Influence of musculoskeletal dysfunction and pain on performance excellence

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Playing-related musculoskeletal disorders (PRMD) and pain are a common phenomenon in professional musicians, with a prevalence of up to 80%. A majority of musicians are not aware that pain influences their performance excellence. Recent research data demonstrate that pain has the impact to change motor control strategies. Musicians with pain experience coordination impairments, muscle inhibition, and changes of motor control, influencing their movement patterns while playing their instruments. Vice versa, motor control impairments in musicians with poor body awareness or body control can have an immense impact on the development of musculoskeletal dysfunctions and pain. There is evidence that musicians suffer double the amount of musculoskeletal dysfunctions than non-musicians. Additionally, evidence is growing that the failure of stabilization systems as the feedforward activation of transversus abdominus muscle for the lumbar spine contributes to the development of a chronic pain syndrome. A study at our clinic has provided clinical data demonstrating the dysfunctions in various stabilization systems. Preliminary results of ultrasound investigations of the activation of the transversus abdominus muscle in musicians with musculoskeletal dysfunctions support these findings. This research data suggest an association of the impairment of the lumbopelvic stabilization system with PRMD.

Keywords: playing-related musculoskeletal disorders; pain; motor control strategies; muscle function; stabilization systems

Although the last 20 years have provided an enormous amount of research data regarding playing-related musculoskeletal disorders (PRMD), prevalence rates persist with up to 80% of musicians affected. PRMD and pain
compromise the capability of musicians to perform and limit their performance excellence. Affected musicians frequently report on coordination impairments associated with PRMD, notwithstanding measuring motor skills or performance excellence remaining challenging. The MIDI-based technique (Musical Instrument Digital Interface) for piano provides an opportunity for analyzing specific movement parameters in piano playing, such as irregularities in key pressing (timing, loudness). Therefore, MIDI-based scale analysis was developed for objective quantification of focal dystonia in pianists (Jabusch et al. 2003). Apart from focal dystonia, data on incoordination or aberrant movement patterns in musician is scarce. Fry et al. (1998) investigated incoordination in pianists with overuse syndrome, also by analyzing characters of key presses (duration, velocity, interval between key presses, time off the metronome beat). Interestingly, musicians with overuse showed distinct incoordination already in basic tasks such as playing C major scales at different velocities. Development of further analyzing methods for string and wind instruments are absolutely essential and should encompass a standardized questionnaire screening for incoordination signs. Moreover, clinicians managing musicians with PRMD should be aware of the influence of pain on motor control strategies in order to provide tailored therapy strategies.

**MAIN CONTRIBUTION**

Muscle activation patterns and recruitment are altered in the presence of pain. Several studies have demonstrated delayed activation of the deep abdominal muscles, especially the transversus abdominus muscle (Hodges and Richardson 1996, Hodges 2001), and increased activity of superficial muscles (Leinonen et al. 2001) in low back pain (LBP). In order to stabilize the spine during limb movements the transversus abdominus muscle precedes in a feedforward activation the contraction of the muscles producing the limb movement (Hodges and Richardson 1996, Hodges and Richardson 1999). Moreover, Hodges and Richardson demonstrated that these changes persist even after the resolution of symptoms.

In LBP, these postural control deficits have been argued to contribute to the recurrence of episodes (Hodges and Moseley 2003, Cholewicki et al. 2005). Likewise, there is evidence that in chronic neck pain the feedforward activation of the deep cervical flexors is delayed in voluntary arm movements (Falla et al. 2004a, 2004b) and that neuromuscular efficiency in the superficial neck flexors as the scalene and the sternocleidomastoid muscle is impaired (Falla et al. 2004c). Additionally, signs of myoelectric muscle fatigue develop in scalene and sternocleidomastoid muscles (Falla et al. 2003). Ex-
Experimental pain studies provide data demonstrating changes in activation patterns of trapezius muscle subdivisions during repetitive shoulder flexion and alterations in task-dependent changes in cervical agonist/antagonist activity (Falla et al. 2007a, 2007b). Furthermore, in the arm, injection of hypertonic saline into biceps and triceps brachii muscles resulted in modification of the elbow flexor and extensor muscle activation during a repetitive elbow movement task (Ervilha et al. 2005) and muscle pain in the biceps brachii muscle increased EMG activity in the trapezius muscle (Ervilha et al. 2004, Schulte et al. 2004, Ervilha et al. 2005). Also, accumulating evidence points to an impairment in the lower division of the trapezius muscle in people with painful shoulder conditions (Ludewig and Cook 2000, Cools et al. 2003, Lin et al. 2005).

Based on these data, in an attempt to transfer these findings on the behalf of musicians, one can presume that:

- Musicians with neck pain show a delay of deep cervical flexor activation during upper limb movement (e.g. playing their instrument).
- In musicians with neck pain, muscle function of scalene and sternocleidomastoid muscles are impaired.
- Pain in the arm and the shoulder alters muscle activation and recruitment patterns of trapezius muscle.
- Musicians with low back pain show signs of delayed deep abdominal muscle activation.

Accordingly, musicians have to be aware that pain has a profound potential to alter their muscle function, contributing to performance impairments.

**Musculoskeletal dysfunction in musicians**

Pain is frequently preceded by musculoskeletal dysfunction. Motor control changes contribute to inhibition or weakness in some muscle groups and increased activity and hypertonicity of others. In consequence, trigger points (local contraction bands or areas causing referred pain) occur and muscle activation patterns, so called stereotypes, change. There is evidence that musicians experience twice the rates of functional disturbances as compared with non-musicians (Steinmetz 2007). A study at our clinic, examining 84 musicians consulting our outpatient clinic for PRMD, has provided clinical data demonstrating impairments in various stabilization systems (Steinmetz and Seidel submitted). Dysfunctions of the postural stabilization systems were present in 77 (92%) of the patients. Most frequently, in 85% impairment
of scapular stabilization system was found within the examination and in 71% the lumbopelvic stabilization system (deep abdominal and back muscles). Preliminary results of ultrasound investigations of the activation of the transversus abdominus muscle in musicians with musculoskeletal dysfunctions support these findings. This research data suggest an association of the impairment of the lumbopelvic stabilization system with PRMD. Muscle dysfunctions and postural stabilization impairments can influence performance excellence in various ways. An example demonstrating this phenomenon is the case of a cellist with impaired interossei muscles, contributing to a lack of stabilization abilities of the fourth finger of the left hand. A second example is a violinist with neck and shoulder pain experiencing an alteration of shoulder muscle activation patterns, resulting in a changed up-bow pattern showing increased trapezius activation.

**IMPLICATIONS**

There is a need of further research to evaluate the influence of the lumbopelvic as well as scapular and cervical stabilization systems on the development of PRMD. The identification of typical motor control changes associated with the impairment of stabilization systems is of highest importance for musicians because of their potential impact on performance excellence.

Treatment regimes in chronic back pain patients have shown that training of these stabilizing muscles can prevent relapses of back pain. Adaptations of these treatment strategies in the therapy of musicians may contribute to a higher success rate in treating musicians with PRMD. Additionally, the therapy of musicians has to implement an approach integrating the work on motor control and muscle function during playing a musical instrument.

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