Comparison of a six month non-aggravating gym rehabilitation program verses usual surgical advice post lumbar discectomy: A prospective randomised control trial with 3 year follow up

Barry Donaldson
University of Otago Christchurch, Christchurch, New Zealand

Introduction

Lumbar discectomy is now the operation of choice for lumbosacral radicular syndrome. Few studies have been undertaken on the post-surgical management of these cases and most have compared one exercise regime to another. The aim of this study was to compare long term outcomes of usual surgical advice involving no formal post-surgical rehabilitation, with a non-aggravating six month gym rehabilitation programme post-lumbar discectomy. This study is a prospective randomized controlled trial using a cohort followed for three years.

Method

The patients were computer randomised into two groups. Group A, (control group) followed usual surgical advice which was to resume normal activity as soon as pain allowed. Group B, (trial group) undertook the gym rehabilitation programme.
Inclusion criteria: Age17 to 65 years, good health and no major medical problems. The surgical level had to be L3, L4, or L5.
Exclusion criteria: Central neurological disorders, communication difficulties, any condition making gym-based exercises unsafe, or if the surgery was indicated for spinal infection, tumour or inflammatory disease.
Patients were followed for a three year period using validated outcome measures (Roland-Morris Questionnaire and Oswestry Low Back Pain Index) and an annual Quality of Life (QoL) questionnaire. A sample of 40 per group provided the study with 80% power ($P<0.05$) to detect a 3.5 point change in the RMQ and a 10% change in the ODI. The annual questionnaire reported information on number of general practitioner (GP) visits, other therapist visits, medication levels and time off work.

Results

Ninety three participants were randomised; Control n=46 and trial n=47. Eighty nine participants completed the study (83%). Randomisation achieved a balance of confounding factors, with the exception of work heaviness, where there were a greater number of participants in the very heavy and heavy categories in the trial group ($P<0.01$).Thirty nine of 47 participants completed the gym programme (83%). Functional outcome measures did not show statistically significant differences between groups over the three year period. However, key findings of cumulative three year data for the QoL questionnaire were: on intent-to-treat analysis; fewer participants in the trial group visited their GP, $P=0.007$ (18% vs 5%). In the per protocol subset; the trial group had fewer episodes off work $P=0.084$ (range control 0-3 vs trial 0-2). Fewer participants visited their GP $P= 0.027$ (range control 0-9 vs trial 0-

3), and of those that did, the trial group had fewer total number of GP visits (some participants visited their GP more than once) P=0.05 (range control 0-22 vs trial 0-6). In the per-protocol minus re-operation group the trial group also had fewer GP visits P<0.014 (range control 0-7 vs trial 0-2), fewer patients requiring medication use P=0.05 (37% control vs 17% trial) and fewer days off work P=0.099 (range control 0-30 vs trial 0-3).

Discussion

Although the functional outcome measures did not significantly differentiate the control and trial groups, the results indicated an advantage with regard to episodes of time off work, GP visits and medication use for the participants in the trial group who completed the programme. As time off work is a significant consideration for funding providers, these results suggest that surgeons should consider referral of discectomy patients to appropriate post-surgical rehabilitation programmes.

The physiotherapy rehabilitation programme used in the study outlined in the abstract above is described in the following sections. The rehabilitation programme itself is first described followed by the principles that underpinned the design of this programme.

The physiotherapy rehabilitation programme

The programme used in this study was of six months (26 weeks) duration and consisted of three phases; conditioning, hypertrophy and strength. All three phases included warm-up and warm-down exercises that were usually rowing on a rowing ergometer, exercycling or using a cardio-glide. The conditioning phase lasted for eight weeks and consisted of eight gymnasium based resistance exercises (Figure1). The hypertrophy phase was nine weeks duration and consisted of three parts; hypertrophy A, hypertrophy B, and hypertrophy C. Each hypertrophy programme was three weeks long and again included eight gymnasium based resistance exercises (Figure1). Therefore, during this phase 24 different resistance exercises were used. The strength phase was a repeat of hypertrophy phase in terms of structure and exercises (Figure1) but used sets and repetitions of 15 (pre-warm-up set) 10-8-6 (training sets).

Figure 1: An outline of all gymnasium based exercises used in the 26 week long programme, including sets and repetitions for each phase.

Conditioning 3x 10,12,15	Hypertrophy 12-10-8			Strength 10-8-6		
(8 weeks)	A (3 weeks)	B (3 weeks)	C (3 weeks)	A (3weeks)	B (3 weeks)	C (3 weeks)
Warm up	Warm up	Warm up	Warm up	Warm up	Warm up	Warm up
Seated bench press	Seated bench press	Flat DB flys / Pec deck	Inclined DB press	Seated bench press	Flat DB flys / Pec deck	Inclined DB press
Prone pull	Prone pull	Seated row	One armed pulls	Prone pull	Seated row	One armed pulls
Prone fly	Prone fly	Inclined prone fly	Reverse pec deck	Prone fly	Inclined prone fly	Reverse pec deck
Front pull down	Front pull down	Close grip pull down	Upright Row	Front pull down	Close grip pull down	Upright Row
Leg press	Leg press	Lunges	Backward lunge	Leg press	Lunges	Backward lunge
Pulley hamstring curls (standing)	Pulley hamstring curls (standing)	Butt kick	Hamstring curl (lying)	Pulley hamstring curls (standing)	Butt kick	Hamstring curl (lying)
Dumbbell bicep curl	Dumbbell bicep curl	Bicep curl with a bar	Inclined DB bicep curl	Dumbbell bicep curl	Bicep curl with a bar	Inclined DB bicep curl
Tricep push down	Tricep push down	Elbow extension	DB press	Tricep push down	Elbow extension	DB press
Warm down	Warm down	Warm down	Warm down	Warm down	Warm down	Warm down

Note: DB = Dumbbell

Standard resistance levels, based on percentage maximums for a particular phase were not used for setting resistance levels in the rehabilitation programme. These percentage maximums are based on one repetition maximum (1RM) resistance levels; they are not appropriate for an injured population due to the risk of further injury.

The conditioning phase: The following method was used to ascertain an initial starting resistance level for participants and then progress them during the conditioning phase:

- The participant was asked to perform an exercise at a low setting on each piece of equipment. This level of resistance was perceived by the physiotherapy trainer to be well within the participant's ability; it initially allowed the participant to feel the movement without significant resistance. The resistance level was then gradually increased to the point whereby the participant was aware of having to work to complete the movement, but was not stressed by doing so. Three sets of 10 repetitions were performed for each exercise, with a 20 - 30 second rest between sets.
- When 3x10 repetitions could be performed comfortably, the repetitions were increased to 3x12.
- When 3x12 was comfortable, the repetitions were increased to 3x15.
- When 3x15 was comfortable the participant increased the resistance level, and decreased the repetitions to 3x10. The level of increase

managed by the participant was either one weight level (this meant moving the pin on the stack to one weight level heavier or a half weight level if this was too much) or if using free weights, a suitable weight was added.

- On this increased resistance level the participant worked up through the repetitions to 3x15, before repeating the cycle.

This method of resistance level progression was a crucial aspect of the programme. Each exercise was increased on an individual basis. As soon as participants were able to increase any individual exercise, they did so. This applied to all exercises throughout the duration of the rehabilitation programme.

The hypertrophy phase: The resistance level was set so that participants could just manage to lift the weight 12, 10, and 8 times with correct technique and with no cheating. Performing the exercises without using 'cheat's tricks' is crucial, as this prevents over-exertion. When participants were able to lift or push the weight 13, 11 and 9 times, whilst maintaining good technique, they were then allowed to increase the level of resistance.

Because 'hypertrophy A' programme exercises were identical to those used in the initial conditioning programme (Figure1), the participants were familiar with these exercises and their resistance levels. This facilitated the physiotherapist in setting appropriate resistance levels for the 'hypertrophy A programme'.

As the participants progressed on to 'hypertrophy B and C' programmes with different exercises, the physiotherapist developed a clinical appreciation of each participant's strength level. When a new exercise was demonstrated, the same routine (used in the conditioning phase) was used to set the resistance level. A relatively light resistance was initially used so that the participant was able to 'feel' the new movement. The participants were asked if this resistance level felt light or medium. The resistance level for each set of 12, 10 and 8 repetitions was set accordingly. At the end of the hypertrophy phase, the final phase of the rehabilitation programme, strength, was explained.

The strength phase: Consisted of three separate programmes, each of three weeks duration. Exercises in the strength phase replicated exercises performed in the hypertrophy phase (Figure 1). The only difference was that in the strength phase, sets and repetitions of 10-8-6 were used.

Participants set appropriate resistance levels according to the following guidelines. The weight that participants lifted (or pushed) in the hypertrophy phase using 8 repetitions, was the starting resistance level in the strength phase with 10 repetitions. For example, in the Prone Pull exercise for the hypertrophy phase; if a participant lifted 15kgs, 17½kgs, and 20kgs for their sets of 12, 10 and 8 repetitions, respectively; in the strength phase the participant might lift 20kgs, 22½kgs, and 25kgs for 10, 8, and 6 repetitions, respectively. By this stage, the participants already knew all of the exercises, and were familiar with formulating levels of resistance.

At the end of the strength phase, the participants were given advice on how to maintain the heightened level of fitness and strength they had achieved. They were encouraged to maintain fitness and health in whatever way they found to be the most enjoyable and convenient (e.g. running, racket sports, swimming, yoga, pilates).

The programme also included abdominal training as advocated by Richardson and Jull (1995), the specific exercise practised was the abdominal indrawing exercise in prone lying using a pressure biofeedback unit or the technique described by Sahrmann in the text Diagnosis and treatment of Movement Impairment Syndrome (Shirley A Sahrmann, pp 373-377). The final component of the rehabilitation programme was one session dedicated to teaching correct functional lifting technique, this technique focussed on body balance and the participant using their own body weight to lift an object.

Principles of exercise prescription for the injured person

Exercises must not aggravate or increase pain; the 'no pain no gain' attitude is not appropriate for the injured person (McGill, 2007). Studies have demonstrated that pain reduces compliance in relation to exercise programmes (DeAnna et al., 2006; Der Ananian, Wilcox, Saunders, Watkins, & Evans, 2006). DeAnna et al. investigated factors that predicted compliance in Gulf War veterans affected by fatigue, musculoskeletal pain and cognitive problems. The strongest predictors of compliance in the follow-up period were less pain and greater age. Der Ananian et al. studied the compliance to exercise programmes among people with arthritis of the knee. They found that pain was the most commonly mentioned barrier to exercise. These studies demonstrate that when prescribing exercise programmes for patients with injuries, it is important that the exercise programme itself does not cause or increase pain, as this may lead to reduced patient compliance.

However, while it is important that exercise programmes do not cause pain, a degree of muscle stiffness due to microtrauma is acceptable. Microtrauma due to increased loading on muscles, causes protein break down within the muscle filaments which leads to an increase in actin and myosin filaments. This process along with sarcomere addition, leads to muscle hypertrophy (Baechle & Earle, 2000) and is a normal physiological side effect of exercise. It occurs when muscles adapt to external loading that leads to increased strength (Zatsiorsky, 1995). It is important to explain microtrauma as this avoids unnecessary fear or surprise when patients experience the resultant sensation of muscle stiffness (Friedrich, Gittler, Arendasy, & Friedrich, 2005). Friedrich et al. conducted a study with chronic low back pain patients comparing a usual exercise programme with the same exercise programme plus a cognitive motivational educational programme. The study demonstrated a long-term benefit in favour of the exercise plus motivation group; this was statistically significant in terms of work ability at five years post-intervention. The work by Friedrich et al. highlights the importance of patient education when prescribing exercise programmes.

Selected exercises must be simple. The exercise movements should be away from and towards the body (Wise, Uhl, Mattacola, Nitz, & Kibler, 2004). Long lever exercises and complex exercises that require high levels of skill should

be avoided (Kraemer & Ratamess, 2004). Large multi-joint muscle groups should be exercised first, followed by small single joint muscles. This order of exercise enhances strength gains (Kraemer & Ratamess, 2004; Ratamess et al., 2009; Stone, O'Bryant, & Garhammer, 1981).

It is preferable to avoid targeting the injured area in the early or acute phase. In the case of the study reported here, the injured area was the low back. In this situation by training the upper and lower body, the lower back and core of the body strengthen by providing a stable base, while the upper and lower body exercises are executed. This concept is evident in the research conducted by (Hodges, 1997; Hodges, Cresswell, & Thorstensson, 1998). In this research Hodges et al. studied the effect on core abdominal muscles when an upper or lower limb was moved. These authors provided evidence indicating that core muscles are exercised indirectly, when the upper or lower limbs are moved or exercised.

Ploutz, Tesch, Biro and Dudley (1994) completed a study where one quadriceps muscle of the participants was trained twice per week for six weeks; the other quadriceps muscle was used as the control muscle. They found that after six weeks, the quadriceps muscle that had been trained had increased its 1 RM strength by 14%; the quadriceps muscle that had no training increased its 1 RM by 7%. The authors explained this objective gain in the untrained muscle due to increased neural activity in the cortex of the brain. Neural brain activity in the motor cortex is an important component of muscle strengthening (Enoka, 1988; Hakkinen & Hakkinen, 1995; Schantz, 1983). This research demonstrated that it is possible to indirectly work one area of the body, whilst focussing specifically on other body areas. In exercise programmes, while the exercises used may focus on the upper or lower body, they may still have an indirect effect on the core or low back areas of the body.

Warm-ups are important for preparing muscles prior to exercise; warm-downs prevent excessive lactate irritation (Beedle & Mann, 2007; Holt & Lambourne, 2008; Stewart & Sleivert, 1998; Tessitore et al., 2008). By increasing blood flow, the body experiences a flushing effect that eliminates excess lactic acid from the blood (Tessitore et al., 2008). In the hypertrophy and strength phases, the pre-warm-up sets are important for preparing the muscles to lift or push heavy weights (Davis, Wood, Andrews, Elkind, & Davis, 2008). Using a pre-warm-up set, the muscle begins the process of motor unit recruitment known as post-activation-potentiation (PAP) (Robins, 2005). Post-activation - potentiation is most commonly used in complex training, where heavy resisted exercise is used in combination with an explosive or pliometric functional exercise such as, a vertical jump (Weber, Brown, Coburn, & Zindor, 2008). By performing a pre-warm-up set of higher repetition and lower weight, PAP better prepares the muscle to withstand greater force.

Correct technique is essential when performing exercises (Zatsiorsky, 1995). Sometimes when a patient is working hard to lift a weight, there is a tendency to use ‘cheat’s tricks’. That is, the patient puts their body weight behind the movement by twisting or leveraging the body; this can cause injuries and

should not be permitted. If a patient has to use ‘cheat’s tricks’ to lift the weight, the weight is too heavy, and should be decreased (Zatsiorsky, 1995).

Injured patients must ‘train not strain’. Whilst performing each exercise, patients should ‘brace their abdominals’ as described by Grenier and McGill (2007). They demonstrated that this abdominal brace technique provided the lumbar spine with maximal spinal stability, and greater stability when compared to the abdominal hollowing technique as described by other authors (Hodges, 1999; Urquhart, Hodges, Allen, & Story, 2005). The Grenier and McGill study is also supported by Brown, Vera-Garcia and McGill (2006). By bracing the abdominals during each exercise, the patient is subconsciously training these muscles to function in this way in everyday life. It is hypothesised that when they are performing activities of daily living, these muscles are more likely to automatically contract, and confer support to the spine. However, no literature could be found concerning the hypothesis that functional training of the abdominals, leads to an improvement in functional performance of the lumbar spine.

Finally, it is important to train with symmetry. This means that all exercises should be performed bilaterally rather than unilaterally. Bilateral exercises tend to balance the forces through the spine. Unilateral exercises lead to imbalanced forces being applied to the spine. This occurs if patients allow their bodies to twist in order to leverage their bodyweight behind the lift, which can lead to stress and strain on the body. Bilateral exercises limit this tendency.

Conclusion

Exercise prescription for the injured person is a complex and evolving area of practise for physiotherapy. When patients suffer injuries that force them to reduce their activity levels for prolonged periods, they physically deactivate. The literature reveals that loss of strength can lead to a loss of function. However, there is also evidence that demonstrates regenerating strength leads to improved functional capacity. The rehabilitation programme used in this study was based on this philosophy and the results of this study, in a limited manner, support the concept of strength training for the injured person. There are currently many different philosophies of treatment available for a variety of injury sub-classifications. Further research is required to assist the clinician in the decision making process as to the best treatment method for each individual patient.

Correspondence: Barry Donaldson, resch@paradise.net.nz

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