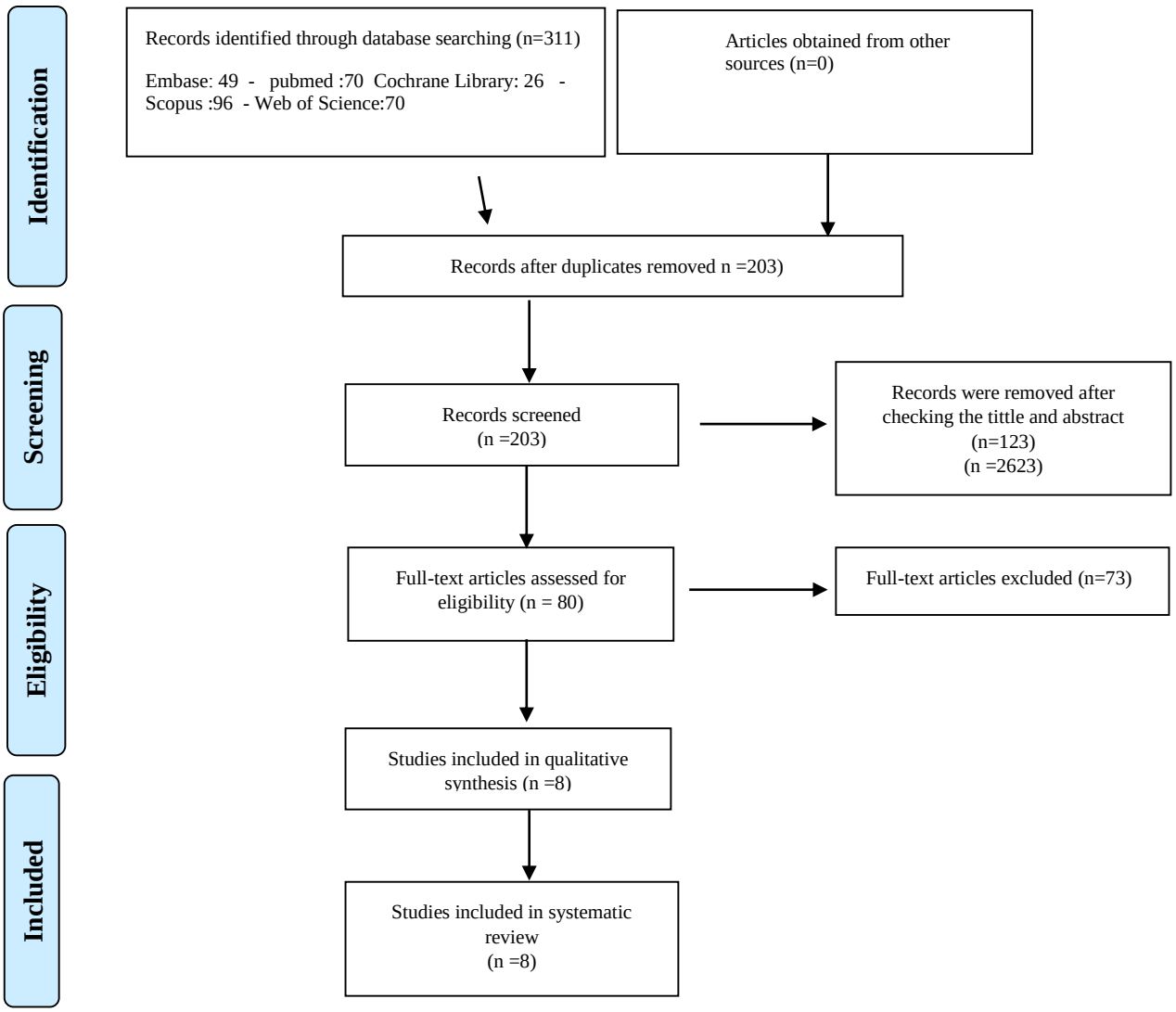
In the initial search, 311 studies were retrieved by reviewing their texts, abstracts, results, and conclusions; finally, eight articles were included in the current systematic review. The flowchart of the present systematic review is given in Feature 1.

Reviewing the quality of the articles showed that all the studies were at a moderate level of heterogeneity. Two studies by Giotis (2011 and 2013) had the highest heterogeneity scores (70), and the rest (n=6) obtained 68.75 (Table 1).

A review of the results of the selected studies showed that the use of knee braces in individuals with knee instability (for whatever reason) has a protective effect on ACL injuries caused by contact. It was also found that these braces can divert a lateral blow away from the joint to farther areas on the tibia and femur. It limits the forces applied to the joint and reduces tension in the ACL. All of the selected studies, except one by Moon (2018), reported that the brace could protect the knee against injury while not restricting mobility (Table 2).

Table 1: Assess the quality of the methodology of studies entered in a systematic review

First Author, Publication Year	Aim (2*)	Selection (8 *)	Comparability (2 *)	Outcome (4 *)	Score * (Maximum score: 16 points)	Score Percent
Giotis(2011)(25)	**	******	*	***	12	75
Giotis(2013)(26)	**	******	*	***	12	75
Steffen Paul Hacker (2018)(27)	**	*****	*	***	11	68/75
Di Wu (2018)(28)	**	*****	*	***	11	68/75
Hanzlíková (2019) (29)	**	*****	*	***	11	68/75
Steffen P Hacker (2019)(30)	**	*****	*	***	11	68/75
Giotis (2013) (31)	**	*****	*	***	11	68/75
Moon (2018) (32)	**	*****	*	***	11	68/75



Feature1: The flow of reviewed studies.

Table 2: Summary of articles included in this systematic review study

Author (Year)	Country	Type of study	Purpose	Participants	Intervention	Result	Final result
Dimitrios Giotis (2011)	Greece	Case–control study	investigate whether knee braces could effectively decrease tibial rotation during high demanding activities	Total: 21 physically active Men: 21 Women: 0	(1)descending from a stair and subsequent pivoting and (2) landing from a platform and subsequent pivoting under three conditions: (A) wearing a prophylactic brace (braced), (B) wearing a patellofemoral brace (sleeved), and (C) unbraced condition	Knee braces resulted in significant changes in knee rotation ($P<0.001$)	The use of knee braces leads to increased translational and rotational forces in people after ACL reconstruction and people with ACL injury.
Dimitrios Giotis (2013)	Greece	prospective comparative study	Effects of Knee braces on knee rotation kinematics of ACL-reconstructed patients	Total: 20 Men undergone unilateral ACL reconstruction: 20 Women: 0	(1) descending from a stair and subsequent pivoting, and (2) landing from a platform and subsequent pivoting. The tasks were repeated under 3 brace conditions for the ACL-deficient knee: (1) wearing a prophylactic brace (braced condition), (2) wearing a patellofemoral brace (sleeved condition), and (3) without brace (unbraced condition).	Using Knee braces significantly leads to lower rotation than in people who have used this brace compared to people who have not used it ($P \leq .022$)	The use of Knee braces reduces the range of motion of the knee; also; braces have the potential to decrease rotational knee instability that still remains after ACL reconstruction.
Steffen Paul Hacker (2018)	Germany	Controlled laboratory study	Investigating the protective effects of Knee Braces from Tibial Moments against impact	Total: 8 Men leg specimens: 2 leg specimens Women: 8	All knees were hit at a 30-degree angle in the laboratory and with a device designed for this purpose; The effects of impact on CAL and tibial moments were evaluated.	Pressure on the knee has reduced the pressure on the CAL; The protective power of the braces over the knee ligaments has also been increased. Also Bracing had no effect on the ACL strain change or kinematics under internal or external moments.	Bracing in contact sports with many lateral or medial impacts might be beneficial
Di Wu (2018)	China	cohort	Protective effects of Knee Braces on Parachute biomechanical condition during landing	Total: 30 Men: 30 Women: 0	Participants were divided into no-brace, elastic brace, and semi-rigid brace groups and jumped from a	peak flexion angle was reduced by 9% in the elastic group and 12% in the semi-	Elastic and semi-rigid braces lead to stability of the knee joint against pressure and descent; However,

					height of 80 and 40 cm. Knee flexion was measured in different positions.	rigid group. peak angular flexion was reduced by 9% in the elastic group and 4.16% in the semi-rigid group.	the effects of semi-rigid knee braces are greater than those of elastic braces. The use of semi-rigid knee braces leads to greater ACL stability.
Hanzlíková (2019)	Uk	Controlled laboratory study	Effects of knee bracing on knee joint stability after anterior cruciate ligament reconstruction	Total: 30 Men: 30 Women: 0	Knee braces were used for participants after reconstruction of the anterior cruciate ligament. Knee kinematics were collected in the sagittal ,coronal and transverse (internal-external rotation) planes.	The brace reduced the peak knee external rotation angle and range of motion in the transverse plane during the pivot turn jump task, and significantly increased the maximum knee flexion angular velocity during the single leg drop jump task.	The positive effects of using knee braces on knee movement stability, knee kinematics and knee joint stability were confirmed after ACL reconstruction
Steffen P Hacker (2019)	Germany	experimental study	Protective effects of knee braces on anterior cruciate ligament rehabilitation	T8 Limbs	Braces were used for each limb in three modes; unbraced, braced and with a misaligned brace. The ligaments of the knee were then pressed and each knee was rotated 10 to 60 degrees. The final results were compared.	The pressure on the ligament was 10 degrees lower when the brace was used than when the brace was not used; Ligament strain was significant in all three cases without changes; effect of bracing on knee kinematics was not detected	Correctly aligned knee leads to greater knee stability and has an effect on the ACL.
Giotis (2013)	Greece	Biomechanical laboratory study	Effects of Knee Braces on tibial rotation in anterior cruciate ligament	Total: 21 Men: 21 Women: 0	Participants were wearing a prophylactic braced (braced condition), wearing a patellofemoral brace (sleeved condition), and without brace. Increased rotational and translational loads on the knee were performed for all of them and finally their results were evaluated.	ACL-deficient knee resulted in lower rotation than the unbraced ($P \leq 0.001$) and sleeved ($P \leq 0.033$) conditions but not in the stair descending and pivoting task ($P = 0.256$)	Knee braces have many positive effects on the stability of people with damaged anterior cruciate ligament. It also plays an important role in preventing ACL damage.
Moon (2018)	Korea	clinical study	Effects of preventive knee braces on protection of the knee joint and	Total: 19 Men: 19 Women: 0	Participants jumped down from a 40 cm box with three different conditions	The results showed that there were no statistically significant	Using a knee brace cannot reduce the pressure on the ACL during the jump and prevent

			ACL during drop jumps		(without a brace / sleeve, with a brace and with sleeve); ACL force was measured after the jump.	differences between the two groups in the variables ACL force(P=0.964) and Normalized ACL force (P=0.976).	damage to the knee ligaments.

Discussion

This study aimed to investigate the preventive effects of knee brace on ACL injuries in susceptible individuals. Most studies on the consequence of knee brace examined the amount of force applied to ACL; however, to the best of the authors' knowledge, no eligible study was found on the effect of braces on the risk factors for ACL injury. These studies used direct and indirect techniques to measure the function of the knee brace on the biomechanics of the knee and ligament. In direct techniques, the amount of stress at the ligament is measured by placing a sensor inside the joint of a corpus with and without bracing, and in indirect techniques, by measuring the amount of flexion and valgus of the knee, as well as shear forces loading in the knee during landing and the hamstring to quadriceps ratio [33-35]. The results of this study showed that preventive use of knee brace could reduce forces applied to the ACL and, at last, stabilize the knee joint. Susceptible subjects in the reviewed studies included athletes and individuals with a history of knee instability. Such individuals are prone to knee and ligament injuries; therefore, using the knee brace for them was evaluated [36, 37].

Ligament injuries typically occur when severe force is directly or indirectly, from valgus stress, applied to the knee. Excessive stretching of a ligament leads to its strain, one of the most common orthopedic complications [38, 39]. The prophylactic Knee brace is the most widely used support in recent years to prevent the number and severity of ACL injuries [40].

Many studies have been performed since prophylactic knee braces were introduced to show their preventive effects on a knee injury. Some of them are conducted on a certain population over a short period. The results of these studies are almost similar; some even denied the positive effects of prophylactic knee braces, and others reported very few positive effects. However, the results of those reporting positive effects of the braces are more consistent with this study. It seems that controversy among the results of various studies is due to wrong intervention, improper bracing, duration of bracing, and inappropriate study design. This systematic review found that high-quality articles indicate the positive effect of prophylactic knee braces on ACL damage [18, 41-43].

As can be deduced from the results of research on the effect of using prophylactic knee braces on the risk factors for ACL injury, the brace reduces the risk of injury in people without ACL. A review study in this field believes that the use of knee braces cannot prevent the improvement of functional, clinical, and biomechanical skills in the long run; However, the use of knee braces cannot improve knee function, the results of which are not in line with the results of our study [44]. Another review study conducted in this area had similar results to this study. The researchers concluded that the use of preventive knee braces could significantly delay the need for surgery; Also, the use of knee braces to reduce pain and increase the strength and function of the knee leads to an improvement in the quality of life of patients; Therefore, it is recommended to use preventive knee braces for patients who are candidates for ACL surgery [14]. In another recently published study, researchers failed to find convincing evidence of the positive effects of using knee braces, and in their study, knee braces failed to improve knee function; They also state that there is no strong evidence regarding the use/non-use of knee braces, but patients with ACL injuries should use these braces [45].

Biomechanical studies are performed on the preventive effect of braces on knee injuries; however,

they do not conclusively and documentarily show the prophylactic effect of these knee braces, and their results are not consistent with those of the present systematic review. Knee injuries due to movements and forces transmitted across the knee and ligaments are preventable when the knee injuries are properly identified, and the proper interventions are subsequently applied [46, 47]. The appropriate application plays a pivotal role in the final results of knee bracing and should be considered. But as a significant point, there are several uncontrollable factors in imposing force on the knee. In addition, conditions such as the type of trauma, the force acting at the knee, and the direction and angle of force transmitted across the knee and ligaments are among the factors that can affect the outcome of using knee braces. All in all, a variety of contributing factors led to different results in different studies.

Conclusion

According to the results of the present review study, in situations where the kinematic variables of speed and agility are important for the individual, the use of prophylactic braces can be advantageous to reduce the risk of ACL injury. Likewise, based on the results of the present study, despite the ambiguous role of braces in haltering the risk factors for ACL injury in individuals with a history of ligament damage, the use of braces can improve the kinetic variables of strength, power, and balance, and those undergoing ACL reconstruction can benefit from their advantages.

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Conflict of Interest Disclosures

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Authors' Contributions

JSM: Article Searching and Summarizes. MM: Article Prepration. AM: Study Design, Methodology search and article Submision

Ethical Statement

This research does not require a code of ethics.

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