EFFICACY OF FUNCTIONAL KNEE BRACES IN SPORT: A REVIEW

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The purpose of this work was to review previously published studies on functional knee braces in an attempt to understand their functionality. A better comprehension of the effects of functional knee bracing could assist ACL-deficient athletes in deciding whether or not these devices could be beneficial in supporting their unstable knee joint during sports. Results showed that functional knee braces alter knee joint kinematics, kinetics and muscle activity. Their mechanism of action, however, might be attributed to the modification of proprioception and motor patterns of the lower limb rather than their mechanical stabilizing effect.

KEY WORDS: functional knee brace, anterior cruciate ligament (ACL) deficiency

INTRODUCTION: Knee injuries are caused either by direct contact or non contact movements and account for up to 50% of all sport injuries (de Loës, Dahlstedt & Thomée, 2000). The three main movements producing knee injury are planting and cutting, straight knee landings and rapid one-step stops (McNair, Marshall Matheson, 1990; Olsen, Myklebust, Engebretsen & Bahr, 2004). During these movements, the anterior cruciate ligament (ACL) tightens with extremes of extension and contraction, accompanied by internal or external rotation of the knee (Ebstrup & Bujsen-Moeller, 2000). Ligamentous tears to the knee, especially to the ACL, are the most debilitating of any sport injury and result in the longest time of absence from sport participation (Thacker et al., 2003). Functional knee braces (FKBs), devices designed to provide support for unstable knees, are frequently utilized to stabilize a ligament-injured knee during sports (Wirth & DeLee, 1990). They include medial and lateral vertical hinges, which may be uniaxial or polyaxial, and a mechanism to limit hyperextension (Martin & the Committee on Sports Medicine and Fitness, 2001). Although functional knee bracing has been extensively documented in literature, no clear consensus has been reached regarding their efficacy. The purpose of this work was to review previously published studies on FKBs in an attempt to assess their efficacy, thereby aiding ACL-deficient and ACL-reconstructed athletes in deciding whether or not a FKB could be beneficial in supporting their unstable knee joint during sports.

METHODS: A search of electronic databases (i.e., PubMed and Scopus from 1975 through March 2009) was performed using the keywords *knee brace, knee orthosis* and *anterior cruciate ligament (ACL)*. The search was then refined using the terms *functional knee brace* and *ACL deficiency*. Citations were further identified from the reference sections of the research papers retrieved. Studies were included in the review if they investigated the effects of FKBs on the knee joint. Abstracts, unpublished studies, papers not written in English and papers that addressed brace types other than FKBs, were excluded. In total, 96 articles were considered for the review. Retained studies consisted of biomechanical analyses on healthy knees, ACL-deficient knees and ACL-reconstructed knees, with and without FKB. In vitro studies on cadavers and knee joint models evaluated the effects of FKBs on the ACL. In these studies, the cadaveric knee or knee model was attached to a testing jig, which assessed torsional and antero-posterior loading via external force transducers and potentiometers (Wojtys, Loubert, Samson & Viviano, 1990; Liu, Lunsford, Gude & Vangsness, 1994). In vivo three-dimensional kinematic analyses of the knee joint were performed using intra-cortical pin implantation. Bone pins, affixed with target clusters, were inserted into the femur and tibia. Roentgen-stereophotogrammetric X-rays were taken with the implanted pins to record the position of the markers and to define the anatomical landmarks of the tibia and femur. Infrared cameras captured the markers about the knee, determining antero-posterior displacement of the tibia as well as tibial rotation of the knee joint (Ramsey et al., 2001). In addition, studies used ACL-implanted strain transducers to measure the displacement behavior of the ACL and calculate its strain response/elongation in vivo (Beynnon & Fleming, 1998; Cerulli, Benoit, Lamontagne, Caraffa & Liti, 2003). Other biomechanical studies examined knee joint kinematics and kinetics, with and without FKB, during quick stops, landings, lateral displacements and change of direction. Some studies have included in their methods surface and needle electromyography (EMG) to determine lower limb muscle activity with and without FKB (Wojtys, Kothari & Huston, 1996). Moreover, investigations conducted in a laboratory setting used dynamometers, such as isokinetic devices, to measure power, peak torques, peak forces and moments of force at the knee joint with and without FKB (Houston & Goemans, 1982). These studies, combined with our experience on biomechanical analyses of FKBs, were used to understand the functionality of FKBs.

RESULTS: Cadaveric studies have shown that FKBs can restrain anterior tibial displacement by 29-39% when the hamstring, quadriceps and gastrocnemius muscles are relaxed and by 70-85% when these muscles are contracted (Wojtys et al., 1990). Conversely, studies on mechanical knee surrogates have demonstrated that the aforementioned effects are present exclusively when the knee is subjected to static or low anterior shear forces; FKBs tend to fail in instances where high loads are present (France, Paulos, Jayaraman & Rosenberg, 1987). In vivo studies supported this finding by demonstrating that FKBs did not significantly reduce anterior tibial displacement during one legged jumps (Ramsey et al., 2001). Furthermore, braces have been shown to decrease peak load on the ACL in weightbearing and non-weightbearing knees (Beynnon et al., 1997) and to some extent control internal rotation of the knee under low loads. They cannot, however, control external rotation of the knee (Beynnon et al., 1992). Kinematic and EMG analyses showed that FKBs altered knee joint kinematics, force distribution characteristics as well as muscle activation patterns during the stance phase of running in normal and in ACL-deficient subjects (Knutzen, Bates, Schot & Hamill, 1987; Théoret & Lamontagne, 2006). In addition, EMG evaluations have found that brace application improved both quadriceps and hamstring muscle response times during anterior tibial translation stress testing and sports. On the contrary, both quadriceps and hamstring muscle reaction times were slowed by the knee braces (Wojtys et al., 1996; Németh, Lamontagne, Tho & Eriksson, 1997). Moreover, surrogate knee models were used to assess FKB composition and its effects on the transmission and absorption of low-level, repetitive impact forces at the knee. The results revealed that stiffer materials better resisted bending and therefore provided more protection to the knee joint given that the ligaments were required to provide a smaller proportion of the total resistance to the impact forces (Patterson & Eason, 1996). Others focused on distal migration of FKBs and concluded that misalignment of the brace does not modify lower limb mechanics during gait (Singer & Lamontagne, 2007). FKBs have been shown to produce several adverse effects on the lower limb. Markedly, EMG analyses demonstrated that knee bracing resulted in decreased hamstring and quadriceps activities during cutting maneuvers (Branch, Hunter & Donath, 1989). Isokinetic testing demonstrated that knee bracing decreased maximal torque output of the quadriceps by 12-30% and reduced maximal knee extension velocity by 20% (Houston et al., 1982). Furthermore, increased energy expenditure and premature muscle fatigue caused by regional muscle ischemia and lactic acid build-up during physical activity were concurrent with knee bracing (Styf, 1999). Similarly, clinical testing revealed that knee bracing reduced individuals' speed and agility (Marans, Jackson, Piccinin, Silver & Kennedy, 1991).

DISCUSSION: FKBs are commonly utilized to counteract the combining effects of antero-posterior displacement and internal rotation of the knee in ACL-deficient and ACL-reconstructed athletes. An ideal brace would synergize with the muscular and ligamentous knee stabilizers throughout the normal range of motion. Also, it would diminish negative effects of valgus, varus, rotational and translational forces exerted on the knee (Martin & the Committee on Sports Medicine and Fitness, 2001). Results revealed that functional knee braces do in fact modify knee joint kinetics and kinematics; however, their mechanisms of action might not necessarily be those initially speculated. Several authors have put forth the idea that perhaps FKBs do not stabilize the knee from a mechanical perspective and, as a result, research should focus on how FKBs alter proprioception and motor patterns of the lower limb. Modification of muscle activation, timing and coordination during physical activity could be beneficial in reducing strain on the ACL, reducing tibial rotation and limiting anterior tibial displacement (Németh et al., 1997; Ramsey, Wretenberg, Lamontagne & Németh, 2003).

CONCLUSION: This work reviewed previously published studies on FKBs in an attempt to assess their efficacy. FKBs seem to have some desirable effects on the knee joint. The use of a FKB can assist ACL-deficient or ACL-reconstructed athletes in continuing their sport practices, although performance may be compromised. These devices, however, should not replace a proper rehabilitation program or necessary surgery. Although numerous studies have investigated the effectiveness of FKBs, most of them focused on the mechanical stabilization effects of such devices. Future research is needed regarding the effects of FKBs on neuromuscular control as well as modification of locomotion patterns.

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