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Managing low back pain in active adolescents

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A B S T R A C T

Adolescent low back pain has received limited research attention despite its potentially considerable impact on quality of life. The role of diagnostic triage to identify serious or specific pathology and/or order relevant investigations is considered. An overview of contemporary pain mechanisms is provided, with specific reference to the wide range of risk factors for persistent low back pain. Education and exercise framed within a biopsychosocial framework are the cornerstones of treatment. There is a lack of data on more comprehensive personalized treatment approaches among adolescents. One such approach – Cognitive Functional Therapy – which has shown promise in adults and active adolescents with low back pain, is described and illustrated using a case study. The most promising avenues, in practice and research, may be those that view adolescent low back pain as less of a local structural spinal issue and more of an indication of the general health of the adolescent.

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Introduction

The problem of LBP among adolescents

There is broad acknowledgement of the major impact of low back pain (LBP) among adults on disability, quality of life, and healthcare consumption [1–3]. However, the importance of LBP among adolescents has received less attention, both in society and in the scientific literature. This lack of attention is of concern not only due to the considerable impact of LBP among adolescents (e.g., school absenteeism and reduced physical activity) but also due to the relationship between adolescent LBP and the development of disabling LBP in the future [4–6].

LBP typically emerges in the early teenage years, with almost one-third of 14 year olds reporting LBP in the last month and approximately 10% reporting persistent LBP [5,7]. By the late teenage years, girls are almost twice as likely as boys to report persistent LBP [8], with one-third reporting LBP in the past month by the late teens [4]. Fortunately, for many, LBP has little impact on daily life, including school and sports, such that they do not seek medical attention [8,9]. In these cases, LBP can simply be one of the common predicaments of life [10], such as tiredness, sadness, or getting a cold; a relatively normal life experience that is not disabling and should not be given any more attention than is necessary to cope with whatever distress or disability is associated with them, if any. Nevertheless, a considerable number – 20% of the 17 year olds – suffer a negative impact of their LBP, such as school absenteeism, taking medication, seeking healthcare, or modifying physical and daily life activities [4,8].

A key question for clinicians is whether we can identify those adolescents with a better, or worse, prognosis for their LBP, with a view to identify those who might benefit from healthcare and/or support, while at the same time avoiding the common risk of overmedicalizing relatively benign complaints of LBP. Furthermore, how can clinicians decide what management options might be best suited to each adolescent with LBP, e.g., Are the needs of adolescents with LBP entirely similar, or entirely different, to those of adults with LBP? This paper seeks to answer some of these common clinical concerns and highlight some practical tips on how to optimize care in this population.

Diagnostic triage

Diagnostic triage is a fundamental component of clinical assessment for both adults and adolescents. The primary purpose is to evaluate the likelihood of any serious or specific pathology explaining the presence of LBP symptoms and, in such cases, refer for appropriate medical management. The remainder will be categorized as having nonspecific LBP.

Screening for serious pathology

While serious pathological causes of LBP (e.g., malignancy, infection, and inflammatory disorders) are rare in adolescence (less than 1%), they must still be considered as part of a clinical triage [11]. The clinical utility of individual red flags (e.g., night pain and weight loss) is increasingly questioned, as most have limited sensitivity or specificity and, if used inappropriately, can lead to the acknowledged problems of inappropriate imaging and overmedicalization [12]. A history of cancer remains the most likely single red flag to warrant further investigation [12,13]. Other signs and symptoms that might, in combination, lead to a decision to investigate further include an insidious onset of severe LBP, fever, unexplained weight loss, neurological deficits, night pain, and prolonged (>30 min) morning stiffness. The urgency with which these signs and symptoms might lead to additional investigations is increased when several of these symptoms are present. Fig. 1 illustrates the process of triaging adolescents with LBP, with a view to inform their management.

Screening for specific spinal pathology

For most adolescents with LBP (95%), a single pathoanatomical "cause" for their pain cannot be accurately determined. In both adolescents and adults, morphological findings on imaging are poorly correlated with LBP. For example, while disc degeneration has a prevalence of approximately 30% among adolescents, this is not strongly associated with LBP [14]. Rates of disc herniation associated

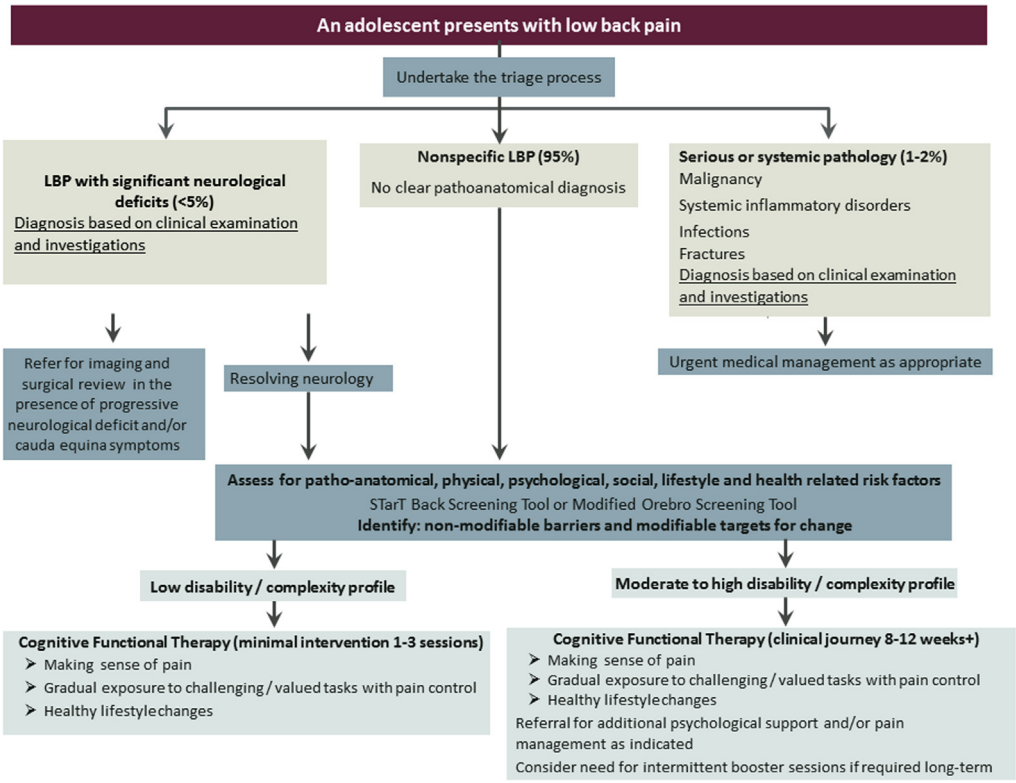

Fig. 1. Triage process for an adolescent presenting with low back pain.

with sciatica are reported to be very low in adolescents (<1%). Consequently, the importance of such investigations in adolescent LBP is relatively small.

However, there are some situations where specific local spinal pathology might be suspected, and where investigations might be appropriate. For example, where LBP is acute, disabling, and associated with a clear history of a traumatic spinal injury (such as a fall off a bike), screening for traumatic fracture may be indicated. Similarly, the presence of neurological/cauda equina symptoms warrants further investigation, not only to consider serious pathology but also to investigate the potential for major disc prolapse or high-grade spondylolisthesis. In addition, the presence of acute sciatica with associated neurological deficits, with or without cauda equina symptoms, may warrant investigation.

The most common "specific" pathology within the adolescent LBP population – with a prevalence in adolescents of approximately 6% – is spondylolysis, defined as a unilateral or bilateral osseous defect of the pars interarticularis. It is thought to indicate congenital susceptibility and/or an acquired stress fracture through repetitive chronic microtrauma [15]. In some cases, perhaps with time and/or enough mechanical stress, the pars interarticularis can fracture, which, in some cases, is associated with slippage of the superior vertebral body relative to the inferior (called spondylolisthesis). L5 is by far the most common vertebral level (85–95%) for spondylolysis [5–8], with most defects occurring bilaterally. Once pars interarticularis fractures occur, nonunion and/or long-term spondylolisthesis are not uncommon. Spondylolisthesis is graded depending on the percentage of vertebral body slip relative to the its length, with grades 1–5 indicating <25%, <50%, <75%, <100%, and >100% displacement [16]. There are no clear clinical findings, from the history or the physical examination, which are adequately sensitive and specific to determine the presence of spondylolysis. Where LBP is localized and associated with sports or activities involving repetitive loading, especially into spinal extension (e.g., gymnastics and volleyball), the index of suspicion is raised. A step deformity on palpation has been

described as indicative of spondylolisthesis, but this is an unreliable finding. This lack of a satisfactory clinical test means investigations are often ordered. This is not without controversy, however, as this condition is often asymptomatic, with many cases detected incidentally on imaging [14].

Finally, while consideration of specific pathology is important, it is merely one part of a multidimensional clinical reasoning process. Even in the presence of pathology, other factors still need consideration as part of assessment, prognostic profiling, and management planning.

Nonspecific LBP

Thankfully, most adolescents will have evidence of neither serious nor specific spinal pathology. Consequently, similar to adults with LBP, they can be categorized as having nonspecific LBP. While this term is not particularly useful as a diagnostic label for the adolescent, it reflects the exclusion of serious pathology as the primary driver for the adolescent's LBP. Rather than indicating that there is no role at all for peripheral tissues contributing to the pain experience, this label simply reflects the fact that spinal tissue morphology is within broadly normal limits, such that their contribution to pain is likely to be just one of multiple components involved in the pain experience. The following sections deal with the most common pain mechanisms seen in adolescents with LBP and the various factors that can be relevant.

Pain mechanisms

A vast amount of research, especially in recent decades, has shown that the experience of pain is not necessarily an accurate indication of the degree of tissue "damage" [17]. In contrast, the pain experience reflects the body's assessment of how dangerous or threatening a particular nociceptive input (e.g., from a joint, disc, or muscle) is, based on not only the intensity of the input but also the person's prior experiences, beliefs, contextual factors, etc. In other words, the pain experience can be related to peripheral drivers of nociception and/or sensitization of the adolescent themselves, including, but not limited to, their central nervous system. A logical extension of this finding would be to offer LBP management strategies that match the key contributors to the LBP experience, whether they are central or peripheral factors. As expected, simply categorizing people with LBP into purely "central" or "peripheral" clusters does not reflect the individual and complex nature of LBP [18], where there is a spectrum of pain presentations that often involve multidimensional interactions between various factors. For some, pain is localized with a clear *"mechanical stimulus – pain response"* (i.e., pain is momentarily provoked and relieved by specific spinal postures, movements, and activities). For others, pain may be distributed more vaguely or widespread, with a *disproportionate "mechanical stimulus – pain response*," (i.e., amplified, inconsistent, and/or sustained pain responses to minor mechanical stimuli). For some, there is an absence of clear reproducible clinical findings where central pain mechanisms are likely to dominate, while for many, their presentation is more mixed.

Contributing factors to persistent LBP in adolescents

The section discusses how a clinician should view LBP through a broad lens and yet not be overwhelmed by the breadth of potential factors to be considered. These factors include pathoanatomical, physical, psychological, social, lifestyle, and general health factors. It is important to understand that different combinations of factors may be present for adolescents presenting with LBP, reflecting a range of clinical complexity. The identification of these factors facilitates the individualization of education and care.

Pathoanatomical factors and the role of imaging

As previously highlighted, most LBP among adolescents has not been proven to be uniquely and completely attributable to nociceptive input from a single spinal "pathology." However, almost any tissue can act as a source of nociceptive input, and this input can then be magnified, or reduced, according to the other potential modifiers of pain (Fig. 2). Considering the aforementioned prevalence of spondylolysis, this section deals with the most common imaging options, and their utility specifically in spondylolysis, to either aid early diagnosis or exclude other differential diagnoses.

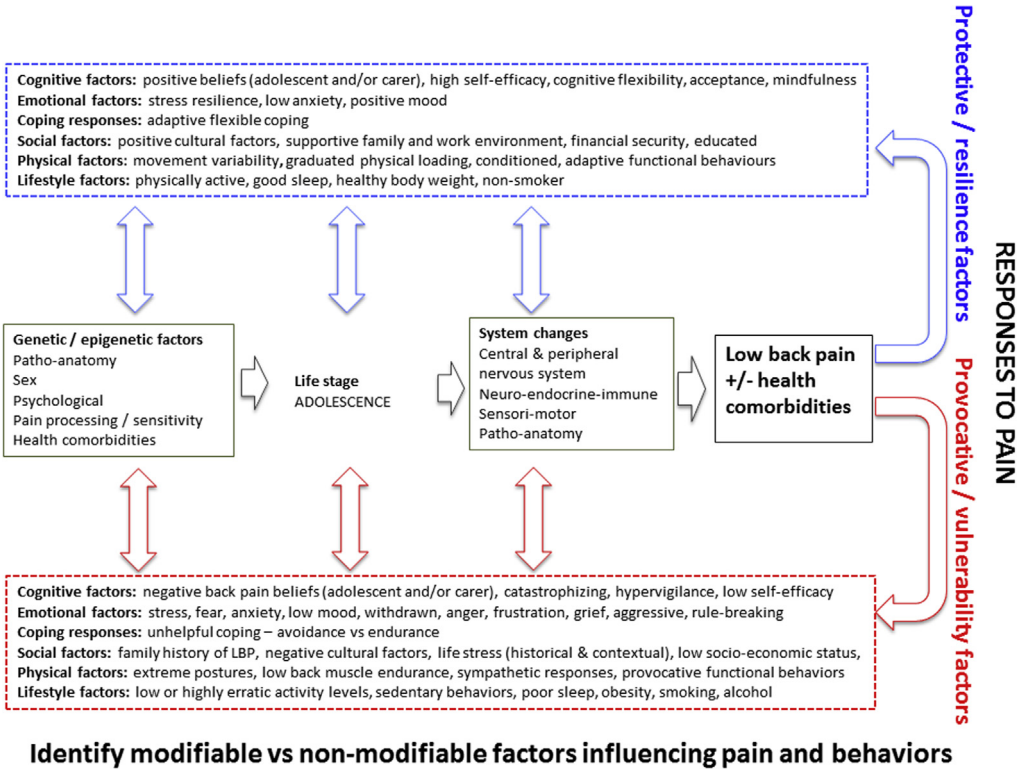

Fig. 2. The interaction of modifiable and nonmodifiable risk factors in adolescent low back pain.

The choice of investigation used, if any, will depend on the differential diagnoses considered, cost, accessibility, acceptability of radiation risk, and patient-specific issues such as tolerance for being positioned in a confined space for a prolonged period. Each modality has its own advantages. For example, MRI has the advantage of minimizing ionizing radiation exposure and improved imaging of soft tissue structures (such as the discs, spinal cord, and paravertebral soft tissues); however, MRI requires the patient to be lying still for 30–45 min for a lumbar spine acquisition, whereas a CT scan is completed in seconds and provides superior osseous detail and spatial resolution. Yet, CT is associated with some radiation exposure.

The plain radiograph is commonly used as a first-line imaging screen in the evaluation of spondylolysis. Most early papers describe the diagnosis made on plain films. Lateral and oblique (Scotty Dog view) radiographs of the lumbar spine are used to evaluate for a discontinuity in the neck of the "Scotty dog." However, plain radiographs, especially oblique views and views of the lumbosacral junction, have significant radiation dose. If plain radiographs are required as a screen, then only AP and lateral views should be acquired, and often, this step can be omitted entirely if the primary purpose of the study is to evaluate for spondylolysis. Conversely, ultrasound is excellent for soft tissue characterization, but imaging fractures, particularly in the spine, are limited in sonography. It may provide use in visualizing paraspinal muscle injuries, collections, and soft tissue edema; however, it has no utility in bony evaluation of the spine.

MRI is considered the best test for suspected spondylolysis in the adolescent for a variety of reasons. It helps to detect early stress response in the pars interarticularis, with fluid-sensitive sequences (T2 and STIR), detecting early high-signal changes (stress reaction or microtrabecular fractures) with no radiation dose penalty (15). Signal change involving the pars may be seen in the form of increased T2 or STIR signal. Linear low T1 signal indicates a fracture plane. High T2/STIR signal without low T1 signal

indicates a stress response also known as trabecular microfracture (Fig. 3). It has been argued that early detection (e.g., stress reaction or microtrabecular fractures through early high-signal changes) might allow earlier intervention to allow bone healing and prevent a displaced pars fracture and spondylolisthesis [15,19,20]. Such early intervention typically involves unloading the spine and avoidance of provocative activities.

CT scans are more sensitive than radiographs in detecting early spondylolytic lesions in the form of stress reaction. This is seen in the form of sclerosis or increased density in the pars interarticularis. This is the phase seen before complete lysis. Bone detail and resolution as well as visualization of the disc, adjacent soft tissues, and facet joints help to include or exclude other possible diagnoses. Dual-energy CT has proven useful in the detection of early bone marrow edema in hip fractures and sacral fractures [21]; however, it has not been explored in characterizing early changes in spondylolysis.

Finally, nuclear imaging (bone scan) is available to look for osseous remodeling. The scan is nonspecific and low resolution; hence, it may be of limited usefulness in differentiating causes of LBP. Single-photon emission computed tomography (SPECT) adds spatial resolution, aiding in diagnostic accuracy. Yet, its use is limited by a high rate of false-positive and false-negative results and by considerable ionizing radiation exposure [20].

Physical factors

Similar to LBP among adults, there remains a widespread belief among healthcare professionals and the public that solely physical factors explain the development of LBP. This belief is persistent despite a lack of strong evidence. In this section, we describe physical factors in terms of intrinsic factors that have been proposed to indicate physical vulnerability (e.g., deficits in posture, strength, or endurance), extrinsic factors that have been implicated in LBP (e.g., chair design, sporting tasks, or movements), and

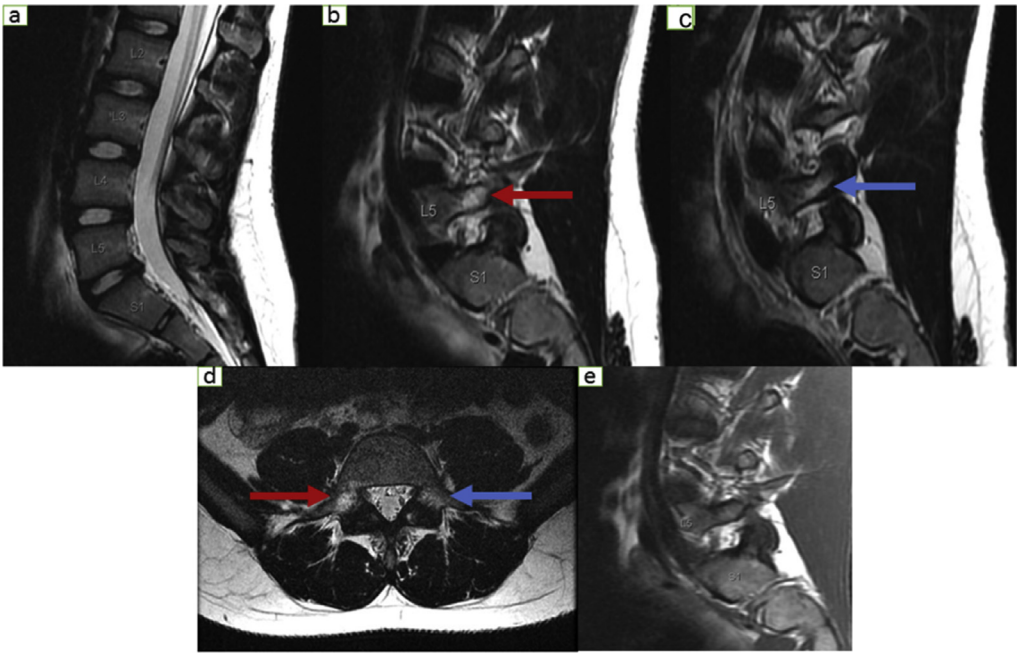

Fig. 3. (a) Sagittal T2W MR image of the lumbar spine shows normal alignment. No spondylolisthesis. (b, c) Right and left parasagittal T2W, and (d) axial T2W images show hyperintense signal (red arrow) in the right L5 pedicle and pars interarticularis extending into the superior articular process compatible with bone marrow edema (stress reaction). Similar subtle signals are evident in the posterior left L5 pedicle (blue arrow). No definite hypointense signal to suggest pars interarticularis defect on (d) T1W Sagittal image.

situations where risk might be considered to reflect an interaction between intrinsic and extrinsic vulnerability (e.g., lifting, carrying school bags, training patterns, and volumes).

Spinal posture and alignment

Flexed sitting postures have long been demonized [22,23] both as a cause of LBP and also indicative of a lazy or disrespectful attitude. There is without doubt considerable variation in spinal posture among adolescents, in both sitting and standing [24]. However, it appears that while slump sitting in adolescents is associated with male sex, higher BMI, greater television viewing, lower back muscle endurance, and lower self-efficacy, slump sitting is not strongly associated with disabling LBP [25]. In contrast, adolescent mental health is more strongly related to LBP [reference?].

Data regarding the relationship between standing posture and LBP are similarly sparse [24,26]. While several cross-sectional associations have been observed between spinal standing posture and LBP, the relationship with future LBP status is weak [24,26]. Furthermore, there is considerable room for confounding variables to explain these associations. For example, a hyperlordotic standing posture is associated with LBP, but hyperlordosis is also associated with a high BMI [25]. Similarly, while scoliosis is seen among adolescents, the prevalence of LBP does not differ between those with and without mild scoliosis [27]. Furthermore, there is no correlation between the degree of spinal curvature and the presence of pain [27].

Back muscle strength or endurance

While deficits in muscle endurance may be weakly associated with LBP, they are only marginally predictive of future LBP [25,28]. These deficits are also associated with lifestyle and psychological factors that could confound this association [28]. Yet, in situations where high demands are being placed on the spine, and the adolescent overall, muscle strength and endurance may still be worth exploring in the clinical examination.

Hypermobility

Generalized joint hypermobility has received considerable attention in several painful musculoskeletal conditions [29,30]. Hypermobility may facilitate performance in certain sports requiring very large degrees of mobility (e.g., gymnastics and dance). While generalized joint hypermobility is common in adolescents, especially girls, it is neither associated with nor predicts LBP or other musculoskeletal pains [31,32]. As such, considerable caution is required in ascribing the development of pain to hypermobility, even when both pain and hypermobility are present.

Chair design

As sitting is a common aggravating factor for LBP [33], it is unsurprising that elements of chair design have been modified in an attempt to manage LBP. However, there is no strong evidence that any one type of chair design has a specific beneficial effect on LBP and sitting comfort [34,35]. Instead, it is clear that while some chair designs might be rated poorly for comfort, the initial enthusiasm reported among teenagers for modified chair designs typically loses its effect after a while, suggesting any initial benefits may simply reflect the novelty of doing something different for a period [36].

Bending and lifting

The relationship of the amount, and pattern, of exposure to mechanical spinal loading and LBP has received vast attention among adult populations. This research has shown that repeated loading, awkward bending, and twisting in daily activities are moderately associated with LBP, without any strong data supporting a causal role for these loads in the development of LBP [37–39]. There has been much less research into the movement patterns of adolescents with LBP during sport or activities of daily living. However, there is at least cross-sectional evidence that adolescent athletes with LBP adopt movement patterns that are provocative for their spine (e.g., holding their spine closer to end-range flexion during repeated cyclical loading or constrained rotational movement) [40,41]. Importantly, this does not necessarily suggest these patterns of movement are causative but instead might represent a means of ongoing provocation of symptoms.

Backpacks and school bags

While occasional cross-sectional associations between carrying a backpack and LBP have been reported [42,43], a recent systematic review concluded that "there is no convincing evidence that aspects of schoolbag use increase the risk of back pain in children and adolescents." [44] Interestingly, perceived schoolbag load may have a stronger relationship with LBP than actual schoolbag load, reinforcing the importance of psychological factors in LBP [42]. Importantly, incorporating physical activity such as walking or cycling to school may be protective against LBP, even when carrying schoolbags for long distances [42].

Psychological factors

There is now overwhelming evidence that psychological factors, both cognitive and emotional, are critical in the both development of and recovery from pain.

Cognitive factors

These refer to *thoughts* that a person has regarding their pain and/or health. One of the strongest predictors of LBP prognosis and outcome is self-efficacy or confidence in one's ability to cope. Several different cognitions likely contribute to one's sense of self-efficacy. For example, more negative thoughts about what LBP indicates (e.g., damage), how it should be managed (e.g., rest, avoid activity, and stay off work or school), and the likely future consequences (e.g., disability and unemployment) are associated with a poor LBP prognosis in both adults [45–47] and adolescents [25]. Catastrophic thoughts about what LBP means are common and linked to a sense of hopelessness, despair, greater disability, and poor treatment response [48]. Unfortunately, it appears that many people with LBP have these beliefs about LBP instilled, or reinforced, by their encounters with healthcare professionals [49,50]. Such thoughts likely also reflect a person's behavioral conditioning based on how others respond to their pain, including family, friends, and society [7]. Interestingly, experiencing LBP as a teenager and coping well with it is associated with even better LBP beliefs than those who never experienced LBP at all [25].

Emotional factors

These refer to a person's *feelings, emotional responses, and/or levels of distress*, which may reflect their response to their pain disorder, social situation, and/or other comorbid mental health issues. One of the most common, understandable, and well-researched patient responses to LBP is fear, which can reflect fear of what is wrong with their back, what they can or cannot do safely, and what the future holds for them [45,51,52]. Poor mental health, as reflected by both internalizing (e.g., anxiety, depression, and social withdrawal) and externalizing (e.g., aggression, recklessness, and rule breaking) behaviors, has been associated with spinal pain even among adolescents [53]. There are data to suggest that within the adolescent LBP population, some have limited mental health disturbance and others have these issues more commonly. Unsurprisingly, those with comorbid LBP and mental health issues report poor general health [25,54].

Social factors

Well-established social determinants of health are also strongly implicated in adolescent LBP [7,25]. These may include cultural and societal factors (e.g., family LBP history, socio-economic status, and education), exposure to stressful life events and situations (e.g. abuse, financial hardship, poor family functioning, and negative school or sports environment), or unhelpful relationships (e.g., punishing or solicitous) [55–57]. These findings suggest that social learning and environmental stressors play a key role in the development of disabling adolescent LBP. Importantly, many of the behaviors identified as unhelpful to an adolescent's chances of recovery (such as care seeking, taking medication, and avoiding physical activity because of LBP) appear to reflect their primary carer's reported behavioral responses to LBP [7]. As such, treatment of LBP in adolescents may need to consider the response to LBP among the adolescent's broader circle (e.g., family, friends, and coach).

Lifestyle factors

Several lifestyle factors have been associated with LBP and other musculoskeletal complaints, both in adult and in adolescent populations [58,59].

Physical activity

The relationship between physical activity and LBP appears to be nonlinear, where both very low and very high levels of physical activity are associated with LBP [60]. For example, participation in sports outside school predicts future disabling LBP among teenagers [32]. Furthermore, highly active teenagers report more LBP at follow-up [25,61]. However, these studies have not always examined how disabling the LBP was [61], or when they do, it appears that a wide range of other factors are also implicated [25]. Overall, very low levels of activity seem to be a more common risk factor for LBP. Furthermore, there is evidence that activity is safe for the body if exposure to higher activity levels is progressed sensibly, and being consistently active is generally associated with lower rates of pain and injury [62].

Sleep

While the precise number of hours needed for each adolescent is likely to vary according to their age, growth status, and activity levels, there is consensus that adolescents require more sleep than adults. This is important, as LBP and disordered sleep are highly comorbid, with consistent evidence of a bidirectional relationship. For example, poor sleep predicts the development, or deterioration, of LBP and other pains, while the presence of LBP predicts future sleep problems [63,64]. Considering the potential for a range of factors to affect sleep (e.g., academic and sporting commitments, as well as social engagements and the usage of mobile phones and social media), exploring an adolescent's sleep is very valuable.

Television and computer viewing

Despite being linked to longer sedentary time overall, which is not ideal from a general health perspective, the frequency of watching television and of using computers does not predict developing disabling LBP in late teenage years [32].

Smoking, alcohol, and drug use

While cross-sectional associations between spinal pain and use of these substances are present in young teenagers (i.e., aged 13–15 years), the association is modest [65–67]. Furthermore, smoking and alcohol do not seem to predict future pain among adults, suggesting the observed associations may be confounded by other factors (e.g., mood and socioeconomics). Nevertheless, asking about the use of these substances can arguably be a useful means to open a conversation about their social circumstances and the means by which they are able to relax.

Diet and obesity

While associations between LBP and obesity have been observed [4], this relationship may not be causal, as again, there are multiple potential confounders (e.g., socioeconomics, mood, and activity levels), which could be implicated. Dealing specifically with adolescents, a range of dietary factors (e.g., specific nutrients, diet quality, and dietary pattern) do not appear to predict LBP with impact among teenagers [32]. While much attention focuses on the potentially increased mechanical spinal load that can result from morbid obesity, it is now thought that increased adiposity is implicated in painful conditions through systemic inflammatory processes [68]. This reinforces the concept that many factors increase the risk of LBP developing or persisting not mainly through increased physical loading of the spine but by making the person completely more susceptible to pain through sensitization of their physiology more generally.

General health factors

A range of other health comorbidities (e.g., fatigue, insomnia, irritable bowel syndrome, painful complaints including headaches and migraine, and somatic complaints) are associated with the

development of pain, and LBP, which is more distressing and disabling [54,69], as well as sensitizing someone to an experience of LBP. These comorbidities strongly influence disability levels and act as barriers to management that may require special consideration. While the evidence that growth and maturation influence the development of musculoskeletal pain is underwhelming [70], broadly evaluating the general health of an adolescent including their growth rate, pubertal development, menstrual cycle, and overall health is a useful consideration.

Clinical reasoning across multiple domains

While there is considerable evidence to support the role of each of these various factors in LBP, the sheer breadth of factors involved can seem overwhelming. It is unsurprising perhaps that many clinicians will state that, while acknowledging their importance, such an approach may not be pragmatic, as their appointments are time limited, and they lack the skills and confidence to help people address many of these factors, especially those in the psychosocial domain [71,72]. While addressing many of these factors can be challenging, clinicians often screen for other factors thought to be related to pain or injury, even if they are nonmodifiable (e.g., age and previous injury). Broad multidimensional screening can be performed relatively easily using some risk profiling questionnaires [73,74], albeit most are validated in adult populations. At the very least, there is some degree of obligation on healthcare professionals to ask about the range of evidence-based factors potentially involved in an adolescent's LBP. Thereafter, they can discuss with the adolescent in a shared-decision making manner which of these factors they both feel are most relevant, most amenable to change right now, and whether other supports might be worth exploring now or later. The specific circumstances of each adolescent may vary, with some factors being more or less modifiable. Nevertheless, there may be considerable value in discussing the relevance of all these factors in LBP, even if some of them are difficult, or even impossible, to address straight away. The aim of such a comprehensive approach is not to train physiotherapists to become psychologists, no more than it is to have psychologists or occupational therapists try to become strength and conditioning coaches. Instead, the aim is to provide a broader multidimensional understanding of pain consistent with other health disorders, to enable the appropriate individualizing of care. The hope is then that an adolescent with LBP who presents to a healthcare professional will get the assistance which will be of most benefit to them, as opposed to only getting whatever assistance that individual healthcare professional feels comfortable providing [75].

It is important to acknowledge that the aforementioned division of the various factors implicated in the development, and persistence, of LBP into groups such as “lifestyle” and “psychological” is in itself artificial. For example, lifestyle factors such as sleep, obesity, and physical activity are often comorbid with psychological factors such as depression and stress [64]. Similarly, an adolescent with LBP may present with low mood and a significant eating disorder (psychological factors) and a poor diet (lifestyle factor) and be the victim of bullying at school (social factor). Furthermore, most of the lifestyle and psychological factors are influenced to some extent by major social factors such as socioeconomic status and the quality of our relationships at work, school, and home [76–78]. Therefore, these factors, and their management, need not be compartmentalized and are seen as distinct entities. Even when we look at data among adolescent athletes, we see the interaction of multiple factors such as high training loads is a risk for pain/injury when combined with poor sleep [79]. In this specific example, a healthcare professional needs to discuss training loads with the coach, as well as discuss reasons for poor sleep with the athlete (e.g., simply poor hygiene or perhaps mental distress) to provide optimal care to the athlete. This interaction of risk factors to determine an adolescent's resilience or vulnerability to LBP is illustrated in Fig. 2 and will be further described in a case study.

Managing LBP in adolescents: current options

A recent systematic review and meta-analysis on conservative management options for LBP in adolescents and children highlights the dearth of high-quality RCTs on the topic [80]. The findings demonstrate that there is moderate-quality evidence that traditional biomedically focused back education programs are not effective in reducing LBP prevalence. In terms of treating ongoing LBP, a supervised exercise program is more effective for pain intensity among adolescents than no treatment.

Perhaps unsurprisingly, this indicates – for both prevention and treatment of LBP – broad agreement with the data from RCTs of adults with LBP and the subsequent guidelines and position statements for adults with LBP [1–3,81].

While the fact that exercise can help alleviate LBP in adolescents is welcome, it is clear that exercise alone will not alleviate all LBP. In adults, there have been encouraging trials [74,82], which seek to build on a foundation of encouraging exercise and physical activity by better matching the needs of people with LBP, such that they receive the type and amount of treatment they need. To cover a broader range of the many risk factors outlined earlier (e.g., social, psychological, and lifestyle) to reflect the bio-psychosocial nature of LBP, such interventions should reflect the manner in which adolescent LBP often presents as a marker of overall poor health [83]. One multidimensional intervention – Cognitive Functional Therapy – has been tested in clinical trials in adults with LBP [82,84], along with some small-scale studies in adolescents [85–87]. While there is a need for RCTs among adolescents using this treatment approach, it will be outlined now as an exemplar of how a multidimensional approach could be implemented among adolescents to reflect the breadth of potential contributing factors involved.

Clinical assessment and management: a cognitive functional approach

The principles underlying the examination and management of LBP in adolescents using Cognitive Functional Therapy are outlined here and then illustrated using a clinical case study.

The subjective interview involves listening to the adolescent's story and concerns while exploring.

- pain history
- levels of disability and pain responses to functional activities
- avoidant coping behaviors such as taking time off school and avoiding physical activity or activities of daily living
- back pain beliefs and pain self-efficacy
- fear of movement and activity, and overall levels of psychological and social distress (e.g., school friendships, bullying, and isolation)
- lifestyle behaviors such as sleep patterns and activity levels
- screening for red flags, specific pathology, and comorbid health conditions

Input might also be sought from other relevant parties, such as their primary carer or coach. The use of multidimensional screening questionnaires (e.g., Orebro and STarTBack) [73,88] is recommended to support this process.

The physical examination considers the interplay between the adolescent's LBP experience and their spinal posture, loading, and levels of muscle conditioning. Identification of pain-related postural and/or movement biases (e.g., flexion or extension) and related deficits in strength and conditioning is part of this process. The examination specifically focuses on personally relevant activities which the adolescent has nominated as painful, feared, and/or avoided during the subjective interview [89].

While posture and movement patterns do not appear to cause LBP, people with LBP commonly display alterations in how they move, which is commonly characterized by stiffer, slower, and less variable and more guarded movements [90,91]. These pain-related functional behaviors are likely motor responses to pain, the threat of pain, and/or pain-related distress. These responses could be protective and adaptive, for example, in the presence of acute tissue pathology. However, in persistent LBP, they are usually unhelpful and provocative and disproportionate to the degree of tissue pathology and persisting beyond tissue healing times. These pain-related functional behaviors may vary from subtle movement and postural changes to overt safety behaviors (e.g., propping with hands, avoidance of loading the spine or a limb, repetitive “checking” of the pain, grimacing, and wincing) among highly distressed people with LBP [87]. In adolescents with persistent LBP, their individual LBP experience and movement pattern should be evaluated because the specific movements and activities that are provocative can vary [33,92]. For example, pain provoked during sitting, forward bending, or lifting may be associated with active bracing of the lumbar spine into flexion or extension. In contrast, for others, the same tasks may be associated with lateral movement and avoidance of loading the painful side.

Depending on the findings from the interview and physical examination, modifiable factors are then identified and targeted, as described in the next section [18,89,93].

Cognitive Functional Therapy in practice: a case study

Background

Ahmed is a 16-year-old footballer who report right-sided LBP, which occurred for the first time approximately four months ago. He reports no history of previous LBP or other significant injuries. He reports no other painful regions. There was no history of trauma – the pain started gradually, and his lower back is now stiff in the morning for approximately 10 min, and sometimes after sitting or standing. He reports no signs and symptoms indicative of a serious medical condition.

The pain started approximately three weeks after he returned to school from his summer holidays. His football team has a new coach who has implemented a tougher training regime this year, as they were knocked out last year in the semi-final stage. Ahmed had been feeling tired when the pain started. He initially attributed this tiredness to training harder, although he also mentions he has been intermittently waking at night "for no reason." His mother tells him he has grown a lot in the last few months, and he reports having become lean. Before returning to school, he had been traveling with his family and did almost no training, and he was much less active than previous vacations. He usually feels fine in training once he warms up but is then sore again after training. He feels better if he pulls his knees to his chest in sitting, and he avoids doing back stretches on his stomach (into spinal extension), as they are painful. The only other movements that he specifically avoids are deadlifts and back squats. He started doing these only a few weeks before the LBP started, and he attributes his pain to these "dangerous" exercises. He stopped all training in the last month, and his symptoms are approximately 20% better since he stopped football. The decision to stop training is related to the LBP and also the concerns of his mother that sport will take away from his academic progress, as he has exams this year and he is studying intensively already because his family wants him to pursue medicine at university. His baseline short-form Orebro score was 52/100 (high risk of persistence).

Investigations

Lumbar X-rays taken two months after the pain started were clear. An MRI performed two weeks ago showed bone marrow edema bilaterally, with no fracture line evident in the pars region of L5 (Fig. 3). Ahmed reports that his team doctor told him that he might never recover from this serious injury.

Key findings on physical examination

His standing posture is unremarkable. There is pain on lumbar extension, with a large degree of mobility available. While flexion is initially painful, there is immediate relief of pain on relaxed flexion in standing. He reports slight pain during a single leg hop. He maintains considerable lumbar lordosis, which is associated with LBP, during a simulated back squat using bodyweight only. A simple behavioral experiment finds this LBP is abolished by shifting weight through his feet more posteriorly and allowing greater thoraco-lumbar flexion.

Clinical reasoning

Ahmed's situation is not uncommon. Undertaking a large increase in activity, especially if unaccustomed to that type of exercise, increases the risk of developing pain [62,94]. Having a very inactive vacation just before the intense training with his new coach is likely to have left him vulnerable to many types of injury and/or pain [62]. As mentioned earlier, many adolescent athletes develop BMO in the region of the pars interarticularis. While the pathogenesis is somewhat unclear, the addition of some back-focused exercises may have loaded his lumbar region to a larger degree than he was used to. These exercises are safe and potentially advantageous for his long-term athletic development. However, they may have been added into his program at a time when he was already overreaching with the rest of his training at the start of the school year (based on his reports of heavy training, fatigue, weight loss, and sleep disturbance). It is now several months since the initial report of mild LBP, which has become more persistent and disabling as evidenced by his withdrawal from sport in the last month. As

such, he is now in a situation where the underlying nociception from the BMO is compounded by provocative movement patterns, poor sleep, high stress, and high fear (Fig. 4).

Intervention

1. Making sense of pain

Critical to an adolescent making sense of their pain is the fact that they feel the education provided is personally relevant. With regard to this, the education provided uses the individual's own story, aligning their pain experience with specific sensitizing factors in their life. Rather than education being something that is "told" to Ahmed, reflective questioning can be used to deepen his awareness of the factors involved in the development of his LBP, and its persistence.

Experiential learning from behavioral experiments can be used to disconfirm previously held beliefs regarding the fragility of the spine and the need for high levels of protection. For example, the role of his current movement patterns in provoking his LBP must be discussed; the pain relief he reports during relaxed flexion and when modifying his back squat technique can help with this reconceptualization. Being taught to move with more relaxation and less muscle guarding and using the legs rather than the trunk and hands to support the body's weight can all form part of this reconceptualization.

Reassuring Ahmed that the nature of his imaging findings is not unduly worrisome is key to de-catastrophize both his current situation and the safety of returning to sport.

In adults, how pathoanatomical findings are reported can increase concern, anxiety, and distress, especially if they are not communicated carefully [95]. While pathoanatomical factors are often non-modifiable, tissue morphology has the potential to resolve, and communicating this with patients is critical [96]. This includes developing an awareness that LBP does not necessarily mean the spine is seriously damaged and that it often instead reflects sensitization of spinal structures related to the various factors already identified as relevant. As such, better understanding the risks of sudden spikes in training load after being inactive must be considered. The presence of additional sensitizing factors such as stress and poor sleep must be addressed also. When provided with the opportunity to disclose why he was waking "for no reason," he confides he feels pressurized to do well in school to meet his family's expectations, and this may be the reason for his initial poor sleep. Such disclosures are made more easily when trust is established as part of a strong therapeutic alliance, and this can be something which develops over the first few appointments [97].

Thereafter, the adolescent is asked to reflect on what they can do to break their own vicious cycle of pain, distress, and disability in order to reach their valued goals. Through this process, clear and realistic self-motivated strategies for behavioral change are identified. Collaborative goal setting can

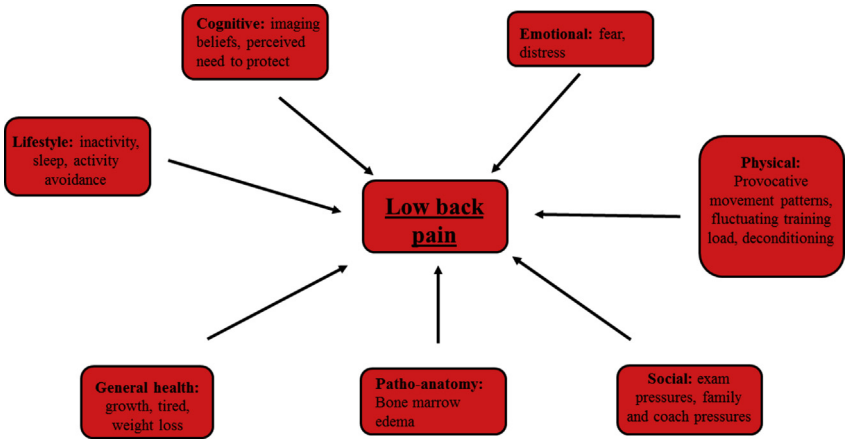

Fig. 4. Illustration of the contributing factors in Ahmed's pain cycle.

then help to build confidence to stay engaged in activities of daily living, physical activity, school, and work. In addition to Ahmed making sense of his pain, others (parents and coaches) are also important in this process as their input could facilitate, or delay, recovery. For example, a coaches leadership style can negatively affect injury rates [98], while negative family beliefs are associated with increased disability [99].

An overall summary of this information is provided in a format that suits Ahmed (e.g., written, audio, and video). Online resources and patient stories are also provided to facilitate this learning process. Critically, his comprehension of the factors involved and why certain treatment options are being pursued is checked and updated at subsequent sessions, reflecting the key emphasis placed on him needing to better understand the nature of the problem.

2. Exposure with control

Experiential learning, where responses and behaviors that manifest during valued tasks, which are painful, feared, or avoided are explicitly targeted in a controlled manner, underpins the concept of exposure with control. In this manner, individuals can be assisted to gradually return to valued functional activities without pain escalation and associated distress. Determining the starting point for such exposure considers their response during behavioral experiments, as well as their distress, conditioning, and sensitivity. For example, when pain is constant and highly distressing, the priority might be on strategies to enhance body awareness and restore control over pain responses (e.g., targeted body relaxation, slow diaphragmatic breathing, and body scanning). Alternatively, if pain is less constant and distressing, or after some degree of pain control has been achieved, more threatening or provocative movements or activities can be targeted.

In the short-term, helping Ahmed to re-learn how to move in a more comfortable and confident manner is the priority to build confidence. In his case, this will focus on those activities that are nominated to be painful and/or feared. Starting with forward bending, this will progress over time to standing, walking, single-leg hopping, and running. Challenging unhelpful habits such as abdominal bracing, breath-holding, or stiffening his legs on landing reduces protective behaviors and build movement self-efficacy. Achieving even slight reductions in pain, which is common, can powerfully disconfirm fear-avoidance beliefs while providing hope for adolescents that valued activities can be attempted safely with less protection and vigilance. Confidence to gradually engage in all relevant activities in a relaxed and variable manner is stressed. These new functional strategies are immediately integrated into activities of daily living, e.g., carrying his schoolbag, order to generalize his learning and build self-efficacy during these tasks.

While this approach will help normalize the manner in which he loads his spine, he cannot immediately run as much as he wants because of pain, thereby limiting running as a form of fitness training. Therefore, other means of conditioning are added to reduce the de-training effect, which will already have partly occurred due to prolonged rest. While cycling and swimming are often a useful option, it is important that his preferences, as well as issues such as cost and access, are considered. It is often possible to do relatively high-intensity training (e.g., high-intensity intervals on a static bicycle) in such situations, with the frequency of such training limited to 2–3 times per week, according to his response to the exercise. Over time, targeted functional conditioning is provided when there are deficits in muscle strength and endurance that act as barriers to achieve personally relevant goals. Where LBP is provoked by specific functional or sports-related activities, graduated conditioning specific to these tasks can enhance pain control and confidence. As expected, pain control may not always be easily achievable during this process, in which case the focus is placed away from pain and toward body relaxation, rather than safety behaviors, while achieving personally relevant functional and lifestyle goals.

While bracing with a corset is still commonly used in situations like this, there is no evidence that it improves outcomes [100]. In Ahmed's case, the fact that his pain can be relieved completely using simple behavioral experiments further reinforces the possibility that complete immobilization may be unnecessary. The absence of a brace equally is not an indication that he can simply continue as normal. The reasons for this approach – to facilitate pain-free movement and allow training as much as

possible to maintain fitness – should be discussed with Ahmed, his family, the medial team, and the coach. Such an approach is further justified by the positive prognosis, where nonoperative management of spondylolysis/spondylolisthesis results in successful outcomes for most people [100].

Reinforcing these less provocative ways of loading the spine is assisted by clear verbal and written explanations, clinician demonstrations, and, occasionally, visual feedback using mirrors and video. Hands-on feedback can serve several useful purposes, including validating individuals' pain experience, challenging beliefs that their spine is structurally vulnerable, providing feedback regarding tissue sensitivity, sympathetic responses, and protective muscle guarding, and decreasing fear of pain and movement. However, hands-on feedback should never be used to promote passive dependence or unhelpful structural beliefs. Thus, hands-on feedback should be a minimal part of sessions, as it could dilute the effect of more active approaches or reduce the priority people place on active self-management.

3. Lifestyle change

Addressing lifestyle factors, discussed while “making sense of pain,” forms a central part of CFT. Engaging in healthy sleep habits, regular physical activity, and maintaining a healthy weight through a balanced diet is encouraged and coached. While the relationship between LBP and both overall diet and adiposity is weak, maintaining a healthy weight while getting adequate nutrition remains important components of overall adolescent health.

All adolescents should be informed of the health-enhancing systemic effects of activity in line with their story (e.g., effect on mood and sleep). Changes in physical activity and/or more formal exercise must consider personal preference, cost, social engagement, accessibility, and personally relevant goals. In some cases, very highly sensitized people may struggle to self-regulate their activity. In such situations, a graduated, time-contingent approach may be used. If unhelpful safety behaviors (e.g., muscle guarding and/or movement avoidance) form a barrier to activity, either a more “relaxed” approach is facilitated or, where necessary, a less provocative activity option may be selected initially, before gradually progressing toward the preferred activity. For those with high levels of sedentary behaviors, activity scheduling is explored. When excessive fluctuations of overactivity and underactivity are present, activity diaries may be beneficial. For active adolescents who develop LBP, the importance of maintaining adequate physical activity to reduce de-training as well as reduce the risk of injury on return to sport is stressed and facilitated where necessary.

The precise aspects of sleep which could be optimized may vary, depending on the issues identified during the interview and examination (e.g., poor sleep hygiene, worries, pain with rolling, comorbid obesity, and sleep apnea). For example, in the case of poor sleep hygiene, ways of engaging in healthful sleep habits are explored (e.g., establishing a daily routine, timing and amount of caffeine intake, and reducing use of electronics in bed). Where sleep is disturbed because of pain, worry, or stress, the influence of body relaxation, breathing regulation, guided meditation techniques, and engaging in relaxed physical activity would be explored. When sleep is affected by postures and movement in bed, specific training of rolling and posturing in bed in a natural, relaxed manner is explored.

In Ahmed's case, the distress he feels relating to family pressures regarding school and his coach's leadership style are key issues for him and are affecting his sleep and overall energy levels. It is important that Ahmed feels that he can discuss this with them or if preferred that his clinician can act as a mediator initially. Thereafter, re-establishing a good sleeping habit and his preferred stress management strategies (sport, and time with friends on one evening of the week, and at weekends) are prioritized. Assessing his diet may also be valuable, considering his recent changes in energy, body composition, and weight.

Deciding on return to sport and activity

Deciding when it is “safe” to return to full training and sport is difficult, and the role of imaging in this decision-making process is controversial. While repeated imaging is often used in cases such as Ahmed's, we know that most, but not all, lesions in the region of the pars interarticularis resolve fully,

usually within three months [15,19,20]. Despite this, there is no evidence that outcomes differ according to the findings on repeat imaging [100]. A lack of imaging studies looking at the long-term significance of imaging findings in adolescents limits the certainty we can offer on whether bone healing is critical to long-term prevention of LBP-related disability. Currently, there are no guidelines to suggest the role of imaging in return-to-play algorithms, and we do not advocate routine repeated imaging to determine rehabilitation progression or return to play. However, further or repeated imaging may have a role if the LBP does not resolve or deteriorates.

Structuring of treatment

Typically, individuals are initially seen weekly for 2 or 3 sessions, after which sessions are extended to every 2 or 3 weeks to build confidence to self-manage over a 12-week period. During this process, the occurrence of pain flares is seen as an opportunity for reinforcing new ways to respond to pain without safety behaviors and avoidance. An exacerbation plan is provided on discharge to positively orientate the individual's emotional and behavioral responses to pain, and booster sessions may be required beyond this time if pain again becomes uncontrollable, distressing, and/or disabling. Rather than being prescriptive, CFT is reflective, in that the individual is encouraged to find new strategies to respond to pain and perform valued activities with confidence and without pain vigilance. In this process, reliance on passive therapies should be avoided so that the adolescent can build self-management strategies. In situations where pain is particularly disabling, distressing, and associated with high levels of depressed mood, anxiety, social stress, and school absenteeism, multidisciplinary referral may be required. It is critical that such interdisciplinary care is appropriately integrated [75], with a consistent person-centered biopsychosocial philosophy in place, to avoid mixed messages causing further confusion for adolescents with LBP.

Summary

LBP often emerges during adolescence and has a considerable impact among a small but significant group both in adolescents and later in life. While LBP can occasionally reflect an underlying specific local pathology, most commonly, the structural integrity of the spine is intact. In such situations, the adolescent's nonspecific LBP can reflect the presence of a range of risk factors across pathoanatomical, physical, lifestyle, psychological, social, and general health domains. There will often be individual variation in the severity of impact and the type of risk factors involved. For many adolescents, LBP is less of a local structural spinal issue and more of an indication of their general health. Supervised exercise and education framed within a biopsychosocial framework are the cornerstones of treatment. More comprehensive personalized treatment approaches such as Cognitive Functional Therapy have shown promising results in adults with LBP, although clinical trials among adolescents are required.

Practice points

- Very few adolescents with LBP have evidence of spinal pathology which adequately explains their pain. Addressing adolescent, parent, and coach fears and concerns regarding spinal damage and/or the perceived need to seek imaging and avoid activity should be a priority in the clinical encounter.
- There is a strong association between LBP among adolescents and a range of other markers of poor health (e.g., mental health, stress, and poor sleep), highlighting the need to evaluate the adolescent as a while, rather than "just" their spine.
- Greater interprofessional integration, while maintaining a consistent biopsychosocial philosophy, may facilitate better outcomes.
- A cognitive functional approach that personalizes pain education and encourages graded activation while addressing lifestyle factors provides a framework for self-management.

Research agenda

- The potential for broader lifestyle and general wellness interventions, which aim to treat LBP and also many related risk factors and comorbidities (e.g. mood, sleep, obesity, social isolation), requires further investigation.
- There is a need to establish whether personalized management, which seeks to directly address whether the contributing factors involved in an adolescent's LBP are feasible, acceptable, and effective.

Conflicts of interest

KOS, POS, and MOK have conducted professional development workshops for clinicians on the management of low back pain, with a specific focus on the use of Cognitive Functional Therapy. BF has an equity position in a private imaging clinic in Vancouver, Canada, which performs ultrasound, CT, and MRI examinations.

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