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One lumbar extension training session per week is sufficient for strength gains and reductions in pain in patients with chronic low back pain ergonomics

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Chronic low back pain (CLBP) is the leading cause of absenteeism from the workplace and research into exercise interventions to address this problem is required. This study investigated training frequency for participants with CLBP. Participants either trained once a week (1 × week, $n = 31$), or twice a week (2 × week, $n = 20$) or did not (control group, $n = 21$). Participants were isometric strength tested in weeks 1 and 12 and trained dynamically either 1 × week (80% of maximum) or 2 × week (80% and 50%). The results (pre vs. post) showed significant increases in maximal strength, range of motion and reductions in pain for both training groups. Pain scores for the 1 × week and 2 × week both reached minimal clinical improvement change unlike the control group. Thus, one lumbar extension training session per week is sufficient for strength gains and reductions in pain in low back pain in CLBP patients.

Practitioner Summary: CLBP is the leading cause of absenteeism from the workplace. The present study using a modified randomised control trial design investigated exercise training frequency for participants with CLBP. One lumbar extension training session per week is sufficient for strength gains and reductions in low back pain in CLBP patients.

Keywords: occupational; exercise therapy; back pain

Introduction

Low back pain is one of the leading causes of work absenteeism around the world (Hamberg-van Reenen *et al.* 2008, Higuchi *et al.* 2010) and is therefore considered a major international problem (Trevelyan and Legg 2010). Indeed, Maniadakis and Gray (2000) suggest 'Back pain is one of the most costly conditions for which an economic analysis has been carried out in the UK' (p. 95). Around the world musculoskeletal diseases are one of the most prevalent causes of disability, with back pain being the most common musculoskeletal disease (Brooks 2006). Dagenais *et al.* (2008) noted that research has shown the indirect costs incurred from low back pain resulting in lost work productivity, produced the largest cost (Australia, Belgium, Japan, Korea, the Netherlands, the UK and the USA). In the UK, up to 50 million working days are lost each year as a result of individuals suffering from lower back pain (Aylward and Sawney 2002), with 20% (one in five) of the UK reporting back pain to their general practitioner (National Institute for Health and Clinical Excellence 2009).

This financial loss to the economy brought the total cost of chronic lower back pain (CLBP) to over £10.6 billion in 1998 (Maniadakis and Gray 2000). This is also true of North America where the increase in CLBP is resulting in a mounting economic burden (May and Donelson 2008), with costs estimated anywhere between $100 and $ 200 billion per annum (£61–122 billion; Katz 2006), and Sweden where the costs were estimated at €1.8 billion (£1.6 billion) in 2001 (Ekman *et al.* 2001). Therefore, a greater understanding of how to implement interventions to reduce CLBP would be extremely valuable socially and financially.

One factor related to the development of CLBP is insufficient strength in the muscles that extend the lumbar spine (Graves *et al.* 1989, Pollock and Graves 1989, De Looze *et al.* 1998). In a similar vein but specifically in a work-related context, Hamberg-van Reenen *et al.* (2008) claimed that CLBP in the working population may be caused by the imbalance between exposure to work related factors and low physical capacity. Consequently, resistance training is often prescribed for prevention and treatment of CLBP (Nelson *et al.* 1995).

The lumbar extension machine (MedX, Ocala, FL) is a dynamometer that can be used to measure the isometric strength of the muscles that extend the lumbar spine and to provide dynamic, variable resistance exercise of those

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same muscles; it has proved to be a reliable and valid measuring and training tool (Graves *et al.* 1990a, Robinson *et al.* 1992). This machine isolates the lumbar muscles through stabilising the pelvis in order to minimise the contribution of the hip and leg muscles (Pollock and Graves 1989). It has been utilised successfully in numerous studies (see Smith *et al.* 2008 for a comprehensive review). The research on asymptomatic participants to date has found that one weekly set of approximately 8–12 repetitions of dynamic, variable resistance exercise to fatigue on the lumbar extension machine can produce significant increases in strength and decreases in low back pain (Tucci *et al.* 1992, Choi *et al.* 2005). A greater frequency or volume of heavy training does not produce greater improvements (Smith *et al.* 2008), and individuals who train more than once a week on the lumbar extension machine can experience orthopaedic discomfort (Graves *et al.* 1990b). However, to date there has been no research using this training on participants that are symptomatic and thus suffer from CLBP.

The manufacturer of the dynamometer, however, also recommends that in the early stages of such therapy a second session per week, involving performing lumbar extensions against very light resistance, is performed. This is hypothesised to improve range of motion (ROM) through maintaining joint mobility and aiding disc hydration (MedX Educational Program 2006). The use of a second dynamic training session, in addition to the one set of 8–12 repetitions, is commonly applied by clinicians, although as yet has still to be scientifically tested. The aim of this project, therefore, is to examine whether the second weekly session is actually beneficial in increasing isometric strength, ROM and decreasing perceived pain.

Materials and methods

Participants

Following approval by the relevant ethics committees, 75 non-specific CLBP patients were assessed for eligibility and of these 72 completed the intervention ($\bar{x} \pm$ SD age = 45.5 $\pm$ 14.1 years; males $n = 42$ and females $n = 30$). Non-completion of training intervention due to relocation from the area ($n = 3$). All participants were attending private physiotherapists in respect of low back pain and provided written informed consent to participate. They were randomly allocated to either training once a week (1 $\times$ week; $n = 31$), twice a week (2 $\times$ week; $n = 20$) or a control group ($n = 21$).

To be eligible, participants had to have suffered from low back pain for at least six months prior to the study but have no medical condition for which exercise is contraindicated. Potential participants completed a health screening form, and those reporting any of the following conditions, symptoms and/or history were excluded from participation: Malignancy or underlying disease, disc herniation, osteoporosis, neurologic or sciatic nerve root compression, previous vertebral fractures, major structural abnormality of the spine, tumour of the spine, problems passing fluid or solids, inflammatory arthritis and pregnancy. All participants were physically screened (by a Chartered physiotherapist with a musculoskeletal and spinal specialty) for significant disc pathology which would exclude their participation. Participants were excluded if the disc problem was significant and caused neural involvement.

A power analysis of previous research with CLBP participants (Holmes *et al.* 1996) was conducted to determine participant numbers (n) using a treatment effect size (ES), calculated using Cohen's d (Cohen 1992), of 1.42 for the MedX lumbar extension. Participant numbers were calculated using equations from Whitley and Ball (2002) and showed that each group required eight to meet the required power of 0.8 at an alpha value of $p < 0.05$.

Study design

A modified randomised control trial design, as defined by Dvir (2007), was adopted. All participants continued their normal course of low back pain treatment and or training, which involved mobilisations, McKenzie protocol, muscle imbalance protocol, home exercises and postural advice/ergonomics to avoid ethical implications of with-holding treatment. The control group continued their normal care but did not train on the lumbar extension machine. Participants within the control group were aware of the study objectives. Following completion of the study the control group were offered the chance to receive the lumbar extension training. Pre testing consisted of maximal lumbar isometric strength, ROM, modified-modified Schober's flexion test and completion of the Oswestry disability index (ODI) and the visual analogue scale (VAS). The intervention consisted of a 12 week training programme which was then followed by post testing (maximal lumbar isometric strength, ROM, modified-modified Schober's flexion test and completion of the ODI and the VAS). The study outcomes were changes in maximal strength, ROM (through measures from the machines goniometer and the modified-modified Schober's test) and reduction in pain (measured by the VAS and ODI).

Strength tests

All isometric strength tests and dynamic strength training sessions were conducted by members of the research team who were fully certified by the manufacturer to operate the lumbar extension machine (MedX, Ocala, FL). The machine incorporates a pelvic restraint mechanism and a counterweighting procedure to counterbalance the mass of the upper body and also the effects of gravity acting on the upper body. The validity and reliability of both the restraint and counterweighting procedures are well-established (Graves *et al.* 1990b, Inanami 1991) and the torque measurements show very high test–retest reliability at all angles ($r = 0.94$–0.98; Pollock *et al.* 1991).

Participants completed two isometric lumbar extension strength tests administered one week apart. As previous research (Graves *et al.* 1990b) has shown, it is important that participants are familiar with the testing procedure to produce reliable results, the initial testing session was designated as a familiarisation session. The second test was used to obtain pre-test measures of lumbar extension strength.

In accordance with standard procedure on this machine, isometric lumbar extension torque was measured at intervals of $12°$ from $0°$ to $72°$ of lumbar flexion with a 10 s rest between each joint angle. Prior to testing, the restraining and counterweighting procedures were carried out, and lumbar ROM in the machine was measured using the machine's goniometer.

Following these procedures, strength tests were conducted at each joint angle using the procedure described above, any tests in which the participant felt he or she did not give a maximal effort were repeated. Following completion of the training protocols described in the following section, the strength tests were repeated.

Strength training

Participants in the $1 \times$ week group performed one lumbar extension training session per week for 12 weeks. This involved one set of approximately 8–12 repetitions at a weight equivalent to approximately 80% of the maximum TFT (tested functional torque, or maximal voluntary isometric torque) through the participant's full ROM on the lumbar extension machine to volitional fatigue within a time frame of 70–105 s. Participants in the $2 \times$ week group performed two lumbar extension training sessions per week for 12 weeks. The first session was identical to that of the $1 \times$ week group. The second weekly session (typically undertaken 3 days after the first session to allow for any delayed onset of muscle soreness to reside) was undertaken with a weight equivalent to approximately 50% of the maximum TFT that resulted in participants exercising for a period of time between 105 and 140s. Both intensities (50% and 80% of maximum TFT) were used as per the manufacturer's guidelines. Repetitions for both groups were performed slowly, with 2 s taken to lift the weight and 4 s taken to lower it. When participants could perform more than 12 repetitions (or for more than 140 s in the second weekly session in the $2 \times$ week group), the weight was increased by approximately 5%. This training protocol is standard in studies using the machine, and has been found to produce optimal strength increases (Graves *et al.* 1990b).

Range of motion tests

ROM was measured by the goniometer within the MedX lumbar extension machine. Standing ROM was measured using the modified-modified Schober's test (Williams *et al.* 1993). The modified-modified Schober's test is a measure of the ROM of the lumbar spine and is widely used in health care settings (Tousignant *et al.* 2004). In order to undertake the modified-modified Schober's test pen marks were made at each of the posterior superior iliac spines (PSIS). Another mark was made at the midline of the lumbar spines horizontal to the PSIS and a final mark was then made 15 cm above this mark. Whilst holding a tape measure close to the participant's skin, he or she bent over as though to touch the toes whilst a reading was obtained to ascertain any change in the original 15 cm measure.

Questionnaires

The ODI was used in this study. It is a questionnaire that gives a subjective percentage score of level of disability in activities of daily living resulting from low back pain (Fairbank *et al.* 1980). It has a high degree of sensitivity as a measure of change following treatment (Fisher and Johnston 1997), high test–retest reliability (intraclass correlation of 0.94; Holm *et al.* 2003) and a high correlation with pain intensity (Gronblad *et al.* 1989). Participants were given explicit verbal instruction on how to complete the ODI and adequate time to ask questions prior to completing it.

The VAS used in this study consisted of a 10cm line anchored by two extremes of pain. Participants were given explicit verbal instruction on how to complete the VAS with appropriate and specific anchoring statements. The participants were given the instruction that the far left end of the line represented 'no pain at all'. They were then

told that the far right end of the line represented 'the worst pain imaginable' and examples were given from the participants' own histories and they were asked to compare this to the worst pain they had ever felt. The participants were then asked to mark a straight line to dissect the VAS line at the point at which they felt their pain was at currently. All participants were asked to confirm they understood the instructions and were provided with opportunity for questions prior to completing the VAS. This method has been shown to be reliable, with no differences found when administered by different testers (Olagun *et al.* 2004) and possesses a high degree of predictive validity (Jensen *et al.* 1986). To investigate if the changes in VAS scores were meaningful, the minimal clinical important change (MCIC) was calculated from the mean differences between the post and the pre intervention VAS scores (Kovacs *et al.* 2008). A MCIC of between 15 and 35 is typically observed in patients with chronic low back pain (Kovacs *et al.* 2007, 2008).

Data analysis

The TFT (maximal strength) was measured in foot pounds (ft.lb^{-1}) and converted to Newton meters (N.m) for analysis. Descriptive statistics were calculated for all dependent variables. A 3×2 (group $\times$ test) ANOVA was performed to examine the between (differences between the groups), within (differences between pre- and post-tests) and interaction effects (combination of both between and within effects) of the interventions on isometric torque, ODI, Schober's flexion and VAS scores, with Tukey LSD tests being completed when appropriate. On further analysis of the pre-test data for Schober's flexion and VAS, it was noted there were significant differences between the groups. To ensure the true effect of the intervention on these measures was determined, the delta values were analysed. The alpha level was set at $p < 0.05$. Paired samples *t*-tests with a Bonferroni adjustment were conducted on each group to determine the within groups effects. Taking into consideration the Bonferroni adjustment, the alpha level for each test was set at $p < 0.017$.

Results

The performance characteristics of the participants are detailed in Tables 1 and 2.

Table 1. Mean ($\pm$ SEM) torque (N.m) pre and post for $1 \times$ week training ($n = 31$), $2 \times$ week training ($n = 20$) and control group ($n = 21$).

	0°[†][*]	12°[†][*]	24°[†][*]	36°[†][*]	48°[†][*]	60°[†][*]	72°[†][*]
1 × week (Pre)	121.0 (±13.2)	179.5 (±19.6)	202.5 (±19.6)	223.3 (±22.6)	243.4 (±24.5)	276.7 (±25.8)	283.3 (±30.2)
1 × week (Post)	215.6 (±15.3)	260.4 (±19.8)	288.1 (±22.1)	295.1 (±24.0)	311.7 (±26.8)	337.9 (±29.5)	332.3 (±29.9)
2 × week (Pre)	115.0 (±12.0)	156.7 (±14.3)	177.5 (±15.0)	197.4 (±16.7)	214.9 (±16.9)	236.8 (±21.3)	273.9 (±25.3)
2 × week (Post)	168.9 (±19.6)	214.2 (±21.2)	238.8 (±18.3)	253.7 (±19.9)	283.4 (±23.8)	301.7 (±22.6)	317.3 (±22.5)
Control (Pre)	151.6 (±18.3)	195.9 (±20.3)	218.1 (±22.5)	241.9 (±24.6)	241.8 (±25.2)	278.8 (±29.5)	265.9 (±28.6)
Control (Post	165.0 (±18.2)	203.5 (±18.9)	229.9 (±23.0)	230.7 (±22.0)	251.1 (±26.5)	274.1 (±28.0)	265.6 (±27.1)

Note: † $p < 0.05$ between training group (1 × week/2 × week) and control; ‡ $p < 0.05$ between training conditions; * $p < 0.017$ between pre-test and post-test.

Table 2. $\bar{x}$ diff ($\pm$ SD) and 95% CI for VAS scores, mean ($\pm$ SEM) Schober's values, Oswestry disability index (ODI) and visual analogue (VAS) scores for $1 \times$ week training ($n = 31$), $2 \times$ week training ($n = 20$) and control group ($n = 21$).

	VAS (mm)			Schober's (cm)	ROM (°)	ODI (%)
	$\bar{x}$ diff ± SD	95% CI				
1 × week	−16.4 ± 14.6[†][*]	−21.2 to −9.6	1 × week (pre)	16.1(±0.6)	65.5 (±1.6)	31.4 (±2.6)
			1 × week (post)	16.7 (±0.6)[†][*]	67.8 (±1.3)*	16.0 (±2.1)[†][*]
2 × week	−21.0 ± 16.4[†][*]	−29.2 to −12.8	2 × week (pre)	19.4 (±0.6)	60.9 (±2.6)	29.2 (±2.6)
			2 × week (post)	20.3 (±0.7)[†][*]	67.7 (±1.6)*	17.1 (±2.4)[†][*]
Control	−0.04 ± 4.5	−2.5 to 1.7	Control (pre)	14.4 (±0.2)	66.6 (±2.0)	32.3 (±1.4)
			Control (post)	14.0 (±0.5)	66.6 (±2.0)	30.4 (±2.0)

Note: † $p < 0.05$ between training group (1 × week/2 × week) and control; ‡ $p < 0.05$ between 1 × week and 2 × week; * $p < 0.017$ between pre-test and post-test.

Maximal strength

There was a significant within groups effect ($F_{(1, 69)} = 61.32$, $p < 0.001$, partial $\eta^2 = 0.47$) when comparing mean post-test scores with pre-test scores and a significant interaction effect ($F_{(1, 69)} = 15.63$, $p < 0.001$, partial $\eta^2 = 0.31$). Statistically significant pre-test differences were not apparent among any of the groups ($F_{(2, 69)} = 0.588$, $p = 0.588$, partial $\eta^2 = 0.017$). Three paired samples *t*-tests with a Bonferroni adjustment were conducted on each group. The findings indicated a significant increase in maximal strength scores when training $1 \times$ week and $2 \times$ week ($t_{(30)} = -6.42$, $p < 0.001$ and $t_{(19)} = -6.68$, $p < 0.001$), respectively (Table 1).

Range of movement (ROM)

The 3×2 ANOVA produced a significant interaction ($F_{(2, 69)} = 8.86$, $p < 0.001$, partial $\eta^2 = 0.20$) and within groups effect ($F_{(1, 69)} = 23.23$, $p < 0.001$, partial $\eta^2 = 0.25$) but not between groups ($F_{(2, 69)} = 0.562$, $p = 0.573$, partial $\eta^2 = 0.016$). Paired samples *t*-tests with a Bonferroni adjustment were conducted on each condition. Significant increases in ROM were yielded by the $1 \times$ week training ($t_{(30)} = -2.65$, $p = 0.01$) and the $2 \times$ week training ($t_{(19)} = -3.85$, $p = 0.001$; Table 2).

Schober's flexion

A significant interaction effect was also found for the Schober's test results ($F_{(2, 69)} = 4.47$, $p = 0.02$, partial $\eta^2 = 0.12$). The within groups effects were also significant ($F_{(1, 69)} = 4.90$, $p = 0.03$, partial $\eta^2 = 0.07$), as were the between groups effects ($F_{(2, 69)} = 19.91$, $p < .001$, partial $\eta^2 = 0.37$). However, further analysis of the difference in pre- and post-training values observed no significant differences between the $1 \times$ week (0.6 ± 0.6) and $2 \times$ week (0.8 ± 1.0) groups ($p = 0.89$). Further analysis using paired samples *t*-tests with a Bonferroni adjustment on each group showed an increase in Schober's flexion in participants in the $1 \times$ week group ($t_{(30)} = -6.06$, $p = 0.001$) and $2 \times$ week group ($t_{(19)} = -3.68$, $p = 0.002$) (Table 2).

Oswestry disability index (ODI)

Significant within groups effects ($F_{(1, 63)} = 57.06$, $p < 0.001$, partial $\eta^2 = 0.48$), between groups effects ($F_{(2, 63)} = 3.95$, $p < 0.024$, partial $\eta^2 = 0.11$) and interaction effects ($F_{(2, 63)} = 15.13$, $p < 0.001$, partial $\eta^2 = 0.32$) were found for the ODI. Three paired samples *t*-tests with a Bonferroni adjustment were performed on the three groups. There were significant decreases in both the $1 \times$ week ($15.5 \pm 12.7\%$) and $2 \times$ week ($13.0 \pm 8.0\%$) training groups ODI scores, $t_{(28)} = 6.34$, $p < 0.001$ and $t_{(16)} = 6.56$, $p < 0.001$, respectively (Table 2).

Visual analogue scale (VAS) for pain

Significant between group effects ($F_{(2, 62)} = 6.1$, $p = .004$, partial $\eta^2 = 0.16$) and within group effects ($F_{(1, 62)} = 56.11$, $p < 0.001$, partial $\eta^2 = 0.48$) were found for the VAS. There was also a significant interaction effect ($F_{(2, 62)} = 13.15$, $p < 0.001$, partial $\eta^2 = 0.30$). However, further analysis of the difference in pre- and post-training values observed no significant differences between the $1 \times$ week (-15.4 ± 14.6 mm) and $2 \times$ week (-21.0 ± 16.4 mm) groups ($p = 0.34$). To identify differences within the groups, three paired samples *t*-tests with a Bonferroni adjustment were conducted. Significant differences between pre- and post-test scores were found in both the $1 \times$ week (16.4 ± 14.6 mm) and $2 \times$ week (21.0 ± 16.4 mm) training groups ($t_{(26)} = 5.49$, $p < 0.001$; $t_{(17)} = 5.43$, $p < 0.001$), respectively. Table 2 shows the VAS $\bar{x}$ differences $\pm$ SD and 95% CI data between the VAS scores obtained before and after the intervention. The MCIC was obtained for both the $1 \times$ week (-16.4 ± 14.6) and $2 \times$ week groups (-21.0 ± 16.4) but not for the control group (-0.04 ± 4.5; Table 2).

Discussion

Most previous lumbar extension research suggests that individuals do not gain greater isometric strength by performing such training more than once a week (Graves *et al.* 1990b, Carpenter *et al.* 1991, Boyce *et al.* 2008); these studies considered asymptomatic un-trained individuals, not those suffering from CLBP. The MedX Educational Program advocates two weekly workouts; the second of which is a 'light recovery session'. The present study was designed to identify whether this second weekly workout promotes improvements in isometric

strength, flexibility (measured through the MedX goniometer and the Schober's test) and pain reduction (measured through the ODI and the VAS).

The pre- and post-isometric strength increases for both $1 \times$ week and $2 \times$ week groups in this study are consistent with previous findings (Graves *et al.* 1990b, Boyce *et al.* 2008). No significant differences between training groups were observed. However, it should be noted that not all literature supports the notion that increases in isometric strength would be of assistance in lessening low back pain or preventing this in the work place.

De Looze *et al.* (1998) reported that when nurses had the strength of their low back musculature tested and then compared this to the success of undertaking specific job demands, there was no evidence that strong low back musculature meant they could undertake their job more effectively. However, it is not clear as to how the researchers account for the effect of low back isolation during their isometric testing and in turn the contribution of other musculature during the job demands rendering the two modes (i.e. the low back isometric strength testing compared against the work place tasks) relatively incomparable. Interestingly, they conclude by suggesting strength-based exercises may still aid in reducing the frequency of low back pain prevalence in nurses.

Holmes *et al.* (1996) found that patients suffering from CLBP significantly ($p < 0.05$) increased ROM (from the MedX goniometer) from $59.2°$ to $68.2°$ which is consistent with the current study's findings. This is a $9°$ increase, equating to 15%, from an average of one workout every 4.85 days. Interestingly, Nelson *et al.* (1995) reported significant increases ($p < 0.001$) from $54°$ to $63°$ (also an increase of $9°$), where participants performed an average of two workouts per week. The research from Nelson *et al.* (1995) appears to suggest that training twice weekly increases ROM although the present study showed it is still possible to significantly improve ROM training only once per week ($p = 0.01$). However, Nelson *et al.* (1995) incorporated aerobic exercise as well as training other muscle groups (abdominals, hamstrings and glutei) which in itself could have contributed to increased ROM, whilst Holmes *et al.* (1996) implemented a protocol where training time was greater than 2 min per workout, or 20 repetitions in comparison to the present study which involved workouts of 70–105 s and 105–140 s for 80% and 50% max TFT respectively. If we also consider the disparity between back pain ailments, that likely affect individual persons in different ways, it makes comparison of ROM between the studies highlighted highly unreliable, except to conclude simply that the evidence suggests training on the lumbar extension machine significantly increases ROM with no discernable difference between training $1 \times$ week and $2 \times$ week.

The Schober's flexion pre-test data from the present study supported an increased ROM and was similar ($\bar{x} \pm$ SD 6.1 ± 3.4 cm) to other data obtained for those with CLBP from research by Tousignant *et al.* (2004; $\bar{x} \pm$ SD 6.3 ± 1.4 cm). The results from the current study showed statistically significant increases in flexibility between pre- and post-tests for the $1 \times$ week ($p = 0.001$) and $2 \times$ week ($p = 0.002$) groups, of 0.6 cm ($1 \times$ week) and 0.9 cm ($2 \times$ week), with no improvement within the control group. Again these changes are consistent with other research using alternative methods of treatment such as acupuncture (Inoue *et al.* 2006: $\bar{x} \pm$ SD 1.0 ± 0.6). In the present study, with an absence of statistically significant differences between the $1 \times$ week and $2 \times$ week groups, we once again conclude that there is nothing to be gained by completing a second weekly workout.

In accordance with the strength and flexibility increases, the MedX training groups demonstrated significant reductions in self-rated disability (ODI) between pre- and post-tests, in contrast to the control group. The ODI showed decreases in subjective pain for both the $1 \times$ week (48%), and $2 \times$ week (41%) groups, respectively, but showed no statistically significant differences between these two groups. This is similar to other research undertaken on participants with CLBP by Brox *et al.* (2003). Their results also showed significant reductions in the ODI scores of 28% for those in the cognitive and exercise intervention group and 36% for those in the surgical lumbar fusion group.

The VAS showed a similar decrease in pain ($p < 0.017$) between pre- and post-test for both training groups, whilst no improvements were seen for the control group. Once again there was no difference in the improvements between the $1 \times$ week and $2 \times$ week groups showing reduction in pain was not further improved by a second weekly workout. Both the $1 \times$ week and $2 \times$ week group did show a reduction that meets the minimally clinical improvement change, which is consistent with other researchers (Kovacs *et al.* 2007, 2008). However, when compared to healthy asymptomatic participants (9 mm; Keyserling *et al.* 2005), who did not use the MedX lumbar extension machine, the change in VAS score in the current study was greater (16–21 mm). This may suggest a potential advantage of undertaking exercise on this machine for those with CLBP.

The data herein further support previous research that muscular pain is potentially a result of muscular weakness (Graves *et al.* 1989, Pollock *et al.* 1989) and that resistance training of the lumbar muscles improves isometric strength and both reduces lower back pain (Nelson *et al.* 1995) and increases flexibility. This is in addition to the findings of Warming *et al.* (2008) who noted that physical training (as the present study has done) in combination with correct lifting and manoeuvring techniques minimised the incidence of CLBP in nursing

personnel. This all suggests important potential applications to the workplace through personnel training on the lumbar extension machine in order to help prevent and/or reduce CLBP.

Research by Mooney *et al.* (1995) has shown that using the MedX lumbar extension machine once a week can increase strength and also reduce the likelihood of injury in the workplace. This was evidenced through a reduction in back injuries from 2.94 per 200,000 employee hours to 0.52. Also, the average worker's compensation liability decreased from $14,430 per month to $ 380 per month. However, in terms of the aims of this study, our findings suggest that these benefits can be obtained from a single weekly workout to fatigue, and that a second weekly workout does not produce additional improvements in these variables. This has implications for workers as it requires less time (1 × week vs. 2 × week) completing the required exercise making this a very time efficient method to improve symptoms and address CLBP.

It should be noted that the present study considered the second weekly workout in the format of a 'light recovery session' (~50% Max TFT) and whilst the consideration of a second or third weekly session to fatigue using a higher% Max TFT showed no benefits to untrained persons (Graves *et al.* 1990b), but it has not been considered with patients suffering from CLBP. This would therefore be an interesting avenue for future research. It has been suggested that regular movement of the lumbar spine may help to reduce the loss in hydration that occurs with aging of the intervertebral discs (Norris 2008) as discs with lower osmotic pressures and decreased annular stresses are more likely to enhance the opening of cracks in the annulus and lead to herniation (Wognum *et al.* 2006). Thus, further study using magnetic resonance imaging should be undertaken to confirm whether the second weekly workout allows for potential disc re-hydration.

In conclusion the present study suggests that in the rehabilitation of workers suffering from chronic lower back pain, resistance training of the lumbar muscles improves isometric strength and ROM, as well as decreasing pain. The data herein support previous literature that shows there is no greater strength benefit to be obtained by training more frequently than once per week which may suggest a more time effective mode of preventative and rehabilitative training. In addition, our findings show that training twice weekly will produce no greater improvements in flexibility (ROM), perceived pain or isometric strength compared to a single weekly workout to fatigue.

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