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Original article

WORK ENVIRONMENT IMPACT ON STRENGTH PRODUCTION FOR ACUTE LOW BACK PAIN SUBJECTS

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Abstract

Aim. Acute low back pain (ALBP) is a major factor of disability among workers, causing absence from work and an increased medical care cost. The purpose of this study was to evaluate maximal isometric strength (MIS) differences between acute low back pain subjects with prolonged sitting jobs and demanding physical work jobs, for extension with pelvic stabilization (EPS) and flexion with pelvic stabilization (FPS).

Methods. Maximal isometric torque for EPS and FPS was measured at two positions (0 and 30-degree flexion angles) on 56 men. Subjects were assigned in four groups, two with ALBP, the first (n=14) with prolonged sitting jobs and the second (n=14) with demanding physical work jobs and the other two (controls) without ALBP, the first (n=14) with prolonged sitting jobs and the second (n=14) with demanding physical work jobs.

Results. ALBP subjects with prolonged sitting jobs and with demanding physical work jobs described lower MIS in both EPS and FPS, in both angles, relative to controls ($p<0.05$). ALBP subjects with prolonged sitting jobs had lower values of MIS in both EPS and FPS, in both angles, than ALBP subjects with demanding physical work jobs ($p<0.05$).

Conclusions. These data indicate that ALBP has impaired both ALBP groups in MIS production, than controls. Demanding physical work for ALBP subjects is a direct factor for greater MIS production, than ALBP subjects with prolonged sitting jobs, despite the presence of ALBP.

Keywords: pain, spine, flexion, extension, strength.

Introduction

Anually the cost of medical care generated by back pain is increasing and it has been estimated to be a major health problem in today's society, being the leading cause of disability globally (Buchbinder R. et al., 2013).

The factors which may contribute to the risk of back pain are the lack of sleep, fatigue, emotional instability, substance abuse (alcohol (Samoladas, E., et al., 2018) and drugs), smoking (Al-Obaidi, S.M. et al., 2004; Gilgil, E., Kaçar, C., Bütün, B. et al., 2005), family problems, overweight, physical inactivity, physical activity performed incorrectly (excessive or incorrect movements), weak muscle endurance, continous and very demanding physical activity at work, prolonged sitting, inaccurate chronic postures in orthostatic position, repeated backfall, flexion, twisting, pushing and/or lifting, prolonged driving vibrations (Bovenzi, M. and Zadini, A., 1992), increased chronic stress (chronic stress is releasing cortisol hormone, which is involved in muscle and tendon injury), low job satisfaction, low motivation for work and mental fatigue (Bigos, S.J., Battie, M.C., Spengler, D.M. et al., 1992).

Back pain is the most frequent cause of limitation of physical activity (Wing, P.C., 2001) or physical demanding work in enclosed workshops (Volinn, E., 1997) among people with age less than 45 years old (McCoy, C.E. et al., 1997). The peak age for spine injuries, generated by weak trunk muscles, is 40 years old (Andersson, G.B.J. et al., 1995). Some authors show, that the incidence of low back pain has a peak age situated in the third decade of life, and the expansion increases until the age of 65 years (Golob, A. and Wipf, J., 2014).

Acute low back pain has an enormous impact in the quality of life (causing poor health), productivity and workers' absenteeism (number of work days lost), which can lead to a significant economic burden to the society and, respectively, to the individuals and their families (Lindgren L., 2003), not only in developed countries but also in developing countries (Galukande M. et al., 2006).

It seems that, the reasons in generating pain or avoiding physical activity, are a cognitive scheme that does not limit physical activity, but only requires the

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avoidance of some specific physical movements (Leonhardt C., Lehr D., Chenot J. F. et al., 2009). Pain and disability caused by pain are not only influenced by organic pathological problems but are also influenced by social and psychological factors (Vlaeyen J. W. S. and Crombez G., 1999). Fear of movement, injury or reinjury and associated avoidance behavior are closely related to the functional disability caused by acute pain and, also, to the pain intensity perception (Leeuw M., Houben R. M., Severeijns R. et al., 2007). Interventions aimed at reducing the pain-induced fear in the acute phase of low back problems can prevent and reduce the restrictions of activities participation and execution (including physical ones) and may have a positive effect in reducing the transition from the acute phase of pain to the chronic phase of pain recorded to the lumbar/thoracic spine (Swinkels-Meewisse I. E., Roelofs J., Schouten E. G. et al., 2006).

In US industry, ocupational low back pain, with a number of ocupational factors such as prolonged sitting and demanding physical work, both of them in combination with awkward postures, is still the primary problem (Murphy P.L. and Volinn E., 1999; Bobick T.G., 2000; Lis A.M., Black K.M., Korn H. et al., 2007). It has been sugested that sitting at work is a risk factor for low back pain, but with no difference then standing at work (Claus A., Hides J., Moseley G. L. et al., 2008; Makhsous M., Lin F., Bankard J. et al., 2009). The motifs that prolonged sitting at work could relate to low back pain are, uninterrupted low-intensity muscle contraction and the loss of muscle strength due to inactivity (Beach T.A., Parkinson R.J., Stothart J.P. et al., 2005). Demanding physical work jobs, like buildings or shipyard construction, could lead to low back pain, especially for subjects who work with heavy loads or in narrow spaces (Watanabe S., Takahashi T., Takeba J. et al., 2018). The difference, in low back pain incidence, in low back pain intensity or in trunk strength, between subjects with prolonged sitting jobs and demanding physical work jobs is unclear. Therefore, the purpose of this study was to evaluate the differences in MIS production between ALBP subjects with prolonged sitting jobs and ALBP subjects with demanding physical work.

Methods

Subjects

This longitudinal study was conducted in Constanta. After the presentation of study aims and methods, fifty-six Romanian men, with no history of orthopedic or cardiovascular contraindications, assigned in four groups, volunteered for this investigation. The subjects with demanding physical work jobs were workers from buildings and shipyard construction and the subjects with prolonged sitting jobs were bank and accountant workers. Fourteen of these subjects (mean age $36^{11} \pm 6^{2}$ (years ^{months})) were assigned to ALBP with prolonged sitting jobs group and 14 subjects (mean age $34^{5} \pm 4^{8}$ (years ^{months})) were assigned to ALBP with demanding physical work group; 14 subjects (mean age $35^{6} \pm 4^{1}$ (years ^{months})) with prolonged sitting jobs, without ALBP and 14 subjects (mean age $33^{5} \pm 3^{12}$ (years ^{months})) with demanding physical work, without ALBP, acted as controls. Characteristics of subjects by groups are shown in table 1. Written informed consent was obtained from all subjects.

Table 1. Characteristics of the subjects [a]

	Prolonged sitting jobs ALBP (n=14)	**Demanding physical work jobs ALBP (n=14)**	**Prolonged sitting jobs witout ALBP (n=14)**	**Demanding physical work jobs witout ALBP (n=14)**
Body height (m.)	1.76 ± 9.9	1.75 ± 7.9	1.73 ± 6.2	1.72 ± 8.6
Body weight (kg.)	86.8 ± 9.2	80.9 ± 8.5	81.8 ± 5.4	76.5 ± 8.5
BMI (kg/m^2) [b]	27.8 ± 1.5	26.2 ± 1.8	27.4 ± 2	25.6 ± 1.4
BF (%) [c]	26.7 ± 2.8	24.3 ± 4.1	27.2 ± 2.7	24.8 ± 2.3

[a] Values are means ± SD;
[b] body mass index;
[c] body fat.

Testing

Each subject completed an MIS test on David F110 lumbar/thoracic EPS device (figure 1) and David F130 lumbar/thoracic FPS device (figure 2) (DAVID Fitness & Medical Ltd., Karitie 9, 01530 Vantaa, Finland). Each test included measurement of maximal voluntary isometric strength of trunk flexor and extensor muscles at 0° and 30° flexion angle. MIS values were recorded on MC-3 microcomputer (figure 3), which was connected to both David F110 lumbar/thoracic EPS and David F130 lumbar/thoracic FPS devices.

At this moment, the DAVID equipment, on which these MIS tests were performed, is one of the best. Reported to other companies (such as Panatta, SportsArt), which produce such biomedical strength estimation devices, the David F110 lumbar/thoracic EPS and David F130 lumbar/thoracic FPS models have received the highest scores in comparative assessment, from the point of view of ergonomics, comfort and movement biomechanics (Gottlob A., 2007).

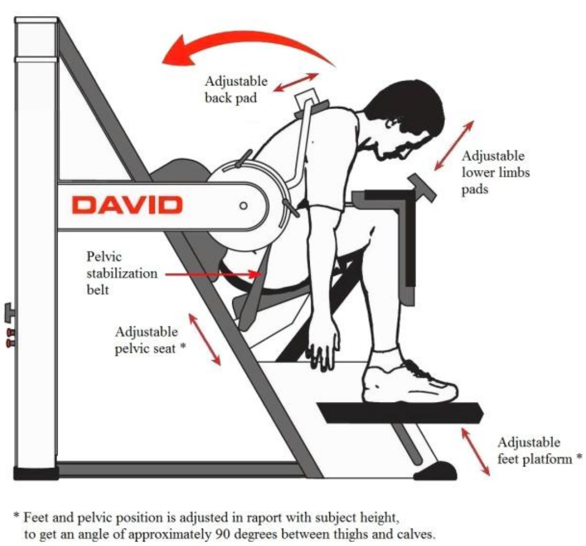

Figure 1. David F110 lumbar/thoracic EPS

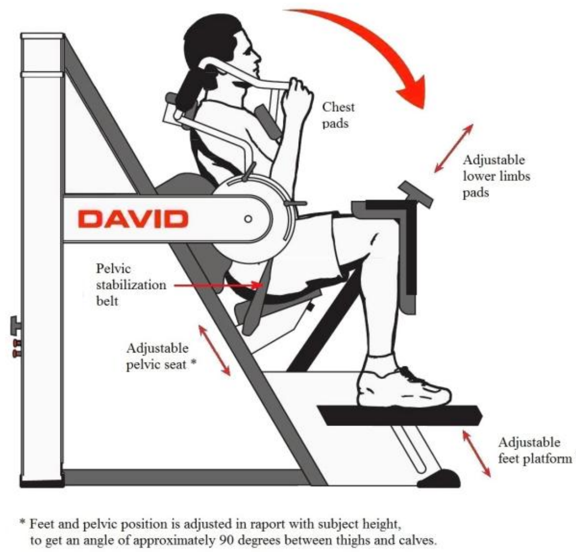

Figure 2. David F110 lumbar/thoracic FPS

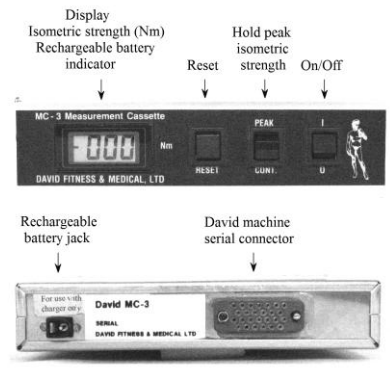

Figure 3. MC-3 digital test module

Subjects were seated in both David F110 lumbar/thoracic EPS and David F130 lumbar/thoracic FPS devices with their knees positioned so that the femurs were parallel to the seat, with the pelvis secured in place (stabilized) by a belt restraint. The lower limbs restraint consisted in an L shaped 90° pads on an adjustable crank, placed in the same time against the inferior and anterior side of the femurs and superior and anterior side of the tibia. These restraints were forcing the pelvis back against the seat. This restraining force stabilized the pelvis, allowing no lateral, vertical or rotational movement.

The subjects were instructed not to exercise for at least 24 hours before testing. To initiate the test on David F 110 lumbar/thoracic EPS device, subjects were first locked in 30° flexion angle and instructed to slowly and continuously make extension of their back against the upper blades pad (movement arm of machine) for 2 to 3 second period, with arms beside the trunk. For David F 130 lumbar/thoracic FPS device, subjects were first locked in 0° angle and instructed to slowly and continuously make flexion of their trunk against the upper chest pads (movement arm of machine) for 2 to 3 second period, with hands firmly grasping the chest pads holders. Once maximal tension had been achived, subjects were instructed to maintain the contraction for an additional 1 to 2 seconds before relaxing. A 5 to 10 minutes rest interval was provided until the next isometric contraction, while the next 0° and, respectively, 30° angles of measurement was set. During the contractions, subjects were verbally encouraged to give a maximum effort. Lower limbs restraint and pelvic restraint were tightened if pelvic movement was observed during testing, to ensure pelvic stabilization.

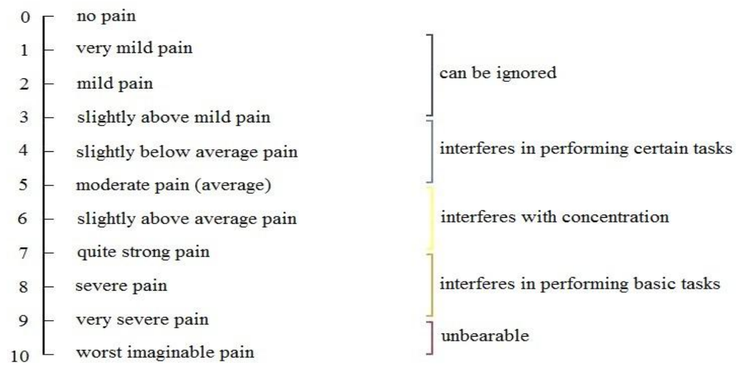

Figure 4. Subjective assessment pain scale

The subjective assessment of ALBP intensity was achieved immediately after performing the MIS tests on both devices and for both angles tested, only on subjects with ALBP. The subjects were instructed to point the place, in the subjective assessment pain scale, where they best describe the acute pain experienced during the MIS tests.

The subjective assessment of ALBP intensity was achieved using a combination of visual pain assessment scale, numerical scale (11 points) to estimate pain intensity and verbal pain assessment scale (figure 4). The visual pain assessment scale is a method of measuring acute or chronic pain. However, the visual pain assessment scale presents inconveniences, concretized by, the misunderstanding of the abstract concept of the 10cm line of visual estimation of pain, many of whom find it difficult to accurately estimate the correct distance between the two extremes of pain. Since the visual pain assessment scale has some practical limitations (Williamson A. and Hoggart B., 2005), we considered it necessary to use this visual pain assessment scale together with the numerical and verbal scale of pain intensity assessment, which describes (more accessible and understandable for the subjects) the intensity of pain in words, for each of the 11 points. Even though the verbal pain assessment scale is less sensitive than the visual pain estimation scale (Breivik E. K. et al. 2000), it seems that the visual pain assessment scale, verbal pain assessment scale (DeLoach L. J. et al., 1998; Soyannwo O. A. et al., 2000; Clark P. et al., 2003) and numerical scale to estimate pain intensity (Ponce de Leon S. et al., 2004) are strongly correlated with each other.

Data analisys

Isometric strength was measured in units of torque (Nm). Means and standard deviations were calculated for MIS test results and subjective assessment of ALBP intensity scores. Between David F110 lumbar/thoracic EPS and David F130 lumbar/thoracic FPS devices in 0° and, respectively, 30° flexion angles, MIS results and, respectively, ALBP intensity scores comparisons were made using two-tailed dependent student t test. The same test was used for MIS results and, respectively, ALBP intensity scores comparisons, between 0° and 30° flexion angle, for each test device. Between groups, MIS results comparisons were made using one-way ANOVA for independent groups and post ANOVA Tukey HSD test for each test device and, respectively, test angle. Also, between groups, ALBP intensity scores comparisons were made using two-tailed independent student t test for each test device and, respectively, test angle. Statistical significance was accepted at $p<0.05$ (Lieber, R.L., 1990; Sheskin, D.J., 2004; Thomas, R.J. and Nelson, J.K., 1996).

Results

Prolonged sitting jobs subjects with ALBP showed significantly lover values in MIS production ($F(3, 52)=17.7$ for 0° test angle and $F(3, 52)=17.9$ for 30° test angle) for trunk EPS, than all other groups. The same significantly lower values, for prolonged sitting jobs subjects with ALBP, were also reported for trunk FPS ($F(3, 52)=11.8$ for 0° test angle and $F(3, 52)=11.7$ for 30° test angle), than all other groups.

Table 3. Lumbar/thoracic extension and flexion MIS (Nm) values [a]

	Subjects	**Testing angles (deg)**	**David F110 Lumbar/thoracic EPS (Nm)**	**David F130 Lumbar/thoracic FPS (Nm)**
ALBP	**Prolonged sitting jobs (n=14)**	0º	255.6 ± 25.9 [b d f g]	172.7 ± 22.3 [c e]
		30º	266.3 ± 23.8 [b d g]	185.2 ± 33 [c e]
	Demanding physical work (n=14)	0º	287.1 ± 17.6 [d g]	197.5 ±20.1 [e f]
		30º	289.7 ± 24.7 [d g]	216.9 ± 25.5 [e]
Without ALBP	**Prolonged sitting jobs (n=14)**	0º	279.2 ± 18.1 [b f g]	196 ± 16.5 [c f]
		30º	290.7 ± 17.8 [b g]	213.2 ± 23.3 [c]
	Demanding physical work (n=14)	0º	313.5 ± 22 [f g]	221.3 ± 26.2 [f]
		30º	326.2 ± 20.3 [g]	243.5 ± 20.7

[a] Values are means ± SD.
[b] compared with demanding physical work subjects, for 0º and, respectively, 30º testing angles, p<0.05;
[c] compared with demanding physical work subjects, for 0º and, respectively, 30º testing angles, p<0.05;
[d] compared with subjects without ALBP, for prolonged sitting jobs and, respectively, demanding physical jobs, for each corresponding testing angle, p<0.05;
[e] compared with subjects without ALBP, for prolonged sitting jobs and, respectively, demanding physical jobs, for each corresponding testing angle, p<0.05;
[f] compared with 30º testing angle, p<0.05;
[g] compared with David F130 Lumbar/thoracic FPS, p<0.05.

Values in MIS production, for trunk EPS, were significantly higher for all subjects and all testing angles, than trunk FPS MIS values (prolonged sitting jobs subjects with ALBP, t=22.4 for 0° test angle and t=8.8 for 30° test angle; demanding physical work subjects with ALBP, t=56 for 0° test angle and t=6.3 for 30° test angle; prolonged sitting jobs subjects without ALBP, t=22.1 for 0° test angle and t=40.6 for 30° test angle; demanding physical work subjects with ALBP, t=33 for 0° test angle and t=49.4 for 30° test angle). MIS results, for trunk FPS and, respectively, trunk EPS, were significantly higher for 30° test angle, than 0° test angle, for all subjects without ALBP (prolonged sitting jobs subjects t=7.5 and demanding physical work subjects t=7.5 for David F110 lumbar/thoracic EPS; prolonged sitting jobs subjects t=4.2 and demanding physical work subjects t=5.5 for David F130 lumbar/thoracic FPS). In contrast, only prolonged sitting jobs subjects with ALBP had significantly higher MIS results for 30° test angle, than 0° test angle in trunk EPS (t=5.3) and, only, demanding physical work subjects with ALBP had significantly higher MIS results for 30° test angle, than 0° test angle in trunk FPS (t=2.9).

Table 4. Subjective ALBP assessment results [a]

	Subjects	**Testing angles (deg)** [f]	**David F110 Lumbar/thoracic EPS**	**David F130 Lumbar/thoracic FPS**
ALBP	**Prolonged sitting jobs (n=14)**	0º	6.3 ± 1.1 [c d]	5.5 ± 1.1 [b d]
		30º	6.3 ± 1 [c d]	5.8 ± 1.2 [d]
	Demanding physical work (n=14)	0º	5.3 ± 0.9 [c]	4 ± 0.7 [b]
		30º	5.4 ± 0.8 [c]	4.3 ± 0.6

[a] Values are means ± SD.
[b] compared with 30º testing angle, for demanding physical work subjects and, respectively, prolonged sittin jobs subjects, p<0.05;
[c] compared with David F130 lumbar/thoracic FPS, for prolonged sitting jobs and, respectively, demanding physical work subjects, for each corresponding testing angle, p<0.05;
[d] compared with demanding physical work subjects, for David F110 lumbar/thoracic EPS and, respectively, David F130 lumbar/thoracic FPS, for each corresponding testing angle, p<0.05.

All ALBP subjects showed significantly higher values of subjective assessment of ALBP intensity for David F110 lumbar/thoracic EPS, than David F130 lumbar/thoracic FPS, in both angles tested (prolonged sitting jobs subjects, t=4.4 for 0° test angle and t=3.5 for 30° test angle; demanding physical work subjects, t=6.7 for 0° test angle and t=7.8 for 30° test angle). Also, prolonged sitting jobs subjects with ALBP showed significantly higher values of subjective assessment of ALBP intensity than demanding physical work subjects with ALBP, on both testing devices and, respectively, both angles tested (David F110 lumbar/thoracic EPS, t=2.4 for 0° test angle and t=2.7 for 30° test angle; David F130 lumbar/thoracic FPS, t=4.1 for 0° test angle and t=4 for 30° test angle).

All ALBP subjects showed significantly higher values of subjective assessment of ALBP intensity for 30° testing angle, than 0° testing angle, but only for David F130 lumbar/thoracic FPS (prolonged sitting jobs subjects, t=2.2 and demanding physical work subjects, t=2.8).

Discussion

Prolonged sitting jobs subjects showed lower values of MIS production, than demanding physical work subjects on both EPS and FPS, despite the presence or not of ALBP. A demanding physical work produces a more pronounced flexion and extension trunk muscles strength development, compared to the sedentary work.

Both ALBP prolonged sitting jobs and demanding physical work subjects showed lower values of MIS production, than controls. It seems that, in chronic and acute low back pain subjects, lumbar extensor muscle strength control is compromised (Pranata A. et al., 2017). Some researchers showed that weak muscle strength is not generated by muscle incapability to produce muscle strength, but, reather, by the problems encountered in motor control (Jull G. A. and Richardson C. A., 2000), especially in low back pain subjects (Hodges P. W. and Richardson C. A., 1996). Nissan M, Bar-Ilan K., Brown S. et al., (2000), have shown that the generation of MIS is different between the subjects with low back pain and healthy subjects. Subjects with age over 40 years, with chronic low back pain, has a lower muscle strength for trunk flexion and extension (more marked for extension movement), compared with controls (subjects without low back pain) (Handa N. et al., 2000).

Trunk EPS muscles produced higher values of MIS, than trunk FPS muscles, for all subjects. Keller T. S. and Roy A. L. (2002), Straton A., (2007, 2009), Straton A. and Cismaş G., (2009), Hasue M., Fujiwara M., Kikuchi S. (1980) and Smidt G. L., Amundsen L. R., Dostal W. F. (1980), confirms that trunk extension muscles generate a significantly higher strength production, then the trunk flexion muscles.

All subjects showed lower values of MIS production in 0° testing angle, than 30° testing angle, on both FPS and EPS. Keller T. S. and Roy A. L., (2002) showed that for the flexion movement the MIS values are recorded at angles between 20° and 30° and for the extension movement the MIS values are recorded at an angle of 50°. The most effective angle of extension muscle strength development is 36° (Graves J. E., Pollock M. L., Leggett S. H. et al., 1992). Straton A. and Cismaş G., in a study conducted on the same DAVID devices, showed that, the highest values of MIS production were made at the 30° angle for flexion and extension movements. In contrast, Wessel J., Ford D., van Driesum D., (1994), concluded that, the production of isometric force, for flexion movement, decreases with the increase of the trunk flexion angle. However, there are still many controversies regarding the optimal angle setting in which the MIS highest value is estimated, due to the many positions of the body (and, implicitly, the body segments), as well as the stabilization possibility, or not, of the various joint rotational axis, when performing the MIS estimation tests.

All ALBP subjects perceived higher values in subjective ALBP assessment for EPS, than FPS. Kakaanpää M., Taimela S., Laaksonen D., et al., (1998), showed that subjects with chronic low back pain perceive higher pain intensity, when performing the MIS test for trunk extension movement at 30° test angle. In contrast, Renkawitz T., Boluki D., Grifka J., (2006) found that, the estimation of MIS for trunk extension movement, in athletes, has no relation to the presence of low back pain or to the neuromuscular disbalance of the right and left spine extension muscles.

Prolonged sitting jobs subjects with ALBP perceived higher values in subjective ALBP assessment, than demanding physical work subjects with ALBP, on both EPS and FPS. It seems that, demanding physical work subjects have a higher threshold of pain tolerance, then prolonged sitting jobs subjects, probably due to the harsh environment in which the subjects work.

Conclussion

ALBP subjects with prolonged sitting jobs have lower values in MIS production and higher values of subjective assessment of ALBP intensity, than ALBP subjects with demanding physical work, in both EPS and FPS. ALBP is not a factor that influences the difference in MIS production between subjects with prolonged sitting jobs and subjects with demanding physical work.

References

Al-Obaidi, S.M., Anthony, J., Al-Shuwai, N., Dean, E., 2004, Differences in back extensor strength between smokers and nonsmokers with and without low back pain, J Orthop Sports Phys Ther, 34(5), 254-260.

Andersson, G.B.J., Fine, L.J., Silverstein, B.A., 1995, Musculoskeletal disorders, in: Levy, B.S. and Wegman, D.H. (Eds.), [Occupational Health: Recognizing and Preventing Work-Related Disease], Little, Brown and Company, New York.

Beach T.A., Parkinson R.J., Stothart J.P., Callaghan J.P., 2005, Effects of prolonged sitting on the passive flexion stiffness of the in vivo lumbar spine. Spine J, 5(2), 145–154.

Bigos, S.J., Battie, M.C., Spengler, D.M., Fisher, L.D., Fordyce, W.E., Hansson, T., Nachemson, A.L., Zeh, J., 1992, A longitudinal, prospective study of industrial back injury reporting, Clin Orthop Relat Res, 279, 21-34.

Bobick T.G.,, 2000, Re: is occupational low back pain on the rise? Spine, 25: 1317-1318.

Bovenzi, M., Zadini, A., 1992, Self-reported low back symptoms in urban bus drivers exposed to whole-body vibration. Spine (Phila Pa 1976), 17(9), 1048-1059.

Breivik E. K., Bjornsson G. A., Skovlund E., 2000, A comparison of pain rating scales by sampling from clinical trial data. Clinical Journal of Pain, 16 (1): 22-28.

Buchbinder. R., Blyth, F.M., March, L.M., Brooks, P., Woolf, A.D., Hoy, D.G., 2013, Placing the global burden of low back pain in co ntext, Best Pract Res Clin Rheumatol, 27(5), 575-589.

Clark P., Lavielle P., Martinez H., 2003, Learning from pain scales: patient perspective. The Journal of rheumatology, 30 (7): 1584-1688.

Claus A., Hides J., Moseley G.L., Hodges P., 2008, Sitting versus standing: does the intradiscal pressure cause disc degeneration or low back pain? J Electromyogr Kinesiol, 18(4), 550–558.

DeLoach L. J., Higgins M. S., Caplan A. B., Stiff J. L. (1998). The visual analog scale in the immediate postoperative period: intrasubject variability and correlation with a numeric scale. Anesthesia and analgesia, 86 (1): 102-106.

Galukande M., Muwazi S., Mugisa B. D., 2006, Disability associated with low back pain in Mulago Hospital, Kampala Uganda. African Health Sciences, 6 (3): 173-176.

Gilgil, E., Kaçar, C., Bütün, B., Tuncer, T., Urhan, S., Yildirim, C., Sünbüloglu, G., Arikan, V., Tekeoglu, I., Oksüz, M.C., Dündar, U., 2014, Prevalence of low back pain in a developing urban setting, Spine, 30(9), 1093-1098 (2005).

Golob, A., Wipf, J., 2014, Low back pain. Med Clin North Am, 98(3), 405-428.

Gottlob A., 2007, Dr. Gottlob Testing. Gerätetest einiger Krafttrainingmaschinen der Firmen DAVID, Panatta und SportsArt. Fitness Tribune, 107: 32-43.

Graves J. E., Pollock M. L., Leggett S. H., Carpenter D. M., Fix C. K., Fulton M. N., 1992, Limited range-of-motion lumbar extension strength training. Medicine and science in sports and exercise, 24 (1): 128-133.

Handa N., Yamamoto H., Tani T., Kawakami T., Takemasa R., 2000, The effect of trunk muscle exercises in patients over 40 years of age with chronic low back pain. Journal of orthopaedic science: official journal of the Japanese Orthopaedic Association, 5 (3): 210-216.

Hasue M., Fujiwara M., Kikuchi S., 1980, A new method of quantitative measurement of abdominal and back muscle strength. Spine, 5 (2): 143-148.

Hodges P. W., Richardson C. A., 1996, Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. Spine, 21 (22): 2640-2650.

Jull G. A., Richardson C. A., 2000, Motor control problems in patients with spinal pain: a new direction for therapeutic exercis. Journal of manipulative and physiological therapeutics, 23 (2): 115-117.

Kankaanpää M., Taimela S., Laaksonen D., Hänninen O., Airaksinen O., 1998, Back and hip extensor fatigability in chronic low back pain patients and controls. Archives of physical medicine and rehabilitation, 79 (4): 412-417.

Keller T. S., Roy A. L., 2002, Posture-dependent isometric trunk extension and flexion strength in normal male and female subjects. Journal of spinal disorders & techniques, 15 (4): 312-318.

Leeuw M., Houben R. M., Severeijns R., Picavet H. S., Schouten E. G., Vlaeyen J. W. S., 2007, Pain-related fear in low back pain: a prospective study in the general population. European journal of pain (London, England), 11 (3): 256-266.

Leonhardt C., Lehr D., Chenot J. F., Keller S., Luckmann J., Basler H. D., Baum E., Donner-Banzhoff N., Pfingsten M., Hildebrandt J., Kochen M. M., Becker A., 2009, Are fear-avoidance beliefs in low back pain patients a risk factor for low physical activity or vice versa? A cross-lagged panel analysis. Psycho-social medicine, 6: In Press.

Lieber, R.L., 1990, Statistical significance and statistical power in hypothesis testing, J Orthop Res, 8(2), 304-309.

Lindgren L., 2003, The bone and joint decade 2000-2010. Bulletin of the World Health Organization, 81(9), 629.

Lis A.M., Black K.M., Korn H., Nordin M., 2007, Association between sitting and occupational LBP. Eur Spine J, 16:283-298.

Makhsous M., Lin F., Bankard J., Hendrix R.W., Hepler M., Press J., 2009, Biomechanical effects of sitting with adjustable ischial and lumbar support on occupational low back pain: evaluation of sitting load and back muscle activity. BMC Musculoskelet Disord, 10,17.

McCoy, C.E., Hadjipavlou, A.G., Overman, T., Necessary, J.T., Wolf, C., 1997, Work-related low back injuries caused by unusual circumstances, J Orthop Sports Phys Ther. 26(5), 260-265.

Murphy P.L., Volinn E., 1999, Is occupational low back pain on the rise? Spine, 24: 691-697.

Nissan M., Bar-Ilan K., Brown S., Luger E., Steinberg E., Dekel S., 2000, Characteristic dynamic differences between healthy and low back pain subjects. Spinal cord: the official journal of the International Medical Society of Paraplegia, 38 (7): 414-419.

Ponce de Leon S., Lara-Muñoz C., Feinstein A. R., Wells C. K., 2004, A comparison of three rating scales for measuring subjective phenomena in clinical research II. Use of experimentally controlled visual stimuli. Archives of medical research, 35 (2): 157-162.

Pranata, A., Perraton, L., El-Ansary, D., Clark, R., Fortin, K., Dettmann, T., Brandham, R., Bryant, A., 2017, Lumbar extensor muscle force control is associated with disability in people with chronic low back pain. Clin Biomech (Bristol, Avon), 46:46-51, doi: 10.1016/j.clinbiomech.2017.05.004. Epub 2017 May 10.

Renkawitz T., Boluki D., Grifka J., 2006, The association of low back pain, neuromuscular imbalance, and trunk extension strength in athletes. The spine journal: official journal of the North American Spine Society, 6 (6): 673-683.

Samoladas E., Barmpagianni, C., Papadopoulos, D. V., Gelalis, I. D., 2018, Lower back and neck pain among dentistry students: a cross-sectional study in dentistry students in Northern Greece. Eur J Orthop Surg Traumatol., doi: 10.1007/s00590-018-2195-x. [Epub ahead of print].

Sheskin D.J., 2004, Handbook of parametric and nonparametric statistical procedures, third ed., Chapman & Hall/CRC Press Company, 160-187.

Smidt G. L., Amundsen L. R., Dostal W. F., 1980, Muscle strength at the trunk. The Journal of orthopaedic and sports physical therapy, 1 (3): 165-170.

Soyannwo O. A., Amanor-Boadu S. D., Sanya A. O., Gureje O., 2000, Pain assessment in Nigerians - Visual Analogue Scale and Verbal Rating Scale compared. West African journal of medicine, 19 (4): 242-245.

Straton A., 2007, Differences between genders regarding maximal isometric force at the level of lumbar-thoracic column. Conferinţa Ştiinţifică Internaţională, „Educaţie fizică şi sport în viziune europeană", Analele Universităţii Ovidius Constanţa, Seria Educaţie Fizică şi Sport, Vol. 7, Seria 7, Ovidius University Press, 19 mai 2007, Constanţa: 559-569.

Straton A., 2009, Laterality reflexion on force production of antagonistic muscles at the level of vertebral column. Journal of Physical Education and Sport, 22 (1): 35-45.

Straton A., Cismaş G., 2009, Diferenţe de forţă izometrică maximă între diferite unghiuri şi diferite tipuri de mişcări ale trunchiului la subiecţii de gen feminin. Palestrica mileniului III, Civilizaţie şi Sport, vol. 10, 1 (35): 83-89.

Swinkels-Meewisse I. E., Roelofs J., Schouten E. G., Verbeek A. L., Oostendrop R. A., Vlaeyen J. W. S., 2006, Fear of movement/(re)injury predicting chronic disabling low back pain: a prospective inception cohort study. Spine, 31 (6): 658-664.

Thomas R.J., Nelson, J.K., 1996, Research Methods in Physical Activity, third ed., Human Kinetics, Champaign, Illinois, 54-55, 115-174.

Volinn E., 1997, The epidemiology of low back pain in the rest of the world. A review of surveys in low- and middle-incomecountries, Spine, 22 (15), 1747-1754.

Vlaeyen J. W. S., Crombez G., 1999, Fear of movement/(re)injury, avoidance and pain disability in chronic low back pain patients. Manual therapy, 4 (4): 187-195.

Watanabe S., Takahashi T., Takeba J., Miura H. (2018). Factors associated with the prevalence of back pain and work absence in shipyard workers. BMC Musculoskelet Disord., 19 (1), 12.

Wessel J., Ford D., van Driesum D., 1994, Torque of trunk flexion and trunk flexion with axial rotation in healthy men and women. Spine, 19 (3): 329-334.

Williamson A., Hoggart B., 2005, Pain: a review of three commonly used pain rating scales. Journal of clinical nursing, 14 (7): 798-804.

Wing, P.C., 2001, Rheumatology: 13. Minimizing disability in patients with low-back pain, CMAJ, 164(10), 1459-1468.