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Case report

Low back pain in the overhead athletes: Evaluation and treatment based on movement system

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ABSTRACT

Introduction: Low back pain (LBP) is a common problem in sports. There is high risk for back pain occurrence in athletes. The knowledge about LBP in overhead athletes is limited. The Movement System (MS) approach is based on association of symptoms and incorrect movements of the spine. The main goal is to identify the localization and direction of improper movements and to restore appropriate motor control of the movement pattern.
Aim: To present functional evaluation and therapeutic approach based on the MS in the case of LBP in overhead athlete.
Case study: The study presents a 26-year-old overhead athlete with chronic mechanical LBP, which is related to his sports activity. He reported exacerbation incidents, which had eliminated him from physical activity.
Results and discussion: Physical examination of the patient had shown deficit of lumbar motor control in directions of extension and rotation of pelvis coupled with functional alterations in muscles. These movements were associated with pain symptoms. The patient had undergone a 4-month-lenght-therapy program, which was focused on spine motor control training and functional reeducation of muscles. A subsequent examination showed an improvement in motor control of the movement and considerable decrease of pain symptoms.
Conclusions: (1) The MS approach allows to identify the incorrect movement and to relate it with pain symptoms. (2) Reeducation of motor control based on movement system evaluation allows decreasing pain symptoms.
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1. Introduction

Low back pain (LBP) is one of the most common reasons why adult people look for medical help.[1–3] It generates work absenteeism and great social costs.[4] Generally, LBP is associated with predominance of the sitting position and lack of physical activity, but on the other hand with overloads.[5,6] Physical activity is recommended as one of the therapeutic and preventive instruments in LBP [7,8]; however, its influence on back pain has not been fully explained.[9] Sports training might be linked with high risk of injuries, overloads and pain.[10–12] Overhead athletes are exposed to high risk of shoulder impingement symptoms, which is widely described in the literature.[13–16] However, the information about LBP in overhead athletes is insufficient.[17]

The Movement System (MS) is founded on the hypothesis that the reason of back pain is linked to incorrect trunk movement in a specific direction through motions of trunk and limbs. Such a situation might be caused by daily application of specific motor strategies, which are composed of repetitive movements in a precise direction. Then adaptive functional changes might occur in musculoskeletal tissues, such as decrease of several muscles elasticity, functional insufficiency of other muscles, and alterations in muscle timing. Prolonged inherence of this state might result in mechanical overload of musculoskeletal tissues, micro-trauma, tissue adaptation and pain.[18,19] The MS evaluation is focused on detecting these functional changes and identifying the direction of the movement causing pain. It is hypothesized that restoring normal control of the direction should result in decrease of pain.[18,20,21,22]

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Table 1
Movement and motor control tests.

Test	Testing task	Points to observe
Forward bending	To bend trunk forward to about 50°	To observe motions and alignment of pelvis and trunk: is the patient able to maintain stability of lumbar spine in sagittal plane during motion?
Hip extension in standing	To extend lower limb in hip joint in standing position	To observe alignment of pelvis and trunk: is the patient able to maintain stability of lumbar spine in sagittal plane and stability of pelvis in horizontal plane during leg motion?
Hip extension in quadruped	To extend lower limb in hip joint with knee flexed in quadruped position	To observe alignment of pelvis and trunk: is the patient able to maintain stability of lumbar spine in sagittal plane and stability of pelvis in horizontal plane during leg motion?
Small knee bending (SKB)	To perform a single-leg small knee bending in standing position	To observe alignment of loaded lower limb: especially is the patient able to maintain leg alignment in frontal plane? To observe alignment of pelvis and trunk: is the patient able to maintain stability of lumbar spine in sagittal plane and stability of pelvis in horizontal plane during SKB?
Hip abduction	To abduct lower limb in the hip joint with hip and knee flexed in supine lying position	To observe alignment of pelvis: is the patient able to maintain stability of pelvis in horizontal plane during leg motion?

2. Aim

The aim of this study is to present possibilities of functional evaluation based on the MS in the case of LBP in the overhead athlete, and to present a potential therapeutic approach based on the MS evaluation and its short-term effects.

Fig. 1. Forward bending test: final position.

3. Case study

The study object is a 26-year-old man engaged in regular volleyball training (4 times per week). His actual problem is mechanical LBP. Symptoms are permanent but pain intensity changes. There were three exacerbation incidents during last 6 months before the patient reported he required therapy. To evaluate pain intensity the numerical rating scale (NRS) (0–10°) was used. The patient defined his pain intensity as 7–8 in

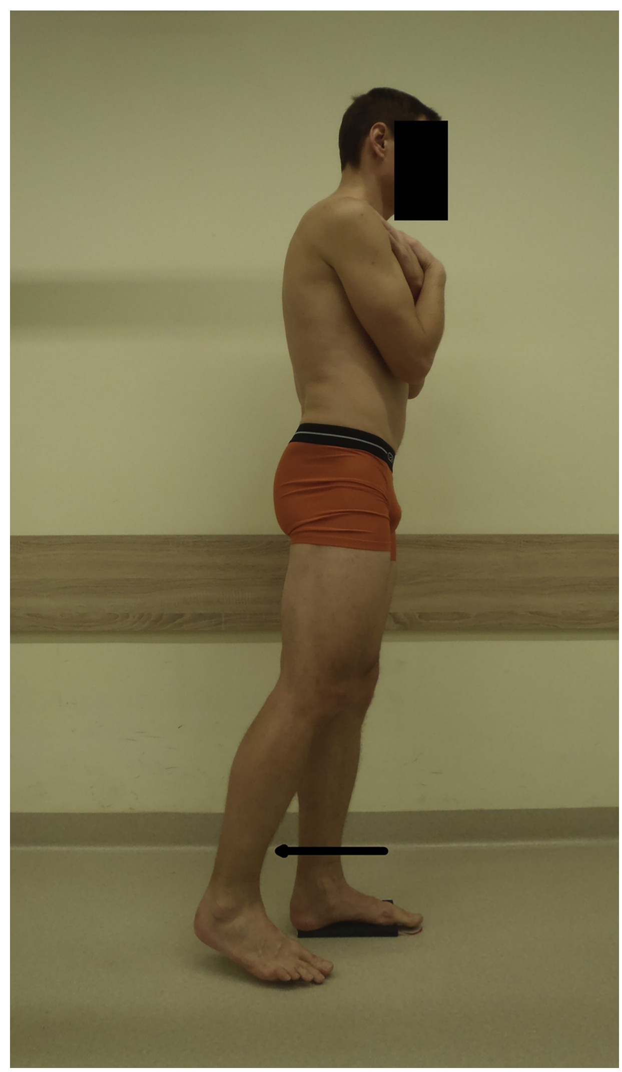

Fig. 2. Hip extension test in standing: final position.

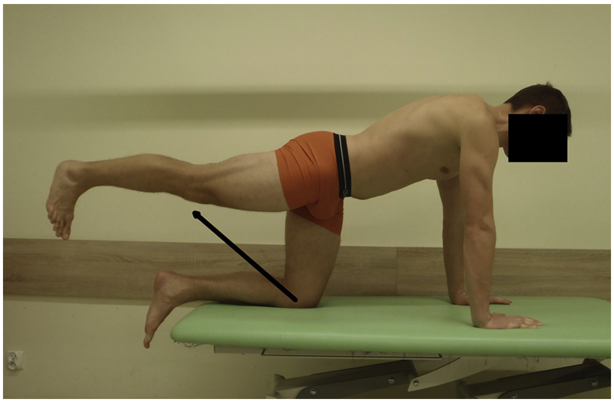

Fig. 3. Hip extension test in quadruped: final position.

exacerbation periods and 2–4 in the remaining time. When the exacerbation occurred the patient was completely eliminated from sports activity for 10–14 days, whereas in remaining time symptoms did not preclude the patient from training but they were the cause of high discomfort. The localization of pain was always the same; it involved the central aspect of lower back and there was no referred pain in legs. The first incident took place about 10 years ago, the patient did not remember what factors induced the pain. For about 4 years the pain was permanent with periods of exacerbation. The patient could not clearly determine what activities increased and decreased the pain but he observed increase of symptoms after volleyball training (about 2 h later), whereas during training the pain was rather constant. He also noticed increase of pain at the end of the day on which he practiced jogging (2–4 days per week). Then he was sleeping in the fetal position, which decreased his pain; sleeping in the prone recumbent position was not possible because of increase in pain. Another position relieving the pain was forward bend sitting with arms support. Till this time patient had not looked for medical help, there were no diagnosis and treatment applied. No drugs were applied in the periods of exacerbation. When it comes to other conditions affecting the locomotor system, the pain of right shoulder occurred. In the past the patient also underwent partial anterior cruciate ligament (ACL) rupture of left knee, which was handled with conservative treatment. There were no symptoms referring to other parts of the body and no permanent use of any drugs.

4. Results and discussion

4.1. Physical examination

At the start of physical examination, the patient determined his pain intensity at the level of 4 in the NRS scale. The examination was divided into three parts: 1) static estimation, 2) specific functional tests, and 3) muscle assessment.

Static estimation included observation of the patient's body alignment in the free standing position. Relationships between several body segments in frontal, sagittal and horizontal planes were observed. The symmetry was also estimated. Observation of static pelvic alignment was estimated by applying markers on superior iliac spines (anterior and posterior) and pubic symphysis in free standing position.

Functional tests were focused on defining the influence of specific movements on pain intensity and estimation of quality of those movements. They were performed in three positions: standing, quadruped and supine lying. Tests are described in Table 1 and shown in Figs. 1–5. The patient was asked to perform limb or trunk movements in a specific direction. The patient's ability to stabilize the lumbo-pelvic region actively during these movements was observed. The influence of movement on pain intensity was also estimated. A deficit in lumbo-pelvic stabilization manifested itself in an incorrect movement of trunk and pelvis in a specific direction. There were considered three possibilities when

Fig. 4. Small knee bending (SKB) test: final position.

Fig. 5. Hip abduction test in supine: final position.

Table 2
Muscle performance tests.

Tested muscle	Testing task
Abdominal oblique	Supine lying with hips and knees flexed; to flex upper part of the trunk, then rotate it to one side, and maintain this position for 10 s
Gluteus maximus	Standing position with hips flexed to 90° degrees and whole trunk forward bended with support on the couch; to extend one hip with knee flexed to couch plane, and maintain this position for 10 s
Gluteus medius	Side lying position; to abduct the hip with knee extended in frontal position, and maintain this position for 10 s

estimating the influence of movement on pain intensity: 1) movement increased pain, 2) movement decreased pain, or 3) there was no influence on pain. The next stage of examination was performing the same tests once again but the patient was asked to hold the pelvis actively in the neutral position before and during movement.[22] Functional tests to assess motor strategies which the patient used in activities associated with his volleyball training were also performed: 1) upward vertical jump, and 2) upper limb movement used to serve a ball. Kinovea software was used in the analysis of patient's movements. Video recording of functional tests was done. Estimation of pelvis alignment during movement was based on observation of applied markers.

Parameters that were estimated during functional assessment of muscles were elasticity and performance. Elasticity was assessed as a potential cause of restriction in the range of motion (ROM). Passive movement with end-feel estimation was used to evaluate muscles elasticity. Muscle performance was assessed as an ability to activate muscles during maintaining a specific position. Muscle testing is described in Table 2 and shown in Figs. 6–8.

Additionally, neurological tests were performed to exclude involvement of neurological structures. SLR in supine and SLUMP in sitting tests were applied. There was no symptoms provocation in those tests.

4.1.1. Outcomes of physical examination

During static examination the patient was asked to assume the free standing position, which was the most comfortable for him. Increased anterior tilt of the pelvis and lumbar lordosis in the sagittal plane were observed. There was no asymmetry in the pelvis alignment in the frontal plane; however, there was slightly excessive internal rotation in both hip joints. The knees were in a slight valgus alignment and a slight pronation of both feet was observed.

A wrong extension pattern and rotation of trunk were observed during examination. Pelvis rotation occurred in the direction of the left leg (left pelvic rotation was more notable while the left limb was moving). The outcomes of this part of examination are shown in Table 3. Each test increased symptoms in the direction of extension and pelvic rotation. The second version of tests (with active pelvis alignment control) resulted in decrease of pain, yet the patient noticed that active control of pelvis was difficult and exhausting for him. Increased pelvic tilt and lumbar lordosis during upward vertical jump, especially in eccentric and final phases of jump were observed. When the patient was serving the ball, increased anterior pelvic tilt and lumbar lordosis also occurred. Additionally, considerable trunk rotation to the right (in the direction of the serving limb) was observed when the arm was being elevated. During those two tasks the patient also reported pain increase.

The assumption was made that excessive motion into extension could overload intervertebral joints of lumbar spine and it might be a structural source of patient's pain.

Evaluation of the muscles demonstrated functional insufficiency of abdominal oblique muscle, gluteus maximus and medius. Decreased elasticity of hip flexors was observed. Trunk erector was also less flexible; additionally, it was sensitized on palpation.

4.2. Therapeutic interventions

The therapy programme was based on classifying the patient's LBP as extension with rotation syndrome. The main goal of treatment was focused on re-education of motor control in the lumbo-pelvic area, both in static and dynamic conditions. The final effect should result in re-integration of active motor control with functional activities – especially with volleyball training. The other goals of the therapeutic programme were to increase performance of insufficient muscles contraction in inner range holding and to increase flexibility of stiff muscles.[23]

The treatment lasted for 4 months. During the first 2 months therapeutic sessions were held once a week, during the subsequent 2 months there was one session per 2 weeks. The patient also received an exercises programme to perform himself at home. The first stage of therapy was to teach the patient to hold the pelvis

Fig. 6. Abdominal oblique muscles test.

Fig. 7. Gluteus maximus muscle test.

Fig. 8. Gluteus medius muscle test.

actively in the neutral position in the sagittal plane. Initially, the therapist provided the pelvis neutral position passively. The next stage consisted in active correction of pelvis alignment to the neutral position and holding it. When the patient mastered those activities, the accessory movements of other parts of the body were added. Starting positions and movements used in the exercises were based on those from tests performed before. Motor tasks used in tests were modified so that the patient could perform them correctly during exercise (regression of the tested task). Depending on the exercise, there were 20–30 repetitions of movement in a single exercise. The next stage was progression of exercises performed by the patient; movement tasks became more difficult and complicated (i.e. use of body mass load and external load). Afterwards, when the patient was able to control the lumbo-pelvic region with no difficulties and not much effort, exercises based on previous functional tests (upward vertical jump and ball serving) were applied. The patient's task was to perform those activities with active control leading to avoiding excessive lumbar extension and rotation. Simultaneously, from the 1st day of the therapy, neuromuscular techniques for increasing muscles elasticity (hip flexors and trunk erector) were used. Exercises were also focused on increasing muscles performance: abdominal oblique muscles, gluteus maximus and gluteus medius. Those exercises consisted of holding an exact position for 10 s, which demanded isometric muscle tension. Exercises were selected to make the patient capable of performing 10 repetitions with no considerable effort. The patient was recommended to resign from volleyball training and jogging for the 1st month of the therapy. He gradually returned to training in the next month (volleyball – 1–2 times per week, jogging – once a week). At the beginning of the 3rd month, the patient returned to full activity.

4.3. Re-testing. Effects of therapy

After 4 months, physical examination was repeated. The patient reported lower pain intensity. He estimated his pain at 1–2 in the NRS scale. There was no pain increase after volleyball training and jogging, which had been observed before. The only factor which still increased the pain was prolonged prone lying, the patient was still avoiding this position. There was no exacerbation incident in the last 4 months. In comparison with the prior examination, a slightly smaller anterior pelvic tilt was observed. Also lumbar lordosis was slightly lower than earlier. In functional tests, increase of motion quality was observed – the patient was able to perform testing tasks with active control of the lumbo-pelvic region. The pattern of lumbar spine extension and rotation improved. There was also no pain increase in each test. The same observations were made during upward vertical jump and ball serving. Higher elasticity of hip flexors was observed; trunk erector was still relatively stiff, yet it was less sensitive. There was significant improvement in abdominal muscles performance. Gluteus maximus performance was also improved, but a slight deficit of endurance in the terminal stage of concentric activity was still observed. Functional testing of gluteus medius still showed functional insufficiency of this muscle.

5. Discussion

The outcomes of evaluation suggest that the cause of patient's back pain might have been a deficit of motor control and poor muscle performance. Results of this deficit were wrong extension of the spine and rotation of the pelvis. During sports training the patient had been using motor strategies including recurrence of movements in those directions. Anterior tilt of pelvis might have been caused by decreased elasticity of hip flexors: rectus femoris, iliopsoas and tensor fasciae latae. It could be accompanied with functional insufficiency of hip extensors (gluteus maximus) and abdominal muscles. Anterior pelvic tilt was observed both in static and dynamic conditions. It led to increase of lumbar lordosis. The hypothesis of the patient's problem was lumbar extension and pelvis rotation syndrome and the therapeutic approach was based on this classification.

Increased anterior tilt of pelvis and lumbar hyper-lordosis might suggest muscle imbalance in the lumbo-pelvic region. The influence of muscle performance on posture has not been precisely explained yet, but we can suspect that functional (activity, tension) and structural alterations of muscles can influence the posture.[19,24–26] Relative stiffness of hip flexors was observed in the patient's examination. It especially involved rectus femoris and tensor fasciae latae. Stiff hip flexors might have resulted in

Table 3
Outcomes of movement and motor control testing.

Test	Outcomes and observations
Forward bending	Increased anterior tilt of pelvis Hyper-extension of lumbar spine
Hip extension in standing	Increased anterior tilt of pelvis Horizontal rotation of pelvis in direction of moving leg Hyper-extension of lumbar spine
Hip extension in quadruped	Increased anterior tilt of pelvis Horizontal rotation of pelvis in direction of moving leg Hyper-extension of lumbar spine
Small knee bending (SKB)	Increased anterior tilt of pelvis Hyper-extension of lumbar spine Increased internal rotation and adduction of hip Increased adduction of knee (knee valgus)
Hip abduction	Horizontal rotation of pelvis in direction of moving leg

decrease of hip extension ROM. In functional conditions (i.e. running) the patient might have compensated this deficit through anterior tilt of pelvis and lumbar extension. It was also seen when functional tests were performed. A deficit of hip extension may have also been a result of functional insufficiency of gluteus maximus, which also was detected in patient's examination. Presence of muscle imbalance between hip flexors and extensors may have resulted in hip flexion being a dominant motor strategy. Hip flexion results in anterior tilt of pelvis. It might be observed either in static or dynamic evaluation. Anterior tilt of pelvis is mechanically coupled with lumbar extension, consequently the patient probably had been using motor strategies with excessive lumbar extension in functional activities.[27]

Pelvis alignment is dependent on abdominal wall muscles and trunk erector in the lumbar region. Alterations of trunk muscles activation in patients with LBP have been confirmed in the literature; however, its nature has not been precisely explained.[28–30] Functional insufficiency of abdominal musculature associated with stiffness of trunk erector might predispose patients to anterior tilt of pelvis. Such findings were observed in the patient's examination. Abdominal oblique muscles participate in trunk rotation control.[31,32]

Generally, it is known that abdominal muscles provide stability of the lumbo-pelvic complex; especially the role of transversus abdominis (TrA) is underlined.[33] TrA is able to control mobility of vertebral segments, but it is incapable of controlling global trunk motions.[31,33] During asymmetric motions of an upper limb (i.e. ball serving), trunk rotation in the direction of the moving limb is observed. A deficit of trunk rotation active control might result in excessive rotation during upper limb activity. Gluteus medius is also engaged in trunk rotation control.[34,35] A deficit in this muscle performance was observed in the case of stiffness of tensor fasciae latae and ilio-tibial band.[36] The outcomes of our patient's evaluation correlate with these observations. A deficit of activation of abdominal oblique and gluteus medius muscles in patients with LBP has been described in the literature.[37]

It was characteristic that the patient's symptoms were increasing more in low-load activities (tests) than in high-load activities. Higher activity of phasic muscles is observed in high-load activities, whereas better activity of tonic muscles is seen in low-load activities. When performance of single-joint muscles is decreased, symptoms may be more evident in low-load activities.[19,38,39] This fact is tried to be explained as imbalance between superficial multi-joint phasic muscle that are dominant also in low load activities where single-joint tonic muscle tend to be inhibited.

Postural re-education and directed muscle training had a beneficial influence on the patient's motor control.[19,23,40,41] The final effect was decrease of pain symptoms.[18,19,41] The therapy was focused only on selected activities related to sports activity. Other daily activities might also include altered motor strategies, thus they can also predispose patients to pain. They were not included in this evaluation and treatment. Another error might occur because of absence of upper limb evaluation in this study. Some limitations in shoulder movements might affect trunk motion, and they should be included in evaluation and treatment. We cannot be sure that our therapeutic strategies would also be effective in other patients with similar symptoms. It is necessary to evaluate a greater group of patients. Therefore, it seems to be very important to create a precise classification system for LBP based on homogenous groups of patients.[18,21,23,42,43]

6. Conclusions

1. The MS is a useful tool for functional evaluation in mechanical LBP in overhead athletes which links symptoms with movement mechanics and motor control alterations.
2. A therapeutic approach based on the MS might be an effective strategy in LBP, reeducation of motor control is associated with pain symptoms decrease.

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