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Assessment and rehabilitation of chronic low back pain in baseball: part II

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Abstract

Repetitive throwing and hitting motions in baseball place mechanical stresses to the lumbar spine which may cause low back pain (LBP). Pain may be due to vertebral stress reactions or insufficiency fractures, intervertebral disc degeneration or intervertebral disc herniation. Untreated chronic conditions have high potential to lead to a more significant injury such as spondylolysis. Chronic LBP increases the risk for missed playing time, early career termination and lower quality of life after retirement. Proper clinical assessment and prevention/rehabilitation of LBP in this population is thus important for performance, play time and overall long-term quality of life. This narrative review synopsizes the available evidence for assessment and rehabilitation of baseball players with LBP, including the structured rehabilitative techniques and programmes which should be administered to affected players. The state of the evidence suggests that there are deficits in identifying the optimal prevention and rehabilitation prescription components for the variety of LBP-inducing injuries in this athletic population.

Keywords

Baseball; injury; low back pain; rehabilitation; clinical exam

Introduction

The prevalence of active baseball players with low back pain (LBP) ranges between 3% and 15% (Bono, 2004; d'Hemecourt, Gerbino, & Micheli, 2000; Dick, Agel, & Marshall, 2007; Posner, Cameron, Wolf, Belmont, & Owens, 2011; Wasser, Zaremski, Herman, & Vincent, n.d.). Proposed mechanisms of LBP and related pathologies include aberrant spine motion and forces, musculoskeletal strength deficits or suboptimal sequence of baseball motion events in throwing or batting (Wasser et al., n.d.). Baseball motions are ballistic in nature, and different considerations should be taken during evaluation for LBP. After identification of the cause of the injury and pain control is initiated in the acute phase, rehabilitation

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programmes are implemented to correct musculoskeletal contributors to the pain. Clinical and biomechanical assessments can help clinicians develop a targeted, structured rehabilitation programme that addresses motion and strength deficits. This narrative will review and summarize the available evidence for assessment techniques and rehabilitation options for baseball players with LBP.

LBP in baseball players

Baseball players routinely experience high torsional and rotational forces on lumbar spine during hitting and throwing. Hitting requires initiation of a violent lumbar rotation with rotation of the hips, and leads to lumbar strain if not timed correctly (Dines et al., 2012). Swinging a bat generates extremely high compressive loads on the spine. In similar high-speed rotational sports like golf, the compressive load is over six times body weight (BW) (REF). The magnitude of electromyography activity of different muscles revealed a suggested link between paraspinal muscles and lumbar spinal loads (Lim, Chow, & Chae, 2012). From a pitching perspective, pitching can lead to back stiffness, sacroiliac joint pain or discogenic or facet joint pain (Dines et al., 2012). Improper sequencing of the trunk and torso can alter upper extremity joint loading that may increase injury risk (Oyama et al., 2014). In order to determine injury risks or mechanisms, screening for injury risks, imaging, dynamic strength testing, examination of the lumbo-pelvic and hip musculature and flexibility and motion patterns can be performed.

History taking unique to baseball

Detailed history taking specific to baseball is critical to obtain key details that lead the clinician to possible tests to perform and to injury mechanisms. Key history questions are summarized in Table 1. The information obtained from answers to these questions may be enhanced with the addition of specific questions of physical manoeuvres that worsen pain. For example: "When pitching is there a specific motion during the pitching cycle that exacerbates pain?" or "If this is a recurrent injury, when did the injury previously occur, how did it occur if known?", and "What was done to improve that prior injury". Determination of throwing arm dominance will allow the prediction of which side a lumbar or abdominal injury may occur according to recent data (Conte, Thompson, Marks, & Dines, 2012). A recent study showed that more than 70% of abdominal strains occur in the contralateral dominant pitching side (Conte et al., 2012). This is important when attempting to differentiate a unilateral lumbar injury versus an abdominal core muscle injury in baseball players. Quantifying the severity of LBP and what specific actions make the pain worse are highly important. For example, in a throwing motion, abdominal muscles contralateral to the throwing arm become activated prior to the ipsilateral abdominal muscles. These muscles must generate high force and release energy in the trunk during the throw. If there is an injury in this abdominal region, there will be pain before ball release (Hirashima, Kadota, Sakurai, Kudo, & Ohtsuki, 2002). Determination of what activities reduce the pain is also helpful in the identification of specific structures about the low back that are involved with pain generation.

Experience-related risk factors for LBP should also be considered. These risks include player position, years of experience and whether there has been a recent change in position. Determination of the seasons of play, the number of teams on which the patient plays currently and number of days and hours of play per week will provide information of volume of baseball played. A rapid ramp-up of playing volume at the start of the season, or addition of multiple teams to the regular schedule, such as school and club team play, will overload the musculoskeletal system and lead to injury (Yang et al., 2014). The number of pitches thrown or innings pitched, the secondary position a player is used to playing and how often that position throws can reveal the stress volume load on the musculoskeletal system (Fleisig et al., 2011; Yang et al., 2014). It is common belief that to reach the best performance in a particular sport that their year-round focus should be on that one sport (National Association for Sport and Physical Education, 2010). However, early specialization in a single sport contributes to overuse injuries, decrease in performance and burnout (Launay, 2015; Malina, 2010; Myer et al., 2015, 2016). It is recommended that young athletes should participate in a variety of unstructured play to improve motor skill development and develop neuromuscular patterns that may be protective of sport-specific overuse injuries (Myer et al., 2016).

History questions about other training methods, weight training practices and stretching will shed light on potential imbalances in the training that could generate deficiencies in core musculature strength, endurance and/or flexibility. This is important because recent data indicated that correction of lower extremity tightness and lumbo-pelvic control in baseball pitchers through stretching and strengthening may improve performance (Chaudhari, McKenzie, Borchers, & Best, 2011; Endo & Sakamoto, 2014).

Physical examination unique to baseball

Diagnosis of injuries in baseball players can be accomplished using the method of Inspection, Palpation, Range of Motion (ROM), Strength Testing and Special Testing. The physical examination should be focused on the location of tenderness, presence of sciatic stretch signs, neurological deficit, manoeuvres that reproduce LBP, back stiffness and ROM (Dines et al., 2012). Alqarni et al. conducted a systematic review of clinical tests and their general diagnostic abilities to detect lumbar spondylolysis and spondylolisthesis (Alqarni, Schneiders, Cook, & Hendrick, 2015). Results of this review highlighted the optimal clinical test (of the 15 different clinical tests reported) for spondylolysis and spondylolisthesis was described by Collaer et al., who used palpation for the presence or absence of pain on a lumbar spinous process (Collaer, McKeough, & Boissonnault, 2006). Fifteen other clinical tests were reviewed for diagnostic ability of spondylolisthesis by Kalpakcioglu, Altınbilek and Senel (2009). Of these tests, those that involved lumbar spinous process palpation, lateral trunk flexion-extension tasks and double-leg raising tasks to induce pain are correlated to spondylolisthesis which was later confirmed with radiological assessment (Kalpakcioglu et al., 2009)(Alqarni et al., 2015).

Common diagnoses in injured baseball players include spondylolysis, spondylolisthesis, herniated disc and muscle strains. Significant rotational motions could suggest stress fracture (spondylolysis), discogenic origin of pain, radicular or nerve root injury and spinal stenosis secondary to facet hypertrophy or disc bulging. Other common low back injuries in baseball players include annular tears of the intervertebral disc with and without disc herniation, facet joint syndrome, sacroiliac joint pain and muscular injuries and contusions of the lumbar paraspinal musculature that are associated with muscle spasms (Dines et al., 2012).

Clinical imaging

Although a full discussion of the use of imaging for diagnosis beyond the scope of this paper, radiography, computed tomography (CT), magnetic resonance imaging (MRI) and bone scans are among the key methods of visualizing injuries. The first-line imaging modality obtained is a radiograph. Radiographs are useful for assessment of bony alignment, masses, sclerosis of bone and detection of bony irregularities such as spondylolysis. Sometimes the early stages of spondylolysis may be difficult to detect via radiography. While radiographic evaluation of early spondolytic defects may only be seen in approximately 30–38% of the cases, MRI may be more useful in the early diagnosis of this condition (Kobayashi, Kobayashi, Kato, Higuchi, & Takagishi, 2013). The most accurate modality for detecting bony defects and osseous healing is a CT scan with multiplanar reformats. However, CT is not sensitive for detection of the early edematous stress response without a fracture line and exposes the patient to ionizing radiation (Leone, Cianfoni, Cerase, Magarelli, & Bonomo, 2011). Some spine specialists prefer single positron emission computerized tomography in young athletes with back pain, as research has shown that a significant portion of young athletes that present with lumbar pain have a positive bone scan (Dines et al., 2012; Papanicolaou, Wilkinson, Emans, Treves, & Micheli, 1985; Spencer et al., 2013). Despite several imaging options available, the optimal scanning protocol for spondylolysis is controversial. Future areas of research should include the use of musculoskeletal ultrasound in identifying problematic areas that contribute to LBP and associated injuries (Heidari, Farahbakhsh, Rostami, Noormohammadpour, & Kordi, 2015).

Functional testing

Several baseball-relevant functional tests may help identify muscular deficiencies of players who are at elevated risk for LBP. First, the single-leg raise test in pitchers can help to determine whether or not a player could maintain a level, stable pelvic position (Chaudhari, McKenzie, Pan, & Oñate, 2014). This test simulates the motion of the initiation of a pitch or the weight transfer during a bat swing and activates musculature such as the gluteals and core stabilizer muscle groups such as abdominals and lumbar paraspinals (Earhart, Roberts, Roc, Gryzlo, & Hsu, 2012). This is highly relevant, as the gluteus medius activates very early during a baseball throw (McGill, Karpowicz, & Fenwick, 2009). The magnitude of the anterior tilt during this single-leg test is considered the “anteroposterior score” (AP score; specificity coefficient range 0.92–0.97 and sensitivity range 0.75–0.99). Among professional pitchers, the single-leg raise test showed that players with an AP score of ≥8.0 had significantly higher prevalence of days missed and incidents of ≥30 days missed than players with lower AP scores (Chaudhari et al., 2014).

Second, a single-leg squat test can also be used to determine the movement control provided by the gluteal muscle group during baseball motions (Wasser & Vincent, 2016). Single-leg dynamic strength is required by a pitcher during the drive off the pitching rubber, and required by hitters just before lead foot plant and during the weight shift of a baseball swing (Oliver & Keeley, 2010). Gluteal muscle weakness is revealed by pelvic lateral drop and excessive hip adduction. The inability to control single-legged motions can contribute to pelvic drop and asymmetric forces acting at the low back.

Third, bridging, active straight leg raises, overhead squats, trunk stability pushups and rotary stability exercises may be useful as core strength tests (Cook, Burton, & Hoogenboom, 2006a, 2006b; Peate, Bates, Lunda, Francis, & Bellamy, 2007; Song et al., 2014). While there is not presently a standard for assessment of core strength, these tests could be strong contenders. Improper form and inability to perform these exercises are indicative of deficits in fundamental movements. By improving on these functional deficits, there have been reduced risks of back injuries (Peate et al., 2007).

Motion analysis and high-speed filming

Three-dimensional motion analysis is very useful for screening and monitoring, if such resources are available. Motion analysis provides insight on the segmental kinematics of specific motions that cannot be obtained through clinical evaluations. The timing of the peak angular velocities of motion during a throw cycle or a bat swing can identify phases of the motion that can be corrected to minimize forces acting at the low back. If force plates are available in the lab setting, simultaneous kinetic data can be collected on the centre of mass location and BW transfers that occur from one leg to the other during throwing or hitting. Motions in the sagittal, frontal and transverse planes can provide a comprehensive picture of how the body segments move in relation to one another. Data exist from which throwing and pitching form can be compared (Fleisig, Bolt, Fortenbaugh, Wilk, & Andrews, 2011; Kageyama, Sugiyama, Takai, Kanehisa, & Maeda, 2014; Nissen et al., 2009; Oyama et al., 2013, 2014; Solomito, Garibay, Woods, Õunpuu, & Nissen, 2015; Wang, Kuo, Shih, Lo, & Su, 2013; Wasser et al., n.d.) while very few comparative data are available for the baseball swing (Inkster, Murphy, Bower, & Watsford, 2011).

In the absence of a full-motion analysis laboratory, high-speed filming can also be very useful. Slow-motion filming from the sagittal and frontal planes can provide qualitative insight on the timing of segmental motion, relative body segment positions and excursions of joint motion. (Figure 1(a–c)) highlight a series of still images obtained from a high-speed video of three different players. Each image captures at the point of maximal shoulder external rotation during the throw. Figure 1a highlights a player with an ideal body position at this phase of a throw. Trunk lean is towards the catcher and the lead knee has appropriate flexion to decelerate forward motion of the body. Figure 1b highlights a pitcher with a nearly fully extended front leg which is not ideal to decelerate the pitcher’s forward motion. The summation of linear and rotational forces at this point will transfer in large part to the low back region. This is a potential mechanism underlying LBP onset. Figure 1c presents a player with suboptimal form at this pitching phase. Here, the pitcher has a near vertical trunk position, with noticeable extension of the lumbar spine during trunk and pelvis forward rotation. Failure to appropriately engage the musculature of the lower extremities and hips during the push off through maximum external rotation decreases the energy transfer into acceleration, ball release and follow-through phases. This necessitates compensation by the torso and upper extremity musculature to exaggerate lumbar extension to develop this energy. If trunk extensor–flexor muscles lack adequate strength and power to control the forces that develop in the lumbar region or the activation of these muscles are delayed (Ganzit, Chisotti, Albertini, Martore, & Gribaudo, 1998; Szpala, Rutkowska-Kucharska, & Drapala, 2014), there is the potential for LBP onset. Lumbopelvic and core rehabilitation is a therefore critical aspect of a baseball player's pathway to pain management and relief.

Core rehabilitation for baseball players with LBP

While few strengthening intervention studies on improving lumbopelvic and core strength and endurance exist specifically in baseball players, the findings of the studies described next can be applied to this population.

Core strengthening

One of the main objectives for rehabilitation is to strengthen core abdominal muscles so that stabilization of the lower back and pelvis can occur. Movement patterns that improve stability of the lumbar spine include enhancing hip and thoracic spine motion instead. These programmes can also stabilize pars defects (Ganzit et al., 1998; Jackson, Shepherd, & Kell, 2011; Kumar, Sharma, & Negi, 2009; Marshall, Desai, & Robbins, 2011; Stuber, Bruno, Sajko, & Hayden, 2014; You, Kim, Oh, & Chon, 2014). Stuber et al. conducted a systematic review of core stability exercises used to treat LBP in athletes. It was found that in 80% of the studies, LBP relief occurred with various core strength and stabilization programmes. Effective programmes contained similar key core strength training exercises: abdominal flexion, lumbar extension and rotational strength (Ganzit et al., 1998; Hides, Stanton, McMahon, Sims, & Richardson, 2008; Jackson et al., 2011; Kumar et al., 2009; Stuber et al., 2014). A note of caution is that two types of commonly used core exercises actually may create greater harm then help when patients exhibit facet or pars related pains. These two exercises, Roman chair/back extensor strengthening machines and traditional sit-ups, have been noted to create compressive forces to the lumbar region that may cause unsafe and injurious results after initial injury (Akuthota, Ferreiro, Moore, & Fredericson, 2008).

Stabilization activities

Stabilization is a critical component of rehabilitation programmes for existing LBP and for LBP prevention programmes. Stabilization activities may: (1) reduce fatigability of targeted muscles; (2) improve postural endurance and (3) improve core control during sport motion. In one study, Ganzit et al. placed athletic participants with chronic LBP into one of two groups, a stability exercise group and a comparison stretching exercise group. The stability group performed machine-based resistance exercises of back extension, rotary torso and abdominal strengthening. Subjects performed 3–5 sets of 25 repetitions, 2–3 times per week for 15 weeks. The comparison exercise group performed postural exercises, stretching and unweighted abdominal and back strengthening exercises for 1 h, two to three times per week for the 15-week period. Statistically significant and clinically important improvements in the intensity of visual analogue scale LBP severity were noted in the stability and comparison groups by 50% and 44%, respectively (Ganzit et al., 1998).

Progressive rehabilitation approach

In cases of severe, or limiting LBP, or poor control about the spine, a progressive rehabilitation approach starting with basic movement control and concluding with baseball motion can be effective. Figure 2 provides the four phases involved in progressive rehabilitation adapted from Cooke and Lutz (Cooke & Lutz, 2000). Phase 1, muscle activation, is a basic technique that needs to be mastered before progression and maintained during the programme. Core muscle activation provides the stability necessary to perform progressive exercises and functional activities. In this phase, emphasis of holding contractions of the lumbar multifidus is made to help restore symmetry and muscle size of the multifidus at the segmental level (Hides, Richardson, & Jull, 1996). Phase 2, stabilization of the painful or injured area, focuses on isometric techniques to maintain muscles in a neutral position in supine and/or quadruped positions. Phase 3, strengthening and neuromuscular control, emphasizes functional movements. Hypertrophy is not the intended goal of Phase 3. Phase 4 includes a technique-focused aspect to the player's rehabilitation and strengthening, where form and sequence of a baseball throwing/swinging motion are emphasized. To graduate from Phase 4, the athlete needs to achieve full ROM without pain, the ability to maintain a neutral spine during baseball-specific activities and exercises, a return to appropriate strength, endurance and control of the core and low back (Cooke & Lutz, 2000).

Randomized, controlled studies show that progressive stages of strengthening from core stabilization to full participation in sport activity had greater effects on treating LBP symptoms than general strength programmes. First, Kumar et al. (2009) examined the comparative efficacy of conventional LBP treatment and dynamic muscle stabilization treatment (DMST) in a group of active people. The conventional group utilized ultrasound and short-wave diathermy modalities and lumbar and trunk extension exercises (10 repetitions per exercises on alternating days). The DMST group went through a 5-week progressive exercise programme that focused on isolation and muscle activation techniques and progressed to increased loading and then high speed and skilled movements. Significant improvements in LBP intensity and functional measures (walking, climbing and standing tests) occurred by week 5. Visual analogue scale LBP values decreased by 39% and 79% in the conventional and DMST groups, respectively (Kumar et al., 2009).

Second, Jackson et al. (2011) compared the efficacy of a "stability intervention" relative to a control condition in middle-aged and older hockey players compared to no-intervention controls. Stability exercises included abdominal crunches, Swiss ball crunches and prone "Supermans" that were performed four times per week for 12 weeks. Control group activities consisted of regular recreational activity twice a week for greater than 60 min. Both the middle-aged and older athletes demonstrated significant improvements in LBP severity and quality of life. LBP was reduced by 26% in both the middle-aged and older athletes, whereas LBP severity increased in the control group by 7% (Jackson et al., 2011). The inclusion of stability exercises as well as core resistance exercises two to three times per week has been shown to be beneficial to those suffering from LBP (Ganzit et al., 1998; Hides et al., 2008; Jackson et al., 2011; Kumar et al., 2009). A potential benefit of physical strengthening of the core and proximal body segments (hip and torso) is to attenuate the delay of muscle activation during movement that is present in patients with LBP (Akuthota et al., 2008). Core strengthening may decrease the risk of onset for LBP (Sharrock, Cropper, Mostad, Johnson, & Malone, 2011). Coaching and training programmes should focus on pelvic, hip and lower extremity muscle strength and coordination (Campbell, Stodden, & Nixon, 2010; Sharrock et al., 2011).

Conclusion

Baseball players with LBP experience repetitive mechanical stressors that are unique. Considerations to sport-specific stressors need to be made while taking a detailed history of an injured player. Advanced techniques such as motion analysis, force measures and high-speed filming may be very useful in identification of specific kinematic or kinetic factors that may contribute to LBP. Lumbopelvic and core muscle weakness or delayed activation during high-speed rotational motions in baseball throwing or hitting can influence LBP. A four-stage progressive rehabilitation programme can allow for players who suffer from LBP to gain core strength, stability and neuromuscular control to alleviate pain and disability. Future interventional studies should be conducted in baseball players suffering with LBP to identify the optimal rehabilitation prescription (volume, intensity, proper exercises and progression) for mild to severe LBP on symptoms and performance.

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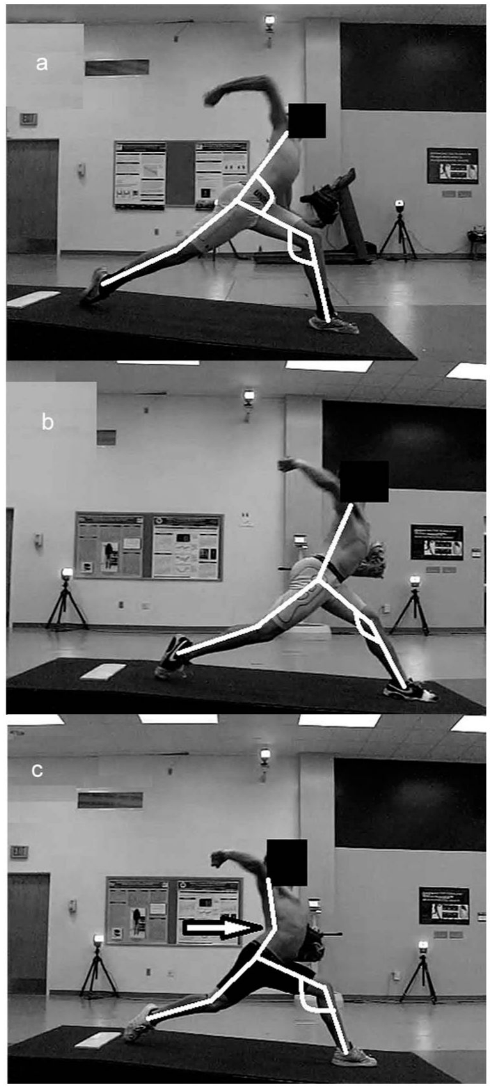

Figure 1.

Sagittal still images obtained from high-speed filming of three players pitching at maximal external rotation. (a) Appropriate sagittal position of drive leg, lead land trunk lean (No LBP). (b) Deficit in lead knee flexion angle, (put arrow at the knee white arrow; LBP) (c) lumbar hyperextension (white arrow), flexed drive leg (LBP).

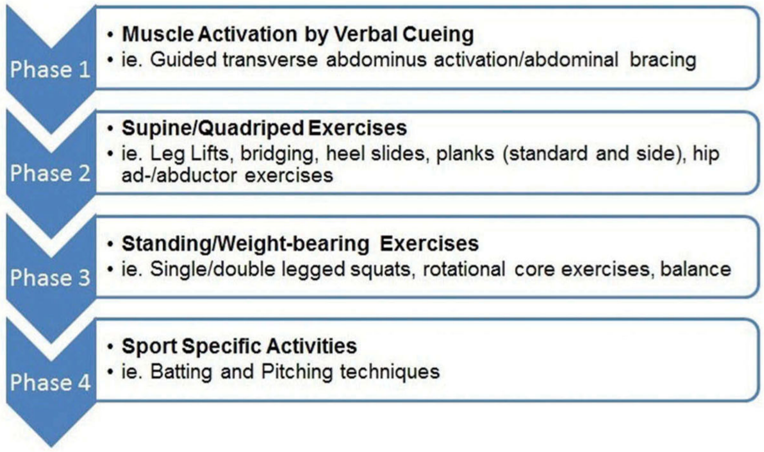

Figure 2.

Suggested progression of core exercises for players with low back pain.

Table 1

Summary of medical history review related to low back pain (LBP) when assessing pain severity and possible related injuries.

Factor	Follow-up questions
Demographics	
Presence, severity and location of pain	When was onset? Was there a trigger or slow onset? Rate pain severity
History of baseball injury, previous low back pain	If yes, when did this occur? What caused the injury (if known) What rehabilitation was done?
When do symptoms feel worst?	During a throwing motion? At end of the throw? During a hitting motion? When during the swing? Is pain worse during or after activity?
Is there anything that makes the pain better?	
Additional risk factors	
Current baseball position	Have you recently changed position?
Current number of teams on which you play?	More than one increases injury risk
Any recent change of volume?	Start of season, middle of season?
Do you play all year, or seasonally?	
Worked on or changed your form recently?	
If younger, any recent growth spurt or other aches/pains?	
What other kinds of sports do you do?	Early specialization may increase risk
What other types of training to do you do?	
Do you do weight training?	Do you exercise all parts of your body?
Do you stretch your major joints and spine regularly?	Multiple times a week, 60 s each stretch?