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EFFECT OF A SPECIFIC EXERCISE PROGRAM ON THE STRENGTH AND RESISTANCE LEVELS OF LUMBAR MUSCLES IN WAREHOUSE WORKERS

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Abstract

Objective: The aim of this study was to verify the influence of a specific exercise program on the strength and resistance levels of lumbar flexors and extensors in warehouse workers. **Materials and Methods:** The population used in this randomized controlled trial included 557 warehouse male workers from a food distribution company in Oporto/Portugal. Upon the application of the selection criteria, 98 workers deemed eligible were randomized in two groups: 57 were assigned to the intervention group and 41 to the control group. The intervention included 9 easily-executed exercises to promote stretching and strengthening of the lumbar region, to be executed daily, at the beginning of the working time, at the company facilities and lasting 8'. Trunk muscles' voluntary strength and resistance were measured using an isometric electronic dynamometer (Globus Ergometer, Globus, Codigné, Italy) at baseline and eleven months after implementing the exercise program. The data was analyzed using SPSS®, version 17.0. **Results:** After implementation of the exercise program, in the intervention group, all variables increased, significant differences were observed as for the muscle strength and resistance values ($p = 0.014$ and $p = 0.006$, respectively), as well as in the ratio extensors/flexors ($p = 0.037$). In the control group, all variables decreased, with a statistically significant decrease of the trunk flexors strength level ($p = 0.009$). **Conclusion:** The results of this study suggest that a specific exercise intervention program can increase trunk extensors strength and resistance.

Key words:
Strength, Resistance, Trunk muscles, Exercise, Occupational health

INTRODUCTION

Low back pain (LBP) is the main cause of incapacity in industrialized countries [1–6]. Epidemiological studies demonstrate the incidence of LBP in approximately 60% of industrial workers throughout their lives [7]. In fact, LBP constitutes the major cause of work absence, as it is one of the causes of limitation of the locomotor system, and one of the most common reasons for seeking medical assistance. As a consequence, LBP is responsible for increased in social costs and a reduction in productivity and in the ability to perform everyday tasks. This, in turn, results in employee replacement by other workers and originates temporary or even definitive retirement [8–10].

It is generally accepted that prolonged, static, sitting postures, such as those adopted during driving, are more likely to aggravate a preexisting LBP condition or instigate

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the development of a new one [11,12]. In fact, adopting a wrong posture, combined with the effects of vibration and prolonged driving times, have been identified as sources of increased risk of low back injuries ranging from disk herniations to general musculoskeletal strains and sprains [13–15].

De Carvalho et al. have shown that during automobile sitting, with no lumbar support, the lumbar spine flattens completely and yet maintains nearly standing levels of intervertebral joint angles at L5/S1 [16]. This situation is highly suggestive of large strains at the posterior aspect of the intervertebral disks at L4/L5. This is not surprising, as this segment is often referred to as one of the most common levels of lumbar disk herniation. Generally this is due to abnormalities in the posterior muscles, tendons and ligaments of the trunk and it can be attributed to various physical activities, such as lifting weight and remaining in a standing or sitting position for long periods of time [17–19].

The musculoskeletal system, above all, guarantees stability to the spine in everyday tasks [20,21]. When it is weakened, spinal joints and ligaments can become overloaded, increasing the probability of injury incidents at the lumbar spine. Muscle weakness proceeds from disuse, remaining in certain positions for long periods or even from tiredness caused by repetitive gestures, resulting in an excessive transfer of load to the spine structures, causing pain [17,20,22–24]. There is also evidence suggesting that muscle weakness is one of the risk factors for LBP [25–30]. The importance of rehabilitating the trunk muscles to maintain the lumbar lordosis is clear, as it seems to have a protective effect on the structures of the spine in different postures. Taking these considerations into account, more relevance has been given to implement the exercise program specifically directed to workers, not only to decrease LBP [31–34], but also to prevent it [30,33,35–37].

While systematically reviewing the literature of all interventions performed in workplaces, Tveito et al. verified that physical exercise has a documented effect on lumbar pain prevention, muscle strength and resistance [34]. On the other hand, van Poppel et al. concluded that there is very limited evidence as to the benefits of applying an exercise program [38]. The aim of this study was to verify the influence of an 11-month specific exercise program on the strength and resistance levels of lumbar flexors and extensors in warehouse workers.

MATERIALS AND METHODS

Study Design

This study was a randomized controlled trial.

Sample

The population used in this study included 557 warehouse male workers from a food distribution company in Oporto/Portugal. All workers were involved in a routine of overcharge tasks and/or repetitive movements and they worked under low temperatures (between 0° and 4°C) during all seasons of the year. According to the company norms, all workers wore cold protective clothing, gloves, boots and lumbar support belts.

After informing the clinical physician and human resources staff on the criteria that would have to be taken into account for subject selection, the company has provided us with an alphabetically organized list of 143 eligible workers, corresponding to 25% of the population. The sample was randomized in two groups (72 in the intervention group and 71 in the control group). Then, the subjects were asked to volunteer to participate in the study based on a written consent. The sample included 57 volunteers for the intervention group and 41 for the control group. At baseline the sample was n = 98, corresponding to 17% of the population.

This study included all male workers who did not oppose to being measured as to their maximal isometric strength and resistance of trunk flexors and extensors and who

completed the exercise program. The subjects were excluded if they met at least one of these criteria:
- presented a clinically diagnosed pathology which prevented them from executing the exercises or the strength and resistance tests [39];
- had been subjected to to abdominal or lumbar-pelvic surgery [26,40];
- suffered from any musculoskeletal injury or chronic illness [40];
- were taking any medication which could influence the viscous elastic properties of soft tissue [41];
- were taking pain killers or AINS [41];
- had been under back pain treatment for the last year [20];
- were unable to maintain a correct posture during the measurement of muscle strength and resistance [21];
- reported LBP [39,42,43]; or
- practiced regular physical exercise [44].

There were 26 losses at the end of the research: 15 (26.32%) from the intervention group and 11 (26.83%) from the control group, leading to the sample reduced at the end of the program to 72 workers, 42 in the intervention group and 30 in the control group. These losses resulted from workers leaving the company, changing workplace or giving up participating in the study before the end of the program.

Individual characteristics of the sample as for age, weight, height and Body Mass Index (BMI) are presented in Table 1.

Instruments

An isometric electronic dynamometer (Globus Ergometer, Globus, Codigné, Italy) was used to measure the resistance (in seconds) and maximal isometric strength (in Kgf) of trunk flexors and extensors. According to Robinson et al. the Intraclass Correlation Coefficient (ICC) of this instrument is 0.93, in the test-retest for the maximal isometric strength, 0.93 in the Pearson Correlation Coefficient, and 0.85 in the test-retest for the isometric resistance [45]. Generic health status survey questionnaires were used to select and characterize the sample.

Procedures

The exercise program was implemented in several stages. At first, visits to the warehouse facilities allowed the researchers to know the type of tasks executed by workers and the most common injuries. Upon evaluation of risks and most repeated gestures, an adequate exercise program was created. This program included nine easily-executed exercises to promote stretching and strengthening of soft tissues responsible for spinal stability, especially lumbar stability. This program was applied, with exercises being executed daily, at the beginning of the working time, at the company facilities and lasting approximately eight minutes. To motivate the workers to adhere to the program and follow it, there were several training sessions and posters illustrating the exercise program to execute were distributed at the company facilities.

Table 1. Sample characteristics (N = 98)

Sample	Intervention group (N = 57)			Control group (N = 41)		
	mean±SD	minimum	maximum	mean±SD	minimum	maximum
Age (years)	33.50±8.17	20.00	49.00	27.40±6.25	20.00	45.00
Weight (kg)	77.00±11.10	56.00	104.00	78.10±14.65	57.00	110.00
Height (cm)	175.00±7.40	161.00	194.00	175.00±9.30	150.00	187.00
BMI (kg/m^2)	25.20±2.05	21.60	27.60	25.60±1.69	25.30	31.50

SD – standard deviation.

Facilitators of the program included physiotherapists who visited the warehouse facilities every 15 days to correct possible execution errors or to answer the doubts and questions from the workers as to the exercise program. The program efficacy was evaluated twice – at baseline and 11 months following the participation in the program.

All evaluations were preceded by a 5-minute warming up, which involved some callisthenic exercises [46–49]. Then, individuals were positioned in the test position. For this, an 8-cm wide band was placed around the subjects' shoulders, just below the medial end of the clavicles and horizontally connected with the dynamometer by a steel cable [28,50]. To increase the stability, pelvic supports were placed by the fourth and fifth lumbar vertebrae and on the inferior third of the thighs. Individuals were asked to stand on a nonslip surface, with their back positioned against a pelvic supporting board as the trunk flexors strength was measured and their front against the board as trunk extensors strength was evaluated [28,50,51]. A short training in the test position, which consisted of 3 submaximal contractions for flexion or extension of the trunk, depending on the test, was performed prior to the measurements. This warming up period allowed the subjects to get used to the equipment an learn how to use it.

After a 1-minute rest, individuals were encouraged to produce their maximal strength for flexion or extension of the trunk. Then, in the same position, resistance tests were made at 60% of their maximum voluntary contraction, both for trunk flexors and extensors [52,53]. During the execution of muscle contractions, verbal encouragement was constantly given, in order to stimulate both the maximal strength and the period of time in which the individuals endured the resistance test. The interval between the strength and resistance tests was 15 minutes [54].

The control group participated in the pre- and post-program tests. At the end of the study this group was offered the possibility of executing the same exercises which were implemented in the intervention group.

The study was conducted between February 2005 and March 2007, with authorization granted by the company and according to a protocol agreed on between the institutions involved. All participants provided written informed consents before entering the study. All procedures were in accordance with the Helsinki Declaration. The study design was approved by the ethics committee of Escola Superior de Tecnologia da Saúde do Porto, in Portugal.

Statistics

Descriptive and inferential statistics were used for the result analysis. The student's t test for independent samples was used to analyze the differences between mean values in both groups. To analyze the differences between the mean values in each group before and after the exercise program, the student's t test for paired samples was used. The level of significance was set as 5%. Statistical analysis was conducted using SPSS® 17.0 for Windows®.

RESULTS

Results in Table 2 illustrate an increase in all variables after the implementation of the exercise program during 11 months, in the intervention group. The results are statistically significant for trunk extensors strength ($p = 0.014$), trunk extensors resistance ($p = 0.006$), and the ratio between the trunk extensors/flexors strength ($p = 0.037$).

In the control group, there was a statistically significant decrease of the trunk flexors strength level ($p = 0.009$). Neither the increase in the flexors' resistance nor the decrease in the extensors' strength and resistance were statistically significant. As for the ratio between the trunk extensors/flexors strength in the control group, there was a decrease, but without statistical significance.

Table 2. Statistical results of the student's t test for paired samples between moments 1 and 2: proof value to the intervention group and the control group

Variables	Intervention			Control		
	moment 1	moment 2	p value	moment 1	moment 2	p value
SFle (Kgf)	72.07±14.33	73.39±14.42	0.257	63.49±20.94	58.81±18.40	0.002
RFle (Sec)	42.43±15.58	44.31±15.89	0.259	42.71±19.45	45.17±17.06	0.464
SExt (Kgf)	79.48±15.94	83.29±13.73	0.014	65.74±18.42	61.90±20.10	0.069
RExt (Sec)	51.57±17.60	58.69±15.38	0.006	62.41±18.46	61.79±18.97	0.859
Ratio	1.10±0.25	1.16±0.21	0.037	1.12±0.30	1.08±0.27	0.312

SFle – Trunk flexors strength; RFle – Trunk flexors resistance; SExt – Trunk extensors strength; RExt – Trunk extensors resistance.
Ratio between trunk extensors/flexors strength.

DISCUSSION

Several studies have documented the association between chronic LBP and decreased muscle performance [13–15,20,27,50]. In this study, we have used isometric tests to evaluate the lumbar muscles' resistance and strength levels, as they are quite easy to teach and perform, which allows applying them to a great number of subjects. Besides, according to Brown and Weir, the isometric strength test provides predictive information about occupational injuries associated with dynamic activities. Furthermore, the isometric strength test has been shown to be more reliable. However, one should not forget that the isometric contraction occurs at a certain specific angle that can be slightly associated with strength values in other joints positions [46]. Despite all these arguments, disagreement arises as to the isometric test capacity to predict dynamic performance. Taking this into account, it would be important to carry out new studies to quantify strength and resistance dynamics.

All strength and resistance measurements were taken with individuals in a standing position as, according to Rantanen et al. and Rantanen and NyKvist [50,51] in this position there is a decrease in the compressive strength upon the lumbar column, generated by the psoas muscle. Only male workers were included in this study, as, according to Ebben and Jensen, there are differences in scope of strength between genders [55].

Although several studies have addressed exercise programs very similar to ours as to intensity and duration and in the methods adopted to measure muscle strength and resistance, none of them have included all these aspects. The strength and resistance levels of lumbar extensors improved after the exercise program. These results are consistent with those obtained in the studies of Mannion et al. and Gundewall et al., which have used a specific exercise program, executed twice a week, with a duration between 10 and 20 minutes [39,56]. Moffroid also verified an improvement in the trunk extensors strength and resistance levels after following an exercise program for 6 weeks [57]. However, this program only included exercises for lumbar extensors. Koumantakies et al. observed an increase in the strength, not only for extensors but also for lumbar flexors, after implementing a 15-minute exercise program applied specifically to the lumbar region [52]. In a study by Holmstrom and Ahlborg the lack of improvement concerning the trunk muscle strength and a small increase in the lumbar extensor muscle resistance were not seen as significant [44]. These results were probably due to the fact that the exercise program adopted global callisthenic exercises only for 3 months and, according to Cohen and Narrow, in such conditions, improvements in strength and resistance are only shown after 6 to 8 months of exercise [58]. This affirms that, in spite of the exercise program showing improvements in the trunk muscles resistance, intervention programs lasting for many months are most effective in improving physical performance [57]. Although in the intervention group there were no statistically significant differences in the trunk flexors strength levels after implementing the exercise program (it increased), in the control group there was a statistically significant decrease in the strength of these muscles. These changes can show the importance of the applied program in preventing atrophy of trunk flexors. The decrease in strength-related values in the control group could be explained by the constant use of lumbar support belts, which, in the long run, promotes abdominal muscle weakness [59]. Nevertheless, the influence of lumbar support belts on muscle strength is still a very controversial issue and, because of that, it should be investigated in future studies. The increased strength and resistance verified in the intervention group can also be justified by the decrease in pain perception and by psychological improvement during the program [39,52].

While analyzing the results, statistically significant differences were verified between the groups as to the trunk extensors muscle strength. The increase of the strength registered in the intervention group, when compared to the control group, is consistent with the studies of Mannion et al., which have used the same methodology for the same measurement of strength and with an intensity and duration of exercises very similar to the present study [39]. According to Trainor and Wiesel, the ratio between the trunk extensors/flexors strength is 1.3/1 [60]. Some studies have revealed that patients with back pain have this ratio altered comparing to the normal population and that a relation of 1.2/1 to 1.5/1 can be verified in individuals without any symptoms (but likely to develop LBP) and of 1.0 in some cases of individuals with back pain [20,61]. The results of this study have shown a significant increasing change in the initial ratio (intervention group), namely from 1.09/1 to 1.15/1 eleven months after following the exercise program. This change can be seen as having a protective nature as, according to Lee et al., the increase in the extensors/flexors strength ratio has revealed the biggest solidity in preventing future episodes of back pain [20]. There were also ratio changes when comparing the intervention group with the control group (intervention group ratio – control group ratio). There are no experimental studies which evaluate the changes in the strength ratio following an intervention, which emphasizes the importance of new studies to analyze this question in greater detail.

This study allowed to evaluate the efficiency of a specific exercise program in warehouse workers. There were significant improvements in the extensor muscle strength and resistance, measured eleven months after following the exercise program. When comparing both groups, the main differences were verified in the lumbar flexors and extensors strength.

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