DOI 10.18019/1028-4427-2018-24-1-102-107

Condition of the muscles of the back under lumbo-sacral orthotic treatment (literature review)

V.B. Voitenkov[1], A.V. Min'kin[2], E.V. Ekusheva[3], N.V. Skripchenko[1], I.G. Samoilova[1], I.V. Cherkashina[1]

[1]Federal State Budgetary Institution *Pediatric Research and Clinical Center for Infectious Diseases* of the Federal Medical-Biological Agency, St. Petersburg, Russia
[2]*Maltri* LTD, St. Petersburg, Russia
[3]Federal State Budgetary Educational Institution of Additional Professional Education *Institute of Advanced Training* of Federal Medical-Biological Agency, Moscow, Russia

Our literature review analyzes the available studies on the effect of long- and short-term lumbo-sacral orthotic (LSO) treatment on the muscles of the back. We reviewed the existing diagnostic approaches to evaluation of muscle changes, including surface EMG, measurements of muscle strength and tolerance, and findings on muscle ultrasound study. It has been revealed that none of the available works confirmed a significant negative effect of LSO, both by short- and long-term application, or atrophic changes in the muscles. Thus, we may conclude that there are no significant data on the effect of the LSO treatment on the main parameters that are measured and reflect spinal muscles weakness and/or atrophy.
Keywords: lumbo-sacral orthosis, atrophy, EMG, muscles

The lumbosacral spine, due to its anatomical location, refers to musculoskeletal system segments that are most loaded. It results in high incidence of its pathology and, accordingly, in a wide variety of treatment options, one of which is the use of orthoses.

According to the official definition, an orthosis is an external device used to modify structural and functional characteristics of the neuromuscular and skeletal systems. Orthotics is the science and skills that are part of the treatment (rehabilitation) or disease prevention with the use of orthoses [1]. There are various classifications of orthoses that base on design features of the products, materials of manufacture, type of production and a number of other parameters. However, in most cases, orthoses are described in relation to body segments and joints using special abbreviations. For orthoses of the lumbosacral spine, the legitimate abbreviation is LSO or *Lumbo-Sacral Orthosis* [2].

Orthotic therapy has been widely used for treatment of spinal pathologies, and the lumbosacral spine in particular [3–6]. In pediatric practice, LSOs are used to treat scoliosis, spinal cord injury complications, and rheumatoid arthritis [7, 8, 9].

Lumbosacral spine pathologies are most common; in particular, pain in the lower back occurs in 80 % of the working age population of up to 45 years old and has a great impact on the quality of life [10, 11]. Chronic dorsalgia is revealed in 10–20 % of working age individuals. This group of patients is characterized by an unfavorable prognosis for recovery [12–17]. A large meta-analysis conducted in 2008 showed that back pain therapy with LSO is more effective than a pure medication therapy [18]; it is also more cost-effective [10]. LSO is recommended in most cases (73 %) for treatment of low back pain abroad, and it is indicated by primary care physicians [19, 20].

There are several theories about the mechanism of LSO action and the effect of its use on the course of low back pain. It is assumed that the orthosis can limit the mobility of the torso and passively reduce the tension of its muscles [21–24]. Another possible mechanism of analgesic effect is the normalization of proprioceptive sensitivity in the lumbosacral region [25, 26], which is considered as an important component of the neurorehabilitation program in managing patients with severe scoliosis [27]. However, the issue of the influence of orthosis on intra-abdominal and intra-disk pressure remains unclear [21].

Despite the obvious clinical effect of the LSO use on reduction of pain, there is a well-established idea of the dangers of muscle weakness and atrophy by its long-term use [28, 29, 30]. The direct mechanical effect of orthosis on the adjacent muscles has been considered as a possible cause [31]. In practice, about 40–45 % of patients present subjective complaints of tiredness and frequent "fatigue" of the muscles of the torso [32]. Therefore, it is justified and relevant to conduct an objective analysis of the available literature on this topic.

The main objective signs of weakness (as the first functional part of the pathological process) and atrophy

Voitenkov V.B., Min'kin A.V., Ekusheva E.V., Skripchenko N.V., Samoilova I.G., Cherkashina I.V. Condition of the muscles of the back under lumbo-sacral orthotic treatment (literature review). *Genij Ortopedii*. 2018. T. 24. No 1. pp. 102-107. DOI 10.18019/1028-4427-2018-24-1-102-107. (In Russian)

(as the onset of organic pathological changes) are the findings of surface electromyography (EMG) with a decrease in the amplitude and an increase in the frequency of the tours of an arbitrary pattern of the extensor muscles of the back; reduction of their muscular strength and endurance, a decrease in their thickness according to ultrasound and magnetic resonance imaging [21, 33].

A recent meta-analysis of literature that included 36 available quality articles, in which the effect of LSO on the spinal muscular strength was assessed, no such effect was found [33]. According to another meta-analysis, there was also no reliable information on the negative effect of using LSO from one to 6 months on the spinal muscles [31, 33].

Surface myography, a neurophysiological technique that objectifies the degree of voluntary muscle tension, has long been used in orthopedic practice [34, 35]. It is not possible to evaluate the function of deep muscles, as well as their differentiation with the surface EMG of the back muscles due to the peculiarities of the technique. Nevertheless, the interference curve of an arbitrary tension can satisfy the goals of analyzing the total activity before and after various rehabilitation interventions [36].

Myographic studies most often assess the parameters of the activity of the muscles that straighten the spine, the rectus abdominis muscle and the external oblique muscle of the abdomen. In general, the amplitudes of the pattern of the arbitrary activity were estimated [37–41]. Some studies report on the development of muscle weakness when using orthoses (by 4 %) in the muscle that straightens the spine [38], and a decrease in its activity on the right under a symmetrical load [42]. A change in muscle activity by 2–3 % or lack of any effect of orthoses was reported [43, 44, 45].

Reduction in the activity of abdominal muscles was noted only in women, by 3 %, while in men, on the contrary, its increase was observed [46]. Similar changes (both upward and downward activity) by 2–4 % of the amplitude were found in other studies on the effect of orthoses on the abdominal muscles [25, 47].

Needle myography, which makes it possible to evaluate the state of the motor units of most human body muscles and is a more accurate technique than surface myography, was used in idiopathic scoliosis. Changes in the activity of motor units, a significant increase in the amplitude of the potentials of motor units of the paravertebral muscles without any significant changes in the character of the arbitrary pattern were revealed [48]. This informative technique was not used for an objective evaluation of the LSO influence on the activity of the back muscles. Such a work would combine an absolute novelty and great practical significance for neurology, clinical neurophysiology and orthopedics.

The effect of LSO on the intra-abdominal pressure was investigated in several studies [49, 50, 51]. Either a lack of any effect from LSO on this parameter or a moderate increase in it was revealed [51].

Muscular strength and tolerance of the abdomen and lumbar muscles were not influenced by LSO usage [52, 53]. On the contrary, an increase in the strength of flexor and extensor muscles of the back was found [30, 54].

Ultrasound estimation of muscle thickness after LSO use found no changes on week 4. A significant decrease in the thickness began to be recorded only after the eighth week of LSO wearing [55].

The works studied describe different methodology. Thus, some authors estimated the strength of the extensor muscles in the relaxed standing position while others at different inclination angles [29, 52, 56]. This can explain the available span in the amplitude of the surface myography and its dynamics. However, even in works reporting a negative effect of LSOs on the amplitude of the interference pattern, its fall does not exceed 3–4 %. Moreover, different LSOs were used in the studies. Some researchers used orthoses made of leather, others the ones that were manufactured from more elastic materials. One study reported that only orthoses made from elastic materials had an effect on the voluntary activity of the back muscles, while none of hard ortheses had any effect on them [25]. It was also reported that it was the rigid orthoses that had an analgesic effect in lumbar pain. The use of more elastic orthoses did not produce it. However, such information was presented only in one paper [38].

Thus, there is no reliable information about the negative impact of LSOs on such a complex neurophysiological parameter as the characteristic of the patterns of the interference curve in surface myography.

When the development of muscle atrophy due to certain effects is supposed, it is necessary to take into account a number of circumstances. The structure of the muscles of the back is different, depending on the myotome in them (for example, muscle fibers of type I or II prevail in the paravertebral muscles and in the muscle that straightens the spine); the same applies not only to the muscles of the back [57, 58]. After a 60-day stay in bed without any exercise, the thickness of the transverse abdominal muscle in adults is reduced by 18 % but the reduction of the internal oblique muscle is only 10 % (according to ultrasound findings) [59]. Significant atrophy of the muscle, straightening the back, was not revealed. Even in the conditions of total death of the conductor and Wallerian degeneration, muscular atrophy, unlike the neural one, can take a considerably long period of time [60, 61, 62]. It is difficult to assume that the use of LSO, which does not exclude the mobility and tension of the corresponding muscles but only restricts them to some extent, can cause significant atrophic changes.

It should be noted that the overwhelming majority of the analyzed literature evaluated neurophysiological and/or clinical parameters. Only one study report-

ed an objective visualization evaluation of muscle thickness with the use of ultrasound [55]. At present, the state of muscles is possible to study with the use of both expert ultrasound techniques and magnetic resonance imaging with quantitative analysis [63, 64]. Visualization works in most cases lack the evaluation of organ function, i.e. the structural changes detected may not reveal its activity in any way. For this reason, a combination of visualization and functional studies is necessary. The implementation of this principle for assessing the effect of prolonged use of lumbosacral (or some other) orthoses on the muscular apparatus of the back is a promising and justified field of further research.

CONCLUSIONS

Based on the analysis of the available literature, it can be concluded that there is no reliable effect of the lumbosacral orthosis on the main measurement parameters that reflect weakness and/or atrophy of the muscles of the back. Thus, there is no reliable information about the negative impact of LSOs on spinal musculature. Future works could be promising and would be those that provide visualization of the trunk muscles before and after the use of orthoses (ultrasound and magnetic resonance imaging), as well as those using the method of needle myography.

The authors of this article report that there is no conflict of interests.

REFERENCES

1. GOST R ISO 8549-1-2011. *Protezirovanie i ortezirovanie. Slovar'. Chast' 1. Obshchie terminy, otnosiashchiesia k naruzhnym protezam konechnostei i ortezam* [State Standard R ISO 8549-1-2011. Prosthetics and orthotics. Vocabulary. Part 1. General terms relating to external limb prostheses and orthoses]. M., Standartinform, 2013. 12 p. (In Russ.)
2. GOST R ISO 13404-2010. *Protezirovanie i ortezirovanie. Klassifikatsiia i opisanie naruzhnykh ortezov i ikh elementov* [State Standard R ISO 13404-2010. Prosthetics and orthotics. Classification and characterization of external orthoses and their elements]. M., Standartinform, 2012. 12 p. (In Russ.)
3. Keier A.N., Rozhkov A.B., eds. *Rukovodstvo po protezirovaniiu i ortezirovaniiu* [Manual for prosthetics and orthotics]. SPb., NII protezirovaniia im. prof. G.A. Al'brekhta, 1999, 624 p. (In Russ.)
4. Khaim Z., Kafingst V., eds. *Ortezirovanie. Per. s nem. iazyka* [Orthotics. Transl. from German]. M., BUFA-GTZ, 1992, pp. 27-82. (In Russ.)
5. Molchanovskii V.V., Trinitatskii Iu.V., Khodarev S.V. *Vertebronevrologiia. V 6 ch. Ch. 6. Nemedikamentoznye lechebno-reabilitatsionnye meropriiatiia pri nespetsificheskoi vertebronevrologicheskoi patologii* [Vertebroneurology. In 6 pt. Part 6. Non-medicamentous treatment-rehabilitation measures for non-specific vertebroneurological pathology]. Rostov na/D., Izd-vo SKNTs VSh IuFU, 2016, 619 p. (In Russ.)
6. Pirozhkova T.A., Tokarev A.D., Smorodina O.I., Mozgovykh A.Iu.Lechenie polozheniem: ortezy [Treatment by positioning: orthoses]. *Med.-sots. problemy invalidnosti*, 2014, no. 1, pp. 67-70. (In Russ.)
7. Sy N., Borysov M., Moramarco M., Nan X.F., Weiss H.R. Bracing Scoliosis – State of the Art (Mini-Review). *Curr. Pediatr. Rev*., 2016, vol. 12, no. 1, pp. 36-42.
8. Nikolaev V.F., Baranovskaia I.A., Andrievskaia A.O. Ispol'zovanie funktsional'no-korrigiruiushchego korseta v lechenii bol'nykh idiopaticheskim skoliozom [Use of a functional correcting brace in treatment of patients with idiopathic scoliosis]. *Genij Ortopedii*, 2016, no. 1, pp. 44-47. (In Russ.)
9. Mironov E.M. Rol' ortezirovaniia v kompleksnoi reabilitatsii bol'nykh s posledstviiami pozvonochno-spinnomozgovoi travmy [Role of orthotics in complex rehabilitation of patients with the consequences of spinal-spinal cord injuries]. *Med.-sots. Ekspertiza i Reabilitatsiia*, 2012, no. 1, pp. 56-57. (In Russ.)
10. Kulikov A.Iu., Abdrashitova G.T. Otsenka ekonomicheskoi effektivnosti primeneniia ortezov pri lechenii liumboishialgii [Evaluation of economic effectiveness of orthoses use in lumboischialgy treatment]. *Zam. glavnogo vracha*, 2014, no. 1, pp. 57-65. (In Russ.)
11. Shmagel A., Foley R., Ibrahim H. Epidemiology of chronic low back pain in US adults: data from the 2009-2010 National Health and Nutrition Examination Survey. *Arthritis Care Res*. (Hoboken), 2016, vol. 68, no. 11, pp. 1688-1694. DOI: 10.1002/acr.22890.
12. Juniper M., Le T.K., Mladsi D. The epidemiology, economic burden, and pharmacological treatment of chronic low back pain in France, Germany, Italy, Spain and the UK: a literature-based review. *Expert. Opin. Pharmacother.*, 2009, vol. 10, no. 16, pp. 2581-2592. DOI: 10.1517/14656560903304063.
13. Damulin I.V. *Boli v spine: diagnosticheskie i terapevticheskie aspekty* [Back pain: diagnostic and therapeutic aspects]. M., RKI Sovero press, 2008, 40 p. (In Russ.)
14. Katz W.A. Musculoskeletal pain and its socioeconomic implications. *Clin. Rheumatol.*, 2002, vol. 21, no. Suppl. 1, pp. S2-S4.
15. Damulin I.V. Bol' v nizhneĭ chasti spiny: klinicheskie osobennosti i obsledovanie bol'nykh [Lower back pain: clinical characteristics and examination of patients]. *Nevrologiia, Neiropsikhiatriia i Psikhosomatika*, 2014, vol. 6, no. 1, pp. 9-15. (In Russ.)

16. Hall H. Back Pain. In: Noseworthy J.H., ed. *Neurological Therapeutics Principles and Practice*. 2nd ed. Vol. I. Chapter 21. Abingdon, Oxon, Informa Healthcare, 2006, pp. 240-256.
17. Patel N. Surgical disorders of the thoracic and lumbar spine: a guide for neurologists. *J. Neurol. Neurosurg. Psychiatry*, 2002, vol. 73, no. Suppl. 1, pp. i42-i48.
18. Van Duijvenbode I.C., Jellema P., Van Poppel M.N., Van Tulder M.W. Lumbar supports for prevention and treatment of low back pain. *Cochrane Database Syst Rev.*, 2008, vol. 16, no. 2, CD001823. DOI: 10.1002/14651858.CD001823.pub3.
19. Bouton C., Roche G., Roquelaure Y., Legrand E., Penneau-Fontbonne D., Dubus V., Bontoux L., Huez J.F., Rucay P., Parot-Shinkel E., Fanello S., Richard I. Management of low back pain in primary care prior to multidisciplinary functional restoration: a retrospective study of 72 patients. *Ann. Readapt. Med. Phys.*, 2008, vol. 51, no. 8, pp. 650-662. DOI: 10.1016/j.annrmp.2008.08.006.
20. Daryabor A., Arazpour M., Samadian M., Veiskarami M., Ahmadi Bani M. Efficacy of corrective spinal orthoses on gait and energy consumption in scoliosis subjects: a literature review. *Disabil. Rehabil. Assist. Technol.*, 2017, vol. 12, no. 4, pp. 324-332. DOI: 10.1080/17483107.2016.1185649.
21. Van Poppel M.N., De Looze M.P., Koes B.W., Smid T., Bouter L.M. Mechanisms of action of lumbar supports: a systematic review. *Spine*, 2000, vol. 25, no. 16, pp. 2103-2113.
22. Utter A., Anderson M.L., Cunnif J.G., Kaufman K.R., Jelsing E.J., Patrick T.A., Magnuson D.J., Maus T.P., Yaszemski M.J., Basford J.R. Video fluoroscopic analysis of the effects of three commonly-prescribed off-the-shelf orthoses on vertebral motion. *Spine*, 2010, vol. 35, no. 12, pp. E525-E529. DOI: 10.1097/BRS.0b013e3181c62fa1.
23. Jegede K.A., Miller C.P., Bible J.E., Whang P.G., Grauer J.N. The effects of three different types of orthoses on the range of motion of the lumbar spine during 15 activities of daily living. *Spine*, 2011, vol. 36, no. 26, pp. 2346-2353. DOI: 10.1097/BRS.0b013e31820921a5.
24. Baldwin K., Yannascoli S.M., Namdari S., Spiegel D.A., Keenan M.A. What's new in orthopaedic rehabilitation. *J. Bone Joint Surg. Am.*, 2013, vol. 95, no. 22, pp. 2071-2077. DOI: 10.2106/JBJS.M.01037.
25. Cholewicki J., Shah K.R., McGill K.C. The effects of a 3-week use of lumbosacral orthoses on proprioception in the lumbar spine. *J. Orthop. Sports Phys. Ther.*, 2006, vol. 36, no. 4, pp. 225-231. DOI: 10.2519/jospt.2006.36.4.225.
26. McNair P.J., Heine P.J. Trunk proprioception: enhancement through lumbar bracing. *Arch. Phys. Med Rehabil.*, 1999, vol. 80, no. 1, pp. 96-99.
27. Smania N., Picelli A., Romano M., Negrini S. Neurophysiological basis of rehabilitation of adolescent idiopathic scoliosis. *Disabil. Rehabil.*, 2008, vol. 30, no. 10, pp. 763-771. DOI: 10.1080/17483100801921311.
28. Eisinger D.B., Kumar R., Woodrow R. Effect of lumbar orthotics on trunk muscle strength. *Am. J. Phys. Med. Rehabil.*, 1996, vol. 75, no. 3, pp. 194-197.
29. Fayolle-Minon I., Calmels P. Effect of wearing a lumbar orthosis on trunk muscles: study of the muscle strength after 21 days of use on healthy subjects. *Joint Bone Spine*, 2008, vol. 75, no. 1, pp. 58-63. DOI: 10.1016/j.jbspin.2007.04.018.
30. Kawchuk G.N., Edgecombe T.L., Wong A.Y., Cojocaru A., Prasad N. A non-randomized clinical trial to assess the impact of nonrigid, inelastic corsets on spine function in low back pain participants and asymptomatic controls. *Spine J.*, 2015, vol. 15, no. 10, pp. 2222-2227. DOI: 10.1016/j.spinee.2015.06.047.
31. Takasaki H., Miki T. The impact of continuous use of lumbosacral orthoses on trunk motor performance: a systematic review with meta-analysis. *Spine J.*, 2017, vol. 17, no. 6, pp. 889-900. DOI: 10.1016/j.spinee.2017.03.003.
32. Ahlgren S.A., Hansen T. The use of lumbosacral corsets prescribed for low back pain. *Prosthet. Orthot. Int.*, 1978, vol. 2, no. 2, pp. 101-104. DOI: 10.1080/03093647809177777.
33. Azadinia F., Takamjani Ebrahimi E., Kamyab M., Parnianpour M., Cholewicki J., Maroufi N. Can lumbosacral orthoses cause trunk muscle weakness? A systematic review of literature. *Spine J.*, 2017, vol. 17, no. 4, pp. 589-602. DOI: 10.1016/j.spinee.2016.12.005.
34. Komantsev V.N., Zabolotnykh V.A. *Metodicheskie osnovy klinicheskoi elektroneiromiografii* [Methodological basis of clinical electroneuromyography]. SPb, Lan', 2001, 350 p.
35. Bergquist E.R., Hammert W.C. Timing and appropriate use of electrodiagnostic studies. *Hand Clin.*, 2013, vol. 29, no. 3, pp. 363-370. DOI: 10.1016/j.hcl.2013.04.005.
36. Demoulin C., Crielaard J.M., Vanderthommen M. Spinal muscle evaluation in healthy individuals and low-back-pain patients: a literature review. *Joint Bone Spine*, 2007, vol. 74, no. 1, pp. 9-13. DOI: 10.1016/j.jbspin.2006.02.013.
37. Ciriello V.M., Snook S.H. The effect of back belts on lumbar muscle fatigue. *Spine*, 1995, vol. 20, no. 11, pp. 1271-1278.
38. Granata K.P., Marras W.S., Davis K.G. Biomechanical assessment of lifting dynamics, muscle activity and spinal loads while using three different styles of lifting belt. *Clin. Biomech.* (Bristol, Avon), 1997, vol. 12, no. 2, pp. 107-115.
39. Escamilla R.F., Francisco A.C., Kayes A.V., Speer K.P., Moorman C.T. 3rd. An electromyographic analysis of sumo and conventional style deadlifts. *Med. Sci. Sports Exerc.*, 2002, vol. 34, no. 4, pp. 682-688.

40. Kingma I., Faber G.S., Suwarganda E.K., Bruijnen T.B., Peters R.J., Van Dieën J.H. Effect of a stiff lifting belt on spine compression during lifting. *Spine*, 2006, vol. 31, no. 22, pp. E833-E839. DOI: 10.1097/01.brs.0000240670.50834.77.
41. Kurustien N., Mekhora K., Jalayondeja W., Nanthavanij S. Trunk stabilizer muscle activity during manual lifting with and without back belt use in experienced workers. *J. Med. Assoc. Thai*., 2014, vol. 97, no. Suppl. 7, pp. S75-S79.
42. Lavender S.A., Shakeel K., Andersson G.B., Thomas J.S. Effects of a lifting belt on spine moments and muscle recruitments after unexpected sudden loading. *Spine*, 2000, vol. 25, no. 12, pp. 1569-1578.
43. Thomas J.S., Lavender S.A., Corcos D.M., Andersson G.B. Effect of lifting belts on trunk muscle activation during a suddenly applied load. *Hum. Factors*, 1999, vol. 41, no. 4, pp. 670-676. DOI: 10.1518/001872099779656662.
44. Lee Y.H., Kang S.M. Effect of belt pressure and breath held on trunk electromyography. *Spine*, 2002, vol. 27, no. 3, pp. 282-290.
45. Zink A.J., Whiting W.C., Vincent W.J., McLaine A.J. The effects of a weight belt on trunk and leg muscle activity and joint kinematics during the squat exercise. *J. Strength Cond. Res*., 2001, vol. 15, no. 2, pp. 235-240.
46. Warren L.P., Appling S., Oladehin A., Griffin J. Effect of soft lumbar support belt on abdominal oblique muscle activity in nonimpaired adults during squat lifting. *J. Orthop. Sports Phys. Ther*., 2001, vol. 31, no. 6, pp. 316-323. DOI: 10.2519/jospt.2001.31.6.316.
47. McGill S.M., Norman R.W., Sharratt M.T. The effect of an abdominal belt on trunk muscle activity and intra-abdominal pressure during squat lifts. *Ergonomics*, 1990, vol. 33, no. 2, pp. 147-160. DOI: 10.1080/00140139008927106.
48. Stetkarova I., Zamecnik J., Bocek V., Vasko P., Brabec K., Krbec M. Electrophysiological and histological changes of paraspinal muscles in adolescent idiopathic scoliosis. *Eur. Spine. J*., 2016, vol. 25, no. 10, pp. 3146-3153. DOI: 10.1007/s00586-016-4628-8.
49. Miyamoto K., Iinuma N., Maeda M., Wada E., Shimizu K. Effects of abdominal belts on intra-abdominal pressure, intra-muscular pressure in the erector spinae muscles and myoelectrical activities of trunk muscles. *Clin. Biomech*. (Bristol, Avon), 1999, vol. 14, no. 2, pp. 79-87.
50. Woodhouse M.L., McCoy R.W., Redondo D.R., Shall L.M. Effects of back support on intra-abdominal pressure and lumbar kinetics during heavy lifting. *Hum. Factors*, 1995, vol. 37, no. 3, pp. 582-590. DOI: 10.1518/001872095779049336.
51. Shah R.K. The Nepalese patuka in the prevention of back pain. *Int. Orthop*., 1994, vol. 18, no. 5, pp. 288-290.
52. Walsh N.E., Schwartz R.K. The influence of prophylactic orthoses on abdominal strength and low back injury in the workplace. *Am. J. Phys. Med. Rehabil*., 1990, vol. 69, no. 5, pp. 245-250.
53. Reyna J.R. Jr., Leggett S.H., Kenney K., Holmes B., Mooney V. The effect of lumbar belts on isolated lumbar muscle. Strength and dynamic capacity. *Spine*, 1995, vol. 20, no. 1, pp. 68-73.
54. Kawaguchi Y., Gejo R., Kanamori M., Kimura T. Quantitative analysis of the effect of lumbar orthosis on trunk muscle strength and muscle activity in normal subjects. *J. Orthop. Sci*., 2002, vol. 7, no. 4, pp. 483-489. DOI: 10.1007/s007760200084.
55. Rostami M., Noormohammadpour P., Sadeghian A.H., Mansournia M.A., Kordi R. The effect of lumbar support on the ultrasound measurements of trunk muscles: a single-blinded randomized controlled trial. *PM R*, 2014, vol. 6, no. 4, pp. 302-308. DOI: 10.1016/j.pmrj.2013.09.014.
56. Holmström E., Moritz U. Effects of lumbar belts on trunk muscle strength and endurance: a follow-up study of construction workers. *J. Spinal Disord*., 1992, vol. 5, no. 3, pp. 260-266.
57. Radchenko V.A., Dedukh N.V., Ashukina N.A., Skidanov A.G. Strukturnye osobennosti paravertebral'nykh myshts v norme i pri degenerativnykh zabolevaniiakh poiasnichnogo otdela pozvonochnika (obzor literatury) [Structural characteristics of paravertebral muscles in norm and for degenerative diseases of the lumbar spine (Review of the literature)]. *Ortopediia, Travmatologiia i Protezirovanie*, 2014, no. 4 (597), pp. 122-127. (In Russ.)
58. Arbanas J., Klasan G.S., Nikolic M., Jerkovic R., Miljanovic I., Malnar D. Fibre type composition of the human psoas major muscle with regard to the level of its origin. *J. Anat*., 2009, vol. 215, no. 6, pp. 636-641. DOI: 10.1111/j.1469-7580.2009.01155.x.
59. Belavý D.L., Gast U., Felsenberg D. Exercise and Transversus Abdominis Muscle Atrophy after 60-d Bed Rest. *Med. Sci. Sports Exerc*., 2017, vol. 49, no. 2, pp. 238-246. DOI: 10.1249/MSS.0000000000001096.
60. Eder M., Schulte-Mattler W., Pöschl P. Neurographic course of Wallerian degeneration after human peripheral nerve injury. *Muscle Nerve*, 2017, vol. 56, no. 2, pp. 247-252. DOI: 10.1002/mus.25489.
61. Unlusoy Acar Z., Yalinay Dikmen P., Yayla V., Başaran K., Emekli U., Öge A.E. Decline of compound muscle action potentials and statistical MUNEs during Wallerian degeneration. *Neurophysiol. Clin*., 2014, vol. 44, no. 3, pp. 257-265. DOI: 10.1016/j.neucli.2014.04.003.
62. Voitenkov V.B., Klimkin A.V., Skripchenko N.V., Pulman N.F., Ivanova M.V. Diagnostic transcranial magnetic stimulation as a prognostic tool in children with acute transverse myelitis. *Spinal Cord*, 2016, vol. 54, no. 3, pp. 226-228. DOI: 10.1038/sc.2015.129.

63. Hyun S.J., Bae C.W., Lee S.H., Rhim S.C. Fatty Degeneration of the Paraspinal Muscle in Patients with Degenerative Lumbar Kyphosis: A New Evaluation Method of Quantitative Digital Analysis Using MRI and CT Scan. *Clin. Spine Surg*., 2016, vol. 29, no. 10, pp. 441-447. DOI: 10.1097/BSD.0b013e3182aa28b0.
64. Ulanovskaia E.V., Karabanovich E.V., Trofimova T.N., Shilov V.V., Kovshov A.A. Vozmozhnosti luchevykh metodov issledovanii v diagnostike professional'nogo miofibroza [Potential of radiation research techniques in diagnosing professional myofibrosis]. *Luchevaia diagnostika i terapiia*, 2016, no. 4 (7), pp. 76-84. (In Russ.)

Received: 17.05.2017

Information about the authors:

1. Vladislav B. Voitenkov, M.D., Ph.D., FSBI *PRCCID* of FMBA of Russia, St. Peteresburg, Russia, Head of the Department of Functional Diagnosing Methods, acting Head of the Department of Functional and Radiation Diagnosing Methods; Email: vlad203@inbox.ru
2. Aleksandr V. Min'kin, M.D., Ph.D., *Maltri* Co. Group, St. Petersburg, Russia, Head of Medical Department; Email: drminkin@mail.ru
3. Evgeniia V. Ekusheva, M.D., Ph.D., FSBEI APE *Institute of Advanced Training* of Federal Medical-Biological Agency, Moscow, Russia, Scientific Department, senior researcher; Email: ekushevaev@mail.ru
4. Natal'ia V. Skripchenko, M.D., Ph.D., Professor, Honored Worker of Science of the RF, FSBI *PRCCID* of FMBA of Russia, St. Peteresburg, Russia, Deputy Director for Research; Email: snv@niidi.ru
5. Irina G. Samoilova, M.D., Ph.D., FSBI *PRCCID* of FMBA of Russia, St. Peteresburg, Russia, chief physician of the clinic; Email: klinika@niidi.ru
6. Irina V. Cherkashina, M.D., Ph.D., FSBI *PRCCID* of FMBA of Russia, St. Peteresburg, Russia, Head of Rehabilitation Department; Email: vulan@mail.ru