Etiology and Intervention for Common Overuse Syndromes Associated with Mountain Biking

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Abstract
Though mountain biking is more often associated with traumatic injuries, athletes who participate in this sport are also at significant risk for developing overuse syndromes. Overuse problems associated with mountain biking are thought to occur due to a combination of repeated, vibratory stresses and the sustained but unnatural positions assumed by participants during long hours of riding over trail-like surfaces. The most commonly reported conditions afflict low back, neck, or knees and are the result of inefficient patterns of motor recruitment as well as environmental factors within the rider’s control. This review describes the mechanisms by which mountain biking-associated overuse conditions are proposed to develop and describes how education and a proper training regimen may help mountain bike riders recover from overuse syndromes or prevent their onset altogether.

ABBREVIATIONS
LBP: Low Back Pain; TA: Transversus Abdominis; LM: Lumbar Multifidis; PFPS: Patellofemoral Pain Syndrome; ITBS: Iliotibial Band Syndrome; TFL: Tensor Fascia Lata

INTRODUCTION
Mountain biking has quickly grown from a niche activity into a popular international sport [1,2], and fundamental to the practice is the rider’s ability to navigate rocky, steep, or slippery trails known as “single-track” [3]. Riding over rough surfaces produces vibration and often-unpredictable impacts that are partially dispersed by equipment, with the remainder introduced to body tissues through contact points with the bike. Such repetitive forces absorbed by the rider’s body can result in micro-trauma to connective tissues. Races, endurance events, and even recreational mountain bike riding can demand that a participant spend hours in the saddle, creating an ample portion of “at risk” time on the bike [4–7]. Fatigue may further increase the risk of overuse injury due to loss of motor control and decreased balance, [8] which potentially allow lapses in optimal body position. A rider’s training habits can also affect overall fitness and contribute to the onset of overuse syndromes. In this way, overtraining can be negatively associated with physical fitness [9,10]. The exploratory nature of mountain biking, in which riders venture forth on trails for multiple hours or even day-long rides, renders these athletes susceptible to the adverse effects of such overtraining. In addition to these factors, a growing number of studies have established correlations between specific variables such as improper bike fit, gearing choice, and riding volume with the onset of overuse injuries.

Although 45 - 90% of mountain bikers experience overuse syndromes [4,11,12], the literature primarily describes acute mountain biking injuries [13–18]. The most common mountain biking-associated overuse syndromes – low back pain (LBP), neck pain, and knee pain – may be resolved with conservative treatment. However, the literature offers minimal recommendations regarding how to best avoid or manage these conditions. Therefore, the focus of this review is to summarize the existing literature describing overuse injuries associated with mountain biking, illustrate how common overuse problems develop, and provide basic recommendations for preventing or alleviating such problems.

Etiology of LBP in Mountain Bikers

The low back is a common source of pain in 24 - 41% of mountain bike riders [4,11,12] and occurs via a variety of proposed mechanisms. Most research describing LBP in mountain biking populations is theoretical and based on factors unique to off-road riding. This includes the introduction of ground reaction forces and increased demand on trunk muscles that occur while riders attempt to maintain balance and negotiate rough terrain.
In addition, much of the literature linking spinal pathology and general cycling is relevant to the mountain biking population.

Fröbose and colleagues propose that a combination of vibrations and jolts during rough downhill riding as well as a relatively static, flexed riding posture stress the spine of mountain bikers [4]. The literature describing pathology in road cyclists affirms the role of the cyclist’s physiologically unnatural, flexed position in causing LBP [19–21]. This is largely due to anterior loading of vertebral discs and traction forces on dorsal structures which are placed in a position of sustained stretch [22–24]. Such stresses are thought to result in deformation of visco elastic structures which occurs over time when passive spinal components are placed under an extended load [25,26].

In the general population, lumbar pain is often associated with impaired motor control of the deep trunk musculature [22,27,28]. Because core muscles such as the transverse abdominis (TA) and lumbar multifidi (LM) are not preferentially recruited during the pedaling motion in mountain biking, it stands to reason that they may become inhibited due to underuse. During trail riding, the upper and lower extremities are somewhat fixed relative to the bike. Therefore, with the body in a posture of trunk flexion, core musculature may not play its customary role of segmental spinal stabilization and the risk of micro-trauma to spinal connective tissue increases [22].

Finally, some literature proposes that over-activity of spinal extensors and/or hip flexors may lead to low back pain. In this way, isometric spinal contractions produced due to the sustained position experienced during long rides may produce ischemic pain. This is because prolonged muscle contractions compress capillaries, which in turn decreases blood flow and limits oxygen delivery to and waste product removal from the area [4,29]. This idea was supported in a study which found that a cycling task induced significant fatigue in the erector spinae muscles [30]. With respect to hip flexor activity, Usabiago et al proposed that excess use of the psoas major muscles during pedaling results in intermittent rotary forces on the spine due to their laterally positioned attachments on the transverse processes of lumbar vertebrae [31].

Management of Mountain Biking-Associated LBP: Effective Recruitment of Spinal Stabilizers

The literature is dear that exercise is effective in reducing LBP. Most authors recommend the training of “core” muscle groups to improve neuromuscular control and coordination of trunk musculature which are inhibited in the presence of LBP [32]. This approach helps limit imbalances that occur when athletes perform their sport in asymmetrical positions, a situation that encourages over-activity and decreased flexibility in certain muscle groups and inactivity in others [33]. The flexed position associated with mountain biking, for example, may promote repetitive contractions and functional shortening of the hip flexors as well as inhibition of abdominal activity.

Therefore, training programs for improving motor control of the spine should emphasize recruitment of stabilizing musculature within an ideal spinal posture. This involves having the participant identify the most asymptomatic position of the spine in which to initiate training and functional movements. Often described as the “neutral” or “functional” position, assuming this protective posture places the spine in a position of stability and minimizes mechanical stress caused by distal perturbations [34]. The next step is to perform small and precise movements of targeted muscles which are then expanded into controlled contractions performed in a variety of contexts [32]. Because of typical recruitment patterns in individuals with LBP, Hodges and Richardson suggest that training programs for this condition focus on the TA and LM muscles [27,28,35,36]. A common starting point is performance of a “drawing-in” maneuver, in which abdominal muscles such as the TA are recruited by having the athlete lightly and inwardly contract the muscles of the lower abdomen. This engages stabilizing musculature and thus facilitates the maintenance of ideal pelvic position [37].

Advancement of this approach includes performing exercise in progressively less-stable positions until the skill is integrated into activity-specific movements involving whole body motions [38,39]. Eventually, activation of core muscles should be maintained during riding. The literature recommends incorporating year-round core conditioning into training regimens to promote trunk stability and lower extremity alignment [29,40–43].

Neck and Upper Back Pain Due to the “Head Up” Position

Mountain bikers must sustain a position of cervical extension and simultaneously stabilize the weight of their heads against perturbing forces while fixing their gaze on the trail ahead. Predictably, neck and upper back pain are common complaints, found in approximately 16% - 43% of mountain bikers [4,12]. Several authors have suggested that “trigger points” – local areas of pain and spasm - in overactive levator scapulae and trapezius muscles may contribute to symptoms in cyclists’ painful necks [24,29,44,45]. Mellion proposed a “multiple micro-whiplash” mechanism among road cyclists due to prolonged vibratory forces during endurance efforts that results in connective tissue injury and the formation of cervical trigger points. It follows that larger and often unpredictable ground reaction forces experienced during off-road cycling may result in similar sequelae [29]. Furthermore, because cyclists’ neck extensors are continually recruited, the levator scapulae and upper trapezius attempt to compensate and can become overworked if they are not supported by larger and more powerful muscles in the upper back. Hyperactivity in these muscles, therefore, is most likely when there is corresponding weakness or fatigue of the middle and lower trapezius and deep cervical flexors, demonstrating a compensatory strategy that may lead to dysfunction and pain [46,47].

Another consideration is the biomechanics associated with the on-bike position of prolonged cervical extension, scapular protraction, and thoracic flexion. This posture can result in over-lengthened posterior shoulder and thoracic muscles and may place the anterior cervical musculature at a mechanical disadvantage [48]. Simultaneously, anterior tissues like the pectoral muscles can become shortened, [49] contributing to the excessive kyphosis and rounded shoulders sometimes seen in cyclists.
Minimizing Neck Pain for Mountain Bikers

Goals during rehabilitation of cervical problems should include regaining neuromuscular control of inhibited muscle groups such as scapular retractors and depressors (i.e., middle and lower fibers of the trapezius), and deep neck flexors [46,50–53]. In the short term, stretching as well as manual therapy – as would be performed by a licensed health care practitioner – have been found to decrease neck pain [54]. Stretching is recommended to facilitate lengthening of functionally-shortened anterior tissue and is commonly focused on the pectoral, scapne, upper trapezius, and levator scapulae muscles [51,55]. Manual stretching combined with trigger point compression has been shown to reduce pain in the upper trapezius [56]. Published Clinical Practice Guidelines for neck pain also recommend joint mobilization and/or manipulation of the cervical and thoracic spine in addition to improving strength, coordination, and endurance in the affected muscles [55]. Self-stretching, self-massage, and relaxation training can also be effective techniques for soft tissue lengthening and relaxation, and are easily taught [48].

Subtle Changes in Alignment and Biomechanics May Lead to Knee Pain

Knee pain most frequently occurs at the anterior and/or lateral aspect of the knee and has been reported in 20–27% of mountain bikers [4,11,12]. Anterior knee pain, known as patellofemoral pain syndrome (PFPS), occurs due to excessive shearing forces on the underside of the patella in the troclear groove of the femur, and can result in pathological changes to the cartilage in this area [4,24,57]. Cyclists prone to this condition experience symptoms during uphill climbs, while using high gears, and/or while pedaling at low cadences [3,57]. Lateral knee pain is often associated with a condition known as iliotibial Band Syndrome (ITBS) and is common among athletes such as mountain bikers, who engage in repetitive knee flexion and extension [20,58]. It has been proposed that pain and inflammation at the distal iliotibial band (ITB) insertion occurs when the posterior fibers of this tract repetitively slide over the lateral femur in an “impingement zone” of approximately 20 to 30 degrees of flexion [58,59].

Factors that disturb the optimal alignment of the knee during cycling predispose mountain bikers to the above conditions. One factor affecting alignment is the strength of proximal musculature and its effect on biomechanical positioning of the hip, knee, ankle, and foot [57,60]. As described in the previous section outlining etiologies for LBP in cyclists, lower extremity movements are preceded and thus stabilized by contractions of trunk musculature such as the TA and LM [27,36,40,42]. Trunk weakness or fatigue can therefore result in altered kinematics in the lower extremities as the core becomes less able to provide a stable platform from which the leg muscles may work. Research demonstrates that core muscle fatigue plays a prominent role in altering lower extremity joint mechanics in cyclists [40]. Mountain biking conditions, such as highly technical trail sections, may demand heightened balance, agility, and stability and require additional recruitment of core musculature. Over time, these fatigued trunk muscles may result in inadequate lower extremity biomechanics as the stability of the pedaling platform diminishes.

Similarly, a lack of proximal strength surrounding the hip joint has been associated with suboptimal alignment in athletes’ knees [61]. Because mountain bikers primarily utilize muscles which function in the sagittal plane, muscles of the lateral hip that provide frontal plane stability may become under-developed unless they are specifically targeted for strengthening and endurance. Friction at the patella or ITB may also be exacerbated by increased tension in the muscles inserting into this structure, including the tensor fascia lata (TFL), gluteus maximus, and vastus lateralis. This, however, is still thought to be related to overloading of the TFL and subsequent increased tension on the ITB due to lack of strength in the primary hip abductors [59].

External factors such as choice of gearing ratio and bike fit have also been correlated with knee pain in mountain bikers [3,4,11]. Because pedaling in a higher-than-necessary gear places undue stress on patellar structures, [57,62] mountain bikers must be efficient in shifting through the optimal gear options. Lebec et al. reported that riders alternating between multiple-gear and single-gear mountain bike riding reported a significantly higher incidence of knee pain than those riding only multiple-gear bikes. This study suggests a possible linkage between excessive gear choice and overuse injury [12]. With respect to bike fit, multiple authors have found PFPS and ITBS to be associated with inappropriate mountain bike seat settings [3,4]. An improperly adjusted saddle or pedal cleat position have both been correlated to unwanted forces because these affect the location of the cyclist’s knee between two fixed points and may lead to misalignment and micro-trauma over the course of thousands of pedal revolutions [3,58]. Additionally, improperly adjusted cleats can produce stress on knee tissues by forcing the knee into excess internal rotation [4,24,57,58,63]. Tension on the ITB and subsequent irritation of the lateral knee can result from an excessively high or posteriorly situated seat or positioning that causes over-pronation of the foot [57].

Limiting Knee Pain on the Trail: Optimal Alignment and Proximal Control

To minimize knee pain, regardless of its location, knee structures must be properly aligned and excess joint forces should be reduced. Alignment can be further maximized by training core musculature [40]. Recent studies involving athletes have supported the strengthening of proximal hip musculature as a means of controlling alignment and reducing knee pain [64–66]. Pinpointing a single source of pain in the knee can be difficult due to the interaction of a variety of internal and external factors that must all be investigated to determine the best course of treatment. Internal biomechanical factors may include anatomical variants such as leg length discrepancies, degree of foot pronation, and anatomical rotation at the hip or lower leg. External influences include training variables, gearing and cadence choices, bike fit, and type of terrain ridden. Cleat rotation is especially important to assess when seeking the source of lateral knee pain [59,62,67]. Because uphill pedaling, low cadence, and heavy training load have been implicated in mountain bikers with knee pain, [3,4,20] these are behavioral factors that should be adjusted early in the rehabilitation process to minimize stress to the knee.
CONCLUSION

The sustained positions of lumbar flexion and cervical extension in combination with high amplitude vibrations sustained by mountain bikers place the low back and neck under significant load. These postures also overwork certain spinal muscles and inhibit others from providing necessary motor control. Altered biomechanics experienced during the repetitive pedaling motions and power strokes required of mountain bikers can result in abnormal forces on soft tissue structures of the knee. Cumulative stresses in the low back, neck, and knees over a mountain biking season may cause micro-trauma which when unmanaged may develop into an overuse syndrome. Environmental influences, such as bike fit and riding style can further compound the development of such problems.

An appropriate rehabilitation program can enhance recovery from mountain bike-related overuse injuries. Similarly, a proper training regimen may help riders minimize unnecessary stresses and avoid such conditions from developing in the first place. Ensuring that external influences such as bike fit, training patterns, riding technique, and choice of gearing ratios can also decrease risk. Health care professionals, trainers, and coaches may help both competitive and recreational mountain bikers reduce their risk of overuse injury by understanding how common overuse problems develop and providing appropriate recommendations.

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