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RESEARCH ARTICLE

DYNAMIC FOLLOW-UP OF ENDURANCE IN BODY MUSCLES EXERTION AFTER ACTIVE TREATMENT OF PATIENTS WITH CHRONIC BACK PAIN

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ABSTRACT

To examine the sustainability of the recovery of the body muscles during physical exertion, after application of a special kinesitherapeutic program in patients with chronic low back pain. The study included 110 patients diagnosed with chronic low back pain, divided equally into two treatment groups. The participants of the experimental group performed the recommended special exercises 3 times a week at home and those in the control group only followed the guidelines of the physician. Endurance exertion test was applied to all participants at the beginning the 12th month. In the experimental group at the end of monitoring there was established a satisfactory improvement of endurance of the body muscles during physical exertion, as a result of the applied special exercises. A worsening of the functional status was established in the participants of the control group at the end of observation, relating to the reduction of the body muscles strength during physical exertion. The kinesitherapeutic program of special exercises was applied in the experimental group with positive effect leading to reduction of complaints and improved endurance during physical exertion of the body muscles. The lack of such a program was associated with deterioration of the strength capabilities of the body muscles in subjects in the control group.

INTRODUCTION

The problem of chronic low back is complex because of its multifactorial nature. Physical and functional methods of treatment of patients suffering from chronic low back are directed nowadays towards techniques aiming to provide overall and multidisciplinary care. The main idea of rehabilitation is to fight muscle loss caused by physical inactivity secondary to the pain (Khalfaoui *et al*., 2003). A number of studies have proven that the application of a functional program in patients with chronic low back pain results in a significant improvement of muscle strength and the cardiovascular functions, and increases the psychological and emotional endurance, which leads to improved professional activities and reduced absences from work (Verfaille *et al*., 2005; Durocher *et al*., 2014; Schaafsma *et al*., 2013; Coudeyre *et al*., 2006). Given the social importance of this disease, for the first time in Bulgaria we have carried out a prospective research with the study of endurance in efforts of the body muscles before and after administration of a kinesitherapeutic program of special exercises at home in patients with chronic low back pain.

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Aims of the study

The aims of this study are to take into account the effect of a kinesitherapeutic program of special exercises for affecting the endurance in exertion of body musclesin patients with chronic low back pain.

MATERIALS AND METHODS

The study is representative, prospective, with test-retest design and tracking, with questionnaires to fill out at the beginning and end of the observation (12 months). It was carried out with the participation of a representative sample of 110 patients with chronic low back pain, distributed equally into two treatment groups (experimental and control) of uniform age and gender. The selection of patients was done according to their appearance in the consulting room of the physiotherapy diagnosis and counseling center in Stambolijski by involving all those who met the inclusion criteria. They were each diagnosed and were undergoing therapy at the time, having been referred to the center by a general practitioner after consultation with a neurologist. All procedures related to the study were performed in accordance with the guidelines of good clinical practices. Prior to procedures, each patient was familiarized with the design of the study and signed an informed consent form. The following inclusion criteria for the study were used: a signed informed consent, age 30 to 60

years; presence of X-ray of the lumbar spine and consultation with a neurologist; diagnosed chronic low back pain; lack of a herniated disc, tumor, trauma, inflammation of the spine and osteoporosis, etiologically related to low back pain; lack of focal neurological deficit - motor, sensory, pelvic reservoir violations; lack of accompanying psychiatric disorders with a view to a better cooperation. 135 consecutive patients with chronic low back pain were initially screened, 25 of which were not included in the survey due to non-compliance with the inclusion criteria. Of 110 patients included in the final stage of the study, a total of 51 patients dropped out (22 of the experimental group due to a temporary improvement or social commitments and 29 in the control group due to lack of motivation). Patient information was obtained by taking a history and focused review of available medical records of the therapist and neurologist. The experimental group was trained to perform special exercises 3 times a week at home, and participants in the control group followed the recommendations of a physician for medical treatment. Patients' follow-up lasted for a year. At the beginning and end of the study, there was applied a physical exertion dynamic endurance test. Weight lifting test for assessment of endurance in exertion was carried out (dynamic test - modification of the US test "Progressive Isoinertial Lifting Evaluation"). It was based on WEST Standard Evaluation (WSE), developed by Leonard Matheson in the 1970s, and also modified by Tom Mayer in the mid 1980 s (Mayer *et al*., 1988).

Protocol

The patient raises a lightweight plastic tray to a height of 75 cm. Lifting the tape causes work in lumbar share in frontal plan from the floor to the stand, located at the height of 75 cm. Men perform the test with 5 kg., and women with 2.5 kg. It measures the number of cycles completed in 20 seconds, while a cycle is considered to involve moving from one level to another i.e. floor- stand or stand - floor /.

The study is suspended at the request of the patient or by a timeout of 20 seconds.

The kinesitherapeutic program applied in patients with chronic low back pain in the experimental group included five types of training:

Training for mobility: suppling in flexion position, supplying in extensional position, axial withdrawal from a bent knee position, abductor muscle active tension, adductor muscle active tension, active tension of the ischiocrural muscle group.

Flexor workout: exercise for strengthening the abdominal muscles from side leg positions, co-contraction training for the anterior oblique system involving the anterior abdominal fascia, dynamic strength training m.obliquusabdomin is externus and m.obliquusabdomin is internus

Training for sensory-motor reprogramming: exercises for the body rotators with abduction of the upper limb to improve the stabilizing function of the spine from its original seating position on a Swiss-ball; exercises for upper limb flexion and extension of homolateral lower limbs from side leg position on a Swiss-ball for improving the proprioception of the spinal column structures, exercises to maintain the neutral position by moving the Swiss-ball on the wall.

Extensors workout: exercises for extension of the spine from a prone position with hands support and holding for 30 sec. in extensional position; strength training of the gluteal muscles from prone position, co-contraction for strength of m. gluteus maximus and m. latissimus dorsi.

Training for lumbar stability: elevation of the pelvis to maintain neutral position, axial withdrawal during co-contraction, maintaining co-contraction with elevation of one foot and abduction of the upper limb, bending the body forward while maintaining a neutral lumbar position, moving from sitting into an upright position while maintaining neutral lumbar position.

Monitoring and evaluation of the results of kinesitherapeutic program was carried out by an experienced physiotherapist. The collected primary information was checked, encoded, and entered into a computer database for statistical analysis. Data were processed using SPSS 13.0. Results for quantitative variables were expressed as mean ± SE (standard error) and results for qualitative variables as percentages. Age, gender, risk factors, as well as the assessments of the VAS and endurance exertion test were compared by means of Pearson's correlation coefficient (r), $\chi 2$ - test, t - test, u - test, and Fisher's criterion (F) were used to analyze the correlation between age, gender, risk factors, pain intensity, and the assessments of endurance effort test. Multiple regression analysis was applied to estimate the simultaneous impact of age, gender, risk factors, and pain intensity on the results of endurance exertion test. The level of significance was et at $P< 0.05$.

RESULTS

At the beginning of the survey the average age of the experimental group was (43.31 ± 1.11), while at the end of the survey it was 44.24 ± 1.35. The average age of the participants in the control group at baseline was 43.90 ± 0.87, and at the end of the survey - 44.57 ± 0.55. The gender distribution in the experimental group showed that at the beginning of the survey -26 (47.27%) were male and 29 (52.73%) were women, and at the end of the survey - 11 (39.39%) were male and 20 (60.61%) were women. In the control group the gender breakdown shows that at the beginning of the survey 24 (43.63%) were male and 31 (56.37%) were women, and at the end of the survey - 8 (30.76%) were male and 18 (69.24%) - women. In the control group at the beginning of the survey 32 (58.18%) of the participants reported risk factors, while 33 (41.82%) did not. At the end of the survey in the same group in 15 (57.69%) of the participants there were risk factors present, while of 11 (42.31%) of the participants there were not. At the beginning of the survey period in the experimental group 33 (60.00%) of all the participants reported risk factors, and 22 (40.00%) such factors were not reported. At the end of the survey in the same group in 19 (57.57%) of the participants there were risk factors, and in 14 (42.43%) of the participants there were not any. At the beginning of the study there were ascertained no significant differences between the participants in the experimental and control groups in terms of mean age $P > 0.05$ ($u = 0.41$), gender $P > 0.05$ ($\chi 2 = 0.15$) and present risk

factors, P > 0.05 ($\chi 2$ = 0.04). No correlation was found between the participants' gender and the presence of risk factors P > 0.05 ($\chi 2$ = 3.51) as well as between age and the presence of risk factors P> 0.05 ($\chi 2$ = 2.81). The average number of cycles performed by the participants in the experimental group at the beginning of the observation for 20 sec. is 8,45 ± 0,30, as nearly half - 54 (49.09%) performed 7-9 cycles (Table 1).

Table 1. Results of the test for endurance in patients from the experimental group at the beginning of the observation

Number of cycles	Absolute number	p %	Sp
Up to 6	12	21,82	5,57
7-9	27	49,09	6,74
10-12	13	23,64	5,73
Over 13	3	5,45	2,97
Overall	55	100,00	-

The average number of cycles performed by the participants of the experimental group at the end of the observation for 20 sec., Is 8,55 ± 0,37, with more than half of the surveyed 21 (63.64%) - performed 7-9 cycles (Table 2).

Table 2. Results of the endurance test in patients of the experimental group by the end of the observation

Number of cycles	Absolute number	p %	Sp
Up to 6	4	12,12	-
7-9	21	63,64	8,37
10-12	6	18,18	6,71
Over 13	2	6,06	-
Overall	33	100,00	-

There has been no statistically significant difference between the initial and final results of the test in the experimental group P> 0,05 (u = 0,92). However, these results show some positive effect which is expressed in the reduction of complaints. For the control group, we have ascertained a statistically significant difference between initial and final test results test P <0,05 (u = 2,21)- (Table 3). Significant changes occurred in the control group. The mean number of cycles has decreased from 8.35 to 7.77, i.e. there has been a deterioration of functional status in the absence of kinesitherapeutic program. In a comparison between the two groups no statistically significant difference between the results at the end of the observation was found P> 0,05 (u = 1,41) – (Table 4). The results of the experimental group at the beginning of the observation correlated with three factors: the intensity of pain (rxy, -0,58, P <0,001), age of the surveyed (rxy, -0,47 P <0,001) and gender (rxy, - 0,70 P <0,001). The correlation for all three indicators is reversed and moderate to significant, as the highest value is the coefficient for gender. The results obtained in the experimental group at the end of the survey are highly dependent upon factors of pain intensity (rxy, - 0,64 P <0,001), sex (rxy, -0,56, P <0,001) and age (rxy-0 42 P <0,05). The correlation for all three indicators is reversed, moderate to significant, as the biggest factor is the factor of pain intensity.

In comparing gender with the test results of the experimental group at the beginning and end of the observation, we have found substantial differences in the endurance of men. They carried a larger number of cycles than women, with initial testing values respectively 10,08 ± 0,35 P <0,001 (u = 5,14) and final testing 10,00 ± 0,51 P <0,001 (u = 3.74) – (Table 5).

Table 3. Comparison between initial and final results in the endurance test in the control group

Variable	Stages	Absolute number	$\bar{x}\pm \bar{S}x$	Sx	u	P
Endurance test	Beginning	26	8,35±0,46	2,35	2,21	<0,05
	End	26	7,77±0,41	2,08		

Table 4. Comparison between the results of the endurance test in the experimental and control groups at the end of the observation

Variabels	Groups	Absolute number	$\bar{x}\pm \bar{S}x$	Sx	u	P
Endurance test	Experimental	33	8,55±0,37	2,14	1,41	>0,05
	Control	26	7,77±0,41	2,08		

Table 5. Comparison by gender with mean results for endurance test in the experimental group at the beginning and at the end of the observation

Variables and stage	Gender	Absolute number	$\bar{X}\pm \bar{S}x$	Sx	u	P
Results at the beginning of test	Male	26	10,08±0,35	1,77	5,14	<0,001
	Female	29	7,00±0,29	1,54		
Resutls at the end of observation	Male	13	10,00±0,51	1,83		
	Female	20	7,60±0,40	1,80	3,74	<0,001

Table 6. Comparison in age with the mean results from the endurance test for the experimental group at the beginning and at the end of the results

Variables and stage	Age	Absolute number	$\bar{x}\pm \bar{S}x$	Sx	t	P
Results at the beginning of observation	Up to 39 yr.	20	9,35±0,48	2,13	20,71	<0,001
	40-49 yr.	18	9,39±0,38	1,61		
	Over 50 yr.	17	6,41±0,38	1,58		
Results at the end of observation	Up to 39 yr.	9	9,22±0,78	2,33	6,82	<0,01
	40-49 yr.	12	9,58±0,43	1,51		
	Over 50 yr.	12	7,00±0,49	1,71		

Table 7. Results of the endurance test in patients from the experimental group at the end of the observation according to pain intensity on VAS

Pain intensity on VAS	Indicators	Endurance test		
		Up to 6 cycles	7-9 cycles	Over 9 cycles
Up to 3 t.	Abs. number	0	11	6
	p±Sp	0,00±0	50,00± 3,31	85,71±2,44
4-6 тt	Abs. number	2	11	1
	p±Sp	50,00±1,41	50,00±3,31	14,29±1,00
Over 7 t.	Abs. number	2	0	0
	p±Sp	50,00±1,41	0,00±0	0,00±0
Total	Abs. number	4	22	7
	p±Sp	100,00±2,00	100,00±4,69	100,00±2,64

By comparing age with the average performance of the endurance test in the experimental group at the beginning and end of the observation we have proved that patients aged over 50 perform a smaller number of cycles. The initial values are 6,41 ± 0,38 P <0,001 (t = 20,71), and the final values - 7,00 ± 0,49 P <0,01 (t = 6,82) – (Table 6). There was no correlation registered between the presence of risk factors and mean results for the endurance test in the experimental group at both the beginning and the end of the observation P> 0,05. The influence of pain intensity on the endurance test results in patients of the experimental group is presented in Table 7. Over 9 cycles were performed by 85.71% of patients with mild pain (up to 3 tons. in SAC), 50% of participants with moderate pain (4-6 t. SAC) and none of those with severe pain (more than 7 tons. by SAC), which is to support the claim that intense pain decreases the patients' endurance. The performed multiple stepwise regression analysis of the results at the beginning of the monitoring shows that the results of the test are formed under the complex influence of gender, intensity of pain and age P <0.001 (F = 107,90). In 90% of all cases a change in these factors will lead to a change in the results. In the same analysis at the end of monitoring three factors are listed in the following manner according to their importance: pain intensity, sex and age P <0.001 (F = 45,32). At this stage in 82% of cases in case of these three factors will lead to a change in the results of the endurance test.

DISCUSSION

Examining the test results we have not found a statistically significant difference between the initial and final results in the experimental group P> 0,05 (u = 0,92). However, in these results we did find some positive effect which is expressed in the reduction of complaints. For the control group we established a statistically significant difference between initial and final test results P <0,05 (u = 2,21), as the mean number of completed cycles of 8.35 to 7.77 decreased. We observed deterioration of the functional status in the absence of kinesitherapeutic program. The positive result in the experimental group is due to the application of the multidirectional training to achieve functional unity of the paravertebral muscles, including exercises for strength and endurance. Our results are confirmed by the study Olivier *et al*., (2008) indicating that as a result of the implementation of endurance training muscle work was improved significantly (Olivier *et al*., 2008). Confirming the opinion of the authors, we applied the exercises for strength to the front and lateral abdominal muscles, cross-training for strength of m. latisimus dorsi and m.gluteus maximus, as well as exercises for strength of the gluteal muscles on the front leg.

We focused on endurance exercises in view of the possibility of provoking spinal injuries and even after minor activities. Trauma can result from an inefficient motor control, increased fatigue. A study Mannion *et al*. (1997) showed that the position of the starting position and knee support lifting both upper and lower contralateral limb creates a good match in terms of contraction compression, but strength training of front leg should be performed in cases when not working for both upper and lower limbs. According to the authors strength training on Roman chair (test type Sorensen) causes strong contractions, at the expense, though, of strong vertebral compression. That is why, it should rather be performed at the end of training. It should be noted that the patient can reduce the compression by remaining in light flexion (20-30º), without fully straightening the body (Mannion *et al*., 1997). The positive result in the experimental group was due to the implementation of exercises for lumbar-pelvic control and the keeping of a neutral lumbar-pelvic position during tilting the body forward with folded hips. Control was exercised simultaneously on the transition from a sitting position.

According to Hodges *et al*. (1996), a key supportive role for the lumbar spine have the joined to it m. transversus abdominis, mm. multifidus, m. erector spinae, which contribute to the opposition of the lumbar spine load. The authors argue that for its normal function it is requires that the deep muscles can develop prolonged tonic activity to support the lumbar lumbar-pelvic area. Patients with more than 30% discrepancy in the cross area of m. multifidus are at increased risk for recurrent low back pain in the absence of exercises for lumbar-pelvic control. The researchers add that m. erector spinae produces extensor force required to lift, but also to stabilize the spine (Hodges *et al*., 1996). We must not omit the applied by us training including exercises for co-contraction of flexors and extensors of the spine. It is used to improve muscle function of the mm. transversus abdomimis, mm. multifidi and erector spine related to intra-abdominal pressure during weightlifting. Cholewicki *et al*. (1999) explain well the role of m. transversus abdominis both for intra-abdominal pressure and for the tension in thoracic-lumbar fascia. The fascia surrounds the multifidi and spinalerectors, but is also supported by both abdominal muscles, which allows for the achievement of stability of the body (Cholewicki *et al*., 1999). Morris *et al*., (1961) estimate that the compression force in the lower lumbar discs can be reduced by 30% by the factor intra-abdominal pressure with weight lifting (Morris *et al*., 1961). The results obtained in the experimental group were highly dependent upon factors of pain intensity, sex and age. The correlation for all three indicators is reversed, moderate to significant, as the biggest factor is the factor of pain intensity.

With multiple stepwise regression the analysis proves that the results of the test at the beginning of the observation were formed under the complex influence of gender, intensity of pain and age P <0.001 (F = 107,90). In 90% of all cases a change in these factors leads to a change in the results. After monitoring, the three factors are listed in the following manner according to their importance: pain intensity, sex and age P <0.001 (F = 45,32). At this stage, in 82% of all cases, changing these three factors leads to a change in the results of the endurance effort test. There has found no correlation between the presence of risk factors and the test results in the experimental group. We did not find in the literature studies with similar data. We have proved that the higher pain intensity is the reason for the poor performance of participants with regard to endurance and the capabilities for lifting weights. In support of this assertion is the study Thomas *et al*., (2007), demonstrating that early activation of the extensors of the body is significantly delayed in subjects with pronounced painful symptoms while they show lower results than those in controls with less pain intensity. The authors note that the latency time for activation of the antagonists of the body increases with the distance to the target and decreases with increasing severity (Thomas *et al*., 2007).

We have ascertained that in subjects over the age of 50 yr. the strength capabilities of the paravertebral muscles decrease and they perform fewer cycles than other age groups in endurance tests at the beginning and end of the study P <0,001. We think that this is due to general disorders in the structure and biomechanical properties of the articular and muscular and ligament apparatus and disc pathology associated with aging. This conclusion is confirmed by the study Colombini *et al*., (2008), wherein the authors reach the conclusion that in many cases, low back pain directly or indirectly is coupled with disc degeneration and progressive structural changes in the organization of lamellar disc coming with age. There is also abnormal tension in the spinal structures, which is determined by degenerated discs (Colombini *et al*., 2008). The gender of the participants of the experimental group also affects the results of the test at the beginning and end of the observation. Men showed a significantly greater endurance and performed a greater number of cycles than women P<0.001. In the literature we did not find data in connection with this claim.

Limitations of the study

The limitations of our study refer to the reduced number of participants and the relatively large number of patients who did not complete the tests. Another limitation was that the participants were only from Plovdiv. However, these limitations do not downplay the results of the first such study in Bulgaria. There are forthcoming studies with a larger number of patients with chronic lumbalgy from different regions of Bulgaria.

Conclusion

As a result of the applied kinesitherapeutic program we reported improved endurance during physical exertion of the muscles of the body. Failure of such a program is associated with deterioration of the functional status of patients and a significant reduction of endurance of body muscles. The performed study motivates us to recommend implementation of such kinesitherapeutic programs to improve the functional status of patients suffering from chronic low back pain.

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