

Investigation of the Lower Back Muscles Activity During Sitting on Stable and Unstable Surfaces

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Introduction. A lot of researches are carried out concerning principles of the activity of the human trunk muscles and posture control during sitting still on stable and unstable surfaces [1, 2, 3] or performing certain exercises [4]. It is found that the deep muscles playing the role of stabilizers are more active in case of unstable base [1, 4]. According Luque-Suárez dorsum stabilizing system consists of three subsystems, toughly interacting in between: (one is off, turns on the other): passive, active and controlling (nervous) [5]. Christopher McLean [6] has analyzed researches performed by Panjabi [7] and other scientists and extracted Bergmark classification [8], which divided active subsystem – muscles – in two parts according the work performed: – local stabilizers and global stabilizers. Local stabilizers (also called tone muscles) usually are located around vertebrae and keep stability of spine segments and perform proprioception function, help to maintain the lumbar lordosis curve. Global stabilizers, or movers, called surface or phasic array muscles, are located away from the spine. Their role is to develop the power to carry out the movement [6].

Lower back pain is fairly common human movement disorder, significantly reducing the quality of life (due to restriction of human mobility). Studies show that patients who suffer from lower back pain have a greater range of motion of the spine thoracic-lumbar segment and lower activity of the longest back muscle [9]. This proves that when stabilization system works incorrectly, passive subsystem turns on, which takes over the work of muscles and tendons [5]. It is also known that important preventive measure against low back pain is keeping a proper trunk inclination angle, so it is important to find out at what trunk forward/backward inclination angle torso muscles abandon their role.

Thus the objective of the study is to find out how deep lower back muscles activity during quietly sitting on the unstable surface depends on the seat: trunk inclination angle from the vertical, trunk posture and type of legs support.

Methods and means. The pilot research was performed with a good physical condition, physically active 23 year old guy (height 183 cm and weight 68 kg). The investigative did not have any health problems that could have affected the outcome of the investigation.

Activity of the three right-hand (deep) back muscles (*erector spinae* Th₁₂-L₁ and L₄-L₅, and *multifidus* L₅-S₁) has been explored in different postures while sitting on the stable and unstable (in the sagittal and frontal planes) surfaces with different trunk inclination angle from the vertical, trunk posture (straight back and slumped back) and type of legs support: feet rest on the stable basis, hung in the air and rest on the unstable support (in total 9 cases described in Table 1). Neuromuscular fatigue has also the influence on muscles work, because tired muscles are compensated by other muscles, other motor unit activation takes place, so the exercises were carried out in 30 sec. with 60 seconds breaks between exercises. In all cases, the hands were crossed on chest, fixed by the fingers touching the collarbones.

Muscles electrical activity (EMG) was measured by the electromyograph Noraxon Myo Trace 400 (sticky surface electrodes attached to the skin were used). The skin was prepared to EMG registration by removing the hair and cleaning with alcohol. Muscle activity measurement data (1000 Hz tone) was processed by MyoResearch XP MT404 Clinical software: signal was rectified, filtered and leveled by means of Finite Impulse Response (FIR) filter type Bandpass (Window – 3 points, low frequency – 5 Hz, high frequency – 500 Hz).

Results and discussion. Investigation revealed that the deep back muscle activity is influenced by all of the factors: seat surface instability, trunk inclination angle and posture and footrests type. Results of measurements were analyzed with regard to basic posture – vertical seat with a straight back (while maintaining a neutral position of the spine) and feet resting on a stable basis. In case of forward lean of 45° muscles activity is significantly higher (dorsal extensors – twice, multiple (*multifidus*) – nearly three times). Backward lean at an angle of 15° reduces deep back muscles activity: dorsal extensors (*erector spinae*) – 2-3 times, multiple (*multifidus*) muscle – about 5 times.

Sitting in slumped back activity of extensors is from 2 to 5 times, and multiple muscles – up to 10 times smaller than sitting with a straight back. These muscles are also less active in the case when the legs are hanging freely, without relying on any supports (in this case the back muscles can help maintain balance). While sitting on the surface unstable in frontal plane only *erector spinae* Th₁₂-L₁ muscles are 3-4 times more active than in case of the sagittal plane instability (other muscles activity does not depend on plane of instability). If to compare sitting on stable and unstable base it may be seen that instability in frontal plane gives practically the same deep back muscle activity, but if the base is unstable in the sagittal plane muscles activity drops about 2 (*erector spinae*) or even 6 (*multifidus*) times. It may be seen also that the type of feet support (dangling legs or instable feet rest were examined) has no influence on deep muscles activity in case of seat instability, but dangling legs reduce activity of *erector spinae* 2-3 times and *multifidus* – even near 6 times.

Table 1. Description of the examined cases and muscles electrical activity (mV)

Nr.	Pose	Muscle					
		Erector spinae Th ₁₂ -L ₁		Erector spinae L ₄ -L ₅		Multifidus L ₅ -S ₁	
		mean	max	mean	max	mean	max
1	Stable base, straight back, vertical trunk, stable feet rest	25,5	42,3	10,7	19,4	17,8	35,2
2	Stable base, straight back, 15° angle backward lean, stable feet rest	7,37	26,3	5,25	16,2	3,34	7,27
3	Stable base, straight back, 45° angle forward lean, stable feet rest	56,1	83,8	34,2	51,1	52	82,2
4	Stable base, slumped back, vertical trunk, stable feet rest	4,94	17,6	2,59	8,09	1,74	5,42
5	Stable base, straight back, vertical trunk, dangling legs	9,4	23,3	3,52	10,8	2,71	5,79
6	Base unstable in sagittal plane, straight back, vertical trunk, dangling legs	6,88	21,4	3,58	10,2	2,83	6,05
7	Base unstable in frontal plane, straight back, vertical trunk, dangling legs	20,1	34,4	5,87	14,1	3,04	8,41
8	Base unstable in sagittal plane, straight back, vertical trunk, unstable feet rest	5,21	21,6	3,92	11,5	3,35	6,32
9	Base unstable in frontal plane, straight back, vertical trunk, unstable feet rest	20,9	45,4	5,94	17,4	3,46	6,17

Summing up the results of the study it can be concluded that the slumped back sitting position should be avoided because in this case the passive subsystem stabilizing the spine is switched off and during the movement will not prevent possible damage to the spine. The best seat is where a neutral lordosis curve of the vertical trunk is maintained. Forward lean up to 45° angle gives maximal activity of deep and superficial muscles, and here should be noted that in all cases it should be avoided sitting hanging off, because at the slightest footrest muscles also work in intensified mode. Forward lean also influences lower deep back muscles activity, but at smaller lean angle range – when it exceeds 15° activity of investigated muscles dropped 2-3 times. In addition, in order to perform a certain movement of household or sports with no harm to the spine, it is important to ensure trunk forward and backward lean angle would not exceed secure range, in which the muscles are able to both keep activity and to perform a protective function.,

Conclusions. The investigation found that the deep muscles activity varies depending on the sitting posture, the seat stability and the footrests type. Seat

instability in frontal plane is less habitual than the instability in sagittal plane, when the posture balance is naturally supported during sitting quietly as well as in a variety of movements. Sitting in forward lean always require higher activity of back surface muscle, because with the forward shift of the mass center the load of back muscles increases. But deep lower back muscles are only active up to some maximal lean angle, and if it is exceeded they are deactivated, and back surface muscles are overloaded, and their strain can lead to premature fatigue of the region. Correct steady sitting position while maintaining proper trunk position and neutral spine curves also do not overstrain and overwork the back muscles, but variation of forward-backward lean within some range is to be considered as better measure for back pain prevention and maintenance of workability.

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Investigation of deep lower back muscles activity during quietly sitting on unstable surface dependencies on seat peculiarities was carried out. Electrical activity of erector spinae and multifidus muscles was examined by using EMG system Noraxon at different trunk inclination angle from the vertical, trunk posture and type of legs support. It was found that the deep muscles activity depend significantly on parameters mentioned. Deep lower back muscles are only active up to some lean angle and if it is exceeded they are deactivated, so the surface muscles are overloaded.