Eur Spine J (1999) 8 : 170–178

ORIGINAL ARTICLE

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Is there a rational basis for post-surgical lifting restrictions? 1. Current understanding

Received: 31 July 1998
Revised: 21 January 1999
Accepted: 11 February 1999

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Abstract Lifting restrictions postoperatively are quite common, but there appears to be little scientific basis for them. Lifting restrictions are inhibitory in terms of return to work and may be a factor in chronicity. The mean functional spinal motion unit stiffness changes with in vitro or computer-simulated discectomies, facetectomies and laminectomies were reviewed from the literature. We modified the NIOSH lifting equation to include another multiplier related to stiffness change post surgery. The new recommended lifts were computed for different lifting conditions seen in industry. The reduction of rotational stiffness ranged from 21% to 41% for a discectomy, 1% to 59% for a facetectomy and 4% to 16% for a partial laminectomy. The recommended lifts based on our modified equation were adjusted accordingly. There is no rational basis for current lifting restrictions. The risk to the spine is a function of many other variables as well as weight (i.e., distance of weight from body). The adjusted NIOSH guidelines provide a reasonable way to estimate weight restrictions and accommodations such as lifting aids. Such restrictions should be as liberal as possible so as to facilitate, not prevent, return to work. Patients need more advice regarding lifting activities and clinicians should be more knowledgeable about the working conditions and constraints of a given workplace to effectively match the solution to the patient's condition.

Key words Lifting · Surgery · Return to work · Low back pain · NIOSH

Introduction

After surgery it is a common practice to prescribe lifting restrictions. These seem to be based on a premise that the spine is weaker and thus subject to re-injury when there has been some disruption of the functional spinal motion unit (FSU) due to surgery. Re-injury is not, however, often reported in the literature. More often a failure of fusion is reported [3, 6, 12, 23, 27, 72, 79].

Recurrent low back pain (LBP) or other impairments may exist after back surgery in up to 50% of operated patients [61]. Robert et al. [71] studied the outcome after operation for lumbar herniated nucleus pulposus (HNP). The median duration of postoperative work incapacity was 3.5 months. Seventy-eight percent of the patients resumed full-time work in their previous job, and 75% were pain free. Predictive factors for a good outcome were a preoperative work incapacity of less than 4 weeks and, for men, no daily lifting of heavy weights.

Although most surgeons employ some kind of postoperative lifting restrictions, there is not much scientific literature upon which to base those limitations. If the empirical basis for limitations were correct, one would expect a consensus on the limitations (i.e., there would be a tendency for physicians to agree on the correct restrictions).

Lifting restrictions are not a trivial issue. A restriction may prevent return to work if the employer is unable, or unwilling, to consider work modification, ergonomic change, or light work. In practice, return-to-work rates range from a low of 15% [5] to a high of 100% [66], with an average of 50% of treated patients returning to employment or vocational rehabilitation [8, 11]. Hall et al. [22] found that the probability of successful return to normal duty increased with a recommendation of return to work unrestricted. Carragee et al. [4] reported that patients undergoing limited open discectomy for lumbar HNP, who were given no restrictions after surgery and were encouraged to return to full activities as soon as possible, had shortened sick leave and reduced complications.

Lindstrom et al. [40] reported on patients with nonspecific mechanical LBP who were studied to compare mobility, strength and fitness after traditional care with or without graded activity with behavioral therapy. The patients in the activity group returned to work sooner. Range of motion, abdominal endurance and lifting capacity correlated with return to work. In a later study they reported that a workplace visit made by a clinician may facilitate the rehabilitation [41].

There are numerous studies relating LBP to lifting in healthy workers. A direct association between occurrence of LBP and frequent lifting was found in several studies [15, 29, 30, 81]. Repetitive heavy lifting, pushing, and pulling was found to be associated with LBP in a retrospective study of a general practice population in the United States [15, 16]. Likewise a cross-sectional survey in England correlated the lifetime occupational history of over 500 adults with the prevalence of LBP [87]. The strongest associations were for lifting and moving weights over 25 kg (relative risk, RR = 2.0). Overexertion leads to a higher risk of HNP [20]. Lifting 11 kg or more with knees straight and back bent was associated with increased risk of HNP (RR = 3.95) [57]. However, many of the studies do not have a strong design and confounders are probable.

Lifting demands and strength are inextricably related, but trunk strength and lifting strength should be separated, because lifting strength refers to a physical whole-body activity, where the limiting muscle group may not be trunk muscles. Strength is less in asymmetric postures [37] and eccentric (lengthening) and isometric contractions produce higher levels of strength than concentric (shortening) contractions [60, 70]. Patients who develop acute LBP will produce a lower force than they were capable of before the pain developed. Acutely, this may not reflect a true loss of strength, but could be a loss of functional strength. Men as a group are stronger than women, but when strength is normalized to body weight, women are as strong as men [32, 58, 74, 75], and trunk strength seems to diminish significantly with age, beginning at 40–50 years [80].

Other biomechanical and epidemiological studies also suggest that the present approach is incorrect. The setting of a lifting limit by weight alone without defining other lifting parameters makes no sense. The NIOSH guidelines [88] point out that the load lifted should be reduced in certain circumstances: a twisted posture, lifts that are close to the knees or above the upper chest, multiple lifts, increased lifting rate, or loads with poor coupling. It is clear from the preceding discussion that any recommendation related to lifting restrictions must take into account more than the weight of the object to be lifted; it also needs to consider all these other factors.

The musculature may be compromised in the chronic LBP patient (CLBP). The importance of maintaining proper muscle control and synchronization was pointed out after observing that cadaveric lumbar motion segments buckled rapidly when loaded with a slightly offset compression load [90, 91]. Muscular co-activation under compressive loading is needed to stabilize the spinal column [7], but the musculature in CLBP patients exhibits atrophy (diminished fiber size, cobweb appearance) and diminished strength and endurance [2]. Also, a decrease in muscle strength and atrophy of the back muscles after back surgery is typical [53]. Abnormal electromyographic (EMG) findings have been observed in back muscles 1 year after surgery. CLBP patients have a diminished ability to recruit the dorsal muscles in response to a sudden load [43]. Thus, CLBP patients may have diminished ability of their muscles to protect a damaged FSU, and this may be exacerbated post surgery. It is also possible that retraction during surgery could further damage the muscles.

Another difficulty, well recognized in the psychophysical literature, is that patients may have difficulty estimating the weights of objects before lifting them [34] and, in general, people are poor at perceiving the stress on the spine during lifting activities [82]. Thus, even if they intend to comply with the lifting restrictions, they may not do so because of lack of knowledge of the weight of common objects. This may act in both ways. Patients may be apprehensive about lifting objects because they think the weight is too great or they may lift a load that the clinician has deemed too heavy.

Thus there is limited justification for current lifting restrictions. Also, the limitations often ignore other reported stressors such as prolonged sitting, pushing/pulling, vibration, high accelerations of loads, lifting unstable loads, smoking, etc. Thus, we decided to survey orthopedic surgeons and neurosurgeons to ascertain what is the range of lifting restrictions for different types of surgery and for different times postoperatively. CLBP patients were also surveyed in terms of what restrictions they had been given. In addition, patients, students, orthopedists and neurosurgeons were also asked to estimate the weight of common objects. A literature analysis was done to see whether there was any biomechanical basis for lifting restrictions.

Materials and methods

Survey of the literature

A survey of the literature of the consequences of surgery was done.

Questionnaires

A questionnaire on lifting restrictions was sent to the 158 surgeons in the International Society for the Study of the Lumbar Spine (ISSLS). In addition, 200 questionnaires were distributed to surgeons attending a European spine meeting. Another questionnaire regarding restrictions of all kinds was sent to 107 previous CLBP patients, who had participated in a rehabilitation program during the past 2 years. Also 64 surgeons and 78 students/faculty were asked to estimate the weight of six common items (bottle of wine, six-pack of beer, six apples, six oranges, six bananas and a 3-month-old infant).

Results

Survey of the literature

Biomechanical studies have provided a basis for a concern that surgery may weaken the spine. The muscles are important dynamic stabilizers [37, 38, 68], while the bony structures act as static restraints.

Surgery or injury to the intervertebral disc and to the articular facets increased the coupled motion under the application of axial torque [62]. In the study of Panjabi et al. on sequential injuries to disc, a significant increase in coupled motions were observed when the specimen was loaded [63]. The effects of muscles on the biomechanics of the lumbar spine was modeled by Goel et al. [18]. The addition of muscular forces led to a decrease in the anteroposterior translation and flexion rotation and imparted stability to the ligamentous segment. The presence of muscles also led to a decrease in stresses in the intervertebral body and the intradiscal pressure. Crisco and Panjabi and Panjabi et al. used a simple biomechanical model to show that the intersegmental muscles are the least effective in providing postural support in lateral bending, and multisegmental muscles were more efficient [7, 64]. A decrease in muscle effectiveness due to deconditioning was simulated by Goel et al. [19, 20]. This was found to increase the displacement, loads on the disc and ligaments (including the capsular ligaments), and the stresses in the vertebral body. Thus, a decrease in the muscular forces will not only make the spine more unstable, but may increase the chances of possible re-injury.

Chronic low back patients undergoing surgery had a reduced proportion of type I fibers and a decrease in fiber size for both fast- and slow-twitch fibers. A selective type II fiber atrophy and changes in the structure of type I fibers in multifidus muscle biopsies were found intraoperatively in patients with herniated discs [47, 93]. However, these alterations could not be proven to be related directly to the surgery as they also occur with disuse. Intraoperative and 5-year postoperative biopsies showed that patients who did clinically well had less type II atrophy at the time of surgery, whereas the atrophy persisted in those patients who did not do as well [69]. It seems that the type II atrophy is due to inactivity and is irreversible.

Questionnaires

The response rate regarding lifting limits was 128 surgeons (36%) and 34 patients (32%). Basically, the results showed a variety of answers provided for the 12 conditions at each of the three time intervals. A number of different non-responses were also included. Other limitations were relatively sparse, but there were several conditions with restrictions for twisting and sitting. Some physicians indicated that patients should engage in an exercise program, while others specifically indicated that exercise should be restricted. A number of physicians who indicated no restrictions supplied additional comments to suggest that they do have different restriction regimes de-

Table 1 Lifting restrictions for less than 2 weeks post surgery (% of responses)

Condition	No restr.	No lifting	2 kg	5 kg	10 kg	15 kg	20 kg	*n*
Radiculopathy	2.7	39.8	4.6	38.9	11.1	0.9		108
Discogenic LBP	4.1	40.6	5.2	42.7	5.2			96
Facet syndrome	5.5	43.3	5.5	40.0	4.4		1.1	90
Instability w. spondylolisthesis	4.8	45.6	6.8	33.3	9.7			103
Instability	4.0	43.4	9.0	34.3	9.0			99
Cauda equina	4.0	43.4	6.0	35.3	9.0	1.0	1.0	99
Spinal stenosis	3.9	40.2	5.9	38.2	8.8	2.0	1.0	102
Degen. lumbar scoliosis	6.8	45.1	6.7	32.3	6.8	1.0		102
Other degen. lumbar deformity	7.2	45.3	7.2	35.1	4.1	1.0		97
Mechanical LBP	5.3	46.2	5.3	37.6	4.3	1.1		93
Failed back syndrome	5.1	48.0	4.1	35.7	7.1			98
Pseudarthrosis	5.0	46.5	4.0	13.1	8.1			99

Table 2 Lifting restrictions for 2–8 weeks post surgery (% of responses)

Condition	No restr.	No lifting	2 kg	5 kg	10 kg	15 kg	20 kg	25 kg	*n*
Radiculopathy	20.4	4.1	1.0	9.2	40.1	7.1	11.2	6.1	98
Discogenic LBP	19.5	4.3	2.2	13.0	38.0	7.6	8.7	6.5	92
Facet syndrome	25.0	3.6	1.2	10.7	32.1	5.9	13.1		84
Instability w. spondylolisthesis	24.7	10.1	3.3	18.0	31.5	5.6	6.7		89
Instability	29.2	6.7	3.4	21.3	29.2	5.6	6.7		89
Cauda equina	29.7	4.4	1.1	17.6	25.3	8.8	9.9	3.3	91
Spinal stenosis	35.2	4.4	1.1	9.9	26.4	13.2	6.6	3.3	91
Degen. lumbar scoliosis	30.0	9.2	1.1	18.4	31.0	3.4	6.9		87
Other degen. lumbar deformity	31.2	7.5	1.1	16.1	34.4	3.2	6.5		93
Mechanical LBP	23.5	5.9	1.2	11.8	41.2	4.7	7.1	4.7	85
Failed back syndrome	26.6	6.4	2.1	11.7	43.6	3.2	6.4		94
Pseudarthrosis	24.7	5.3	2.2	20.4	38.7	3.2	5.4		93

Table 3 Lifting restrictions for 9–28 weeks post surgery (% of responses)

Condition	No restr.	No lifting	2 kg	5 kg	10 kg	15 kg	20 kg	25 kg	30 kg	35 kg	40 kg	50 kg	*n*
Radiculopathy	56.4	0	0	2.1	8.5	11.7	2.1	11.7	2.1	1.1			94
Discogenic LBP	43.8	1.1	0	2.2	13.5	21.3	2.2	12.4	1.1		1.1	1.1	89
Facet syndrome	50.0	0	0	4.2	11.1	18.1	4.2	11.1	1.4				72
Instability w. spondylolisthesis	42.1	2.1	0	3.2	15.8	14.7	8.4	6.3	1.1	0	1.1	6.3	95
Instability	37.8	2.2	0	3.3	26.7	10.0	7.8	5.5	1.1	0	0	5.5	90
Cauda equina	64.1	0	0	4.7	15.1	5.8	4.7	3.5	2.3				86
Spinal stenosis	53.4	0	0	3.4	13.6	5.7	6.8	10.2	2.3	0	4.5		88
Degen. lumbar scoliosis	51.1	1.1	0	4.3	14.1	8.7	8.7	9.8	2.2				92
Other degen. lumbar deformity	50.1	1.1	0	3.3	14.6	10.1	5.6	11.2	3.4				89
Mechanical LBP	42.4	0	0	2.4	16.5	18.8	4.7	11.8	1.2	0	1.2	1.2	85
Failed back syndrome	43.6	1.1	0	2.1	18.1	18.1	5.3	7.4	2.1	1.1	0	1.1	94
Pseudarthrosis	42.2	1.1	0	3.3	21.1	13.3	7.7	4.4	2.2	0	0	4.4	90

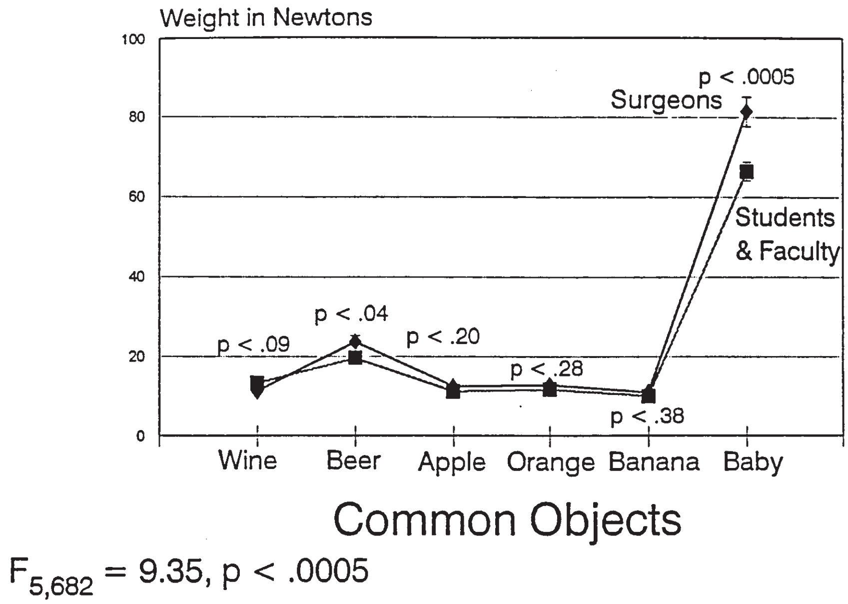

Fig. 1 Summary of surgeons' and student/faculty estimates of the weight of six common objects, where true values in Newtons are as follows: wine: 13.1, beer: 34.0, apples: 14.5, oranges: 16.3, bananas: 13.6, and baby: 54.0

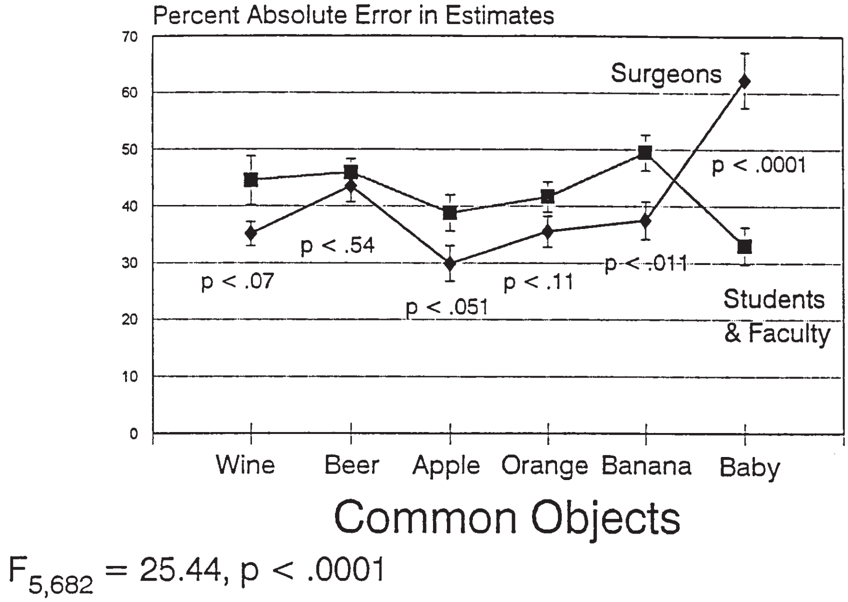

Fig. 2 Summary of surgeons' and student/faculty percentage of absolute error [100 × (estimate-true weight)/true weight] associated with six common objects

pending on the specific needs of a patient, but indicated no restrictions because their protocol does not generalize across patients. The results are shown in Tables 1–3.

Two groups – students/faculty and surgeons – each estimated the weight of six common objects. Respondents could indicate weight in pounds, kilograms, or Newtons. The weight estimations were made by 64 surgeons, and 78 students/faculty (100% response). The reported outcomes were analyzed in raw form (Fig. 1) and as the percentage difference between an estimate and the specified value for each object (Fig. 2). This 2bGroup × 6wObject factorial experiment was analyzed using analysis of variance (ANOVA) techniques. The results indicated a significant Group by Object interaction for all three forms of the outcome. These interactions are summarized in Figs. 1 and 2, respectively. From Fig. 1 it is clear that although the surgeons generally had closer or better estimates of the weights of the common objects, this was definitely not the case with regard to the estimated weight of a 3-month-old baby.

Discussion

The decision about when to allow return to full activities after spine surgery is important to the patient. Workers who are self-employed or with limited sick leave, those of limited means, mothers with small children, owners of small businesses, and professionals often cannot afford a long convalescent period. Many workers feel a keen desire to return to work because of a sense of pride. However, companies may not allow a worker to rejoin the work force with lifting restrictions. Light work, rest periods, and ergonomic changes to the workplace may not be available. In the postoperative period, a tentative approach to resuming activities or warning against re-injuring their back by medical professionals may be counterproductive.

Patients with poor coping skills or a pre-existing exaggerated fear of pain may be predisposed to developing CLBP and disability [35]. If these restrictions are unnecessary, health care providers may exacerbate fear-avoidance behavior in these patients. Restrictions after surgery also preclude normal and routine spinal mobility. It is well accepted that lack of physical or physiologic activity can rapidly decondition the spine and may itself be a cause of back trouble [35]. The optimum time, if any, to refrain from vigorous activities after surgery is unknown. Mayer and Gatchel [51] use the term “deconditioning syndrome” for patients with poor aerobic capacity and poor trunk muscle performance. Those patients often display inadequate pain behavior. The poor physical condition is probably the result of pain avoidance behavior, leading to a decrease in daily activities. Poor physical condition reinforces CLBP, and patients may respond to it with increased inadequate pain behavior, accompanied by inability to respond to surprise loads. The relationship between the psyche, pain and mechanical deconditioning thus seems reasonably clear. They may enter a vicious circle that should be promptly dealt with in the postoperative rehabilitation phase. Thus, graduated postoperative lifting guidelines are extremely important as a means of avoiding entry to this vicious circle.

Several studies have found that the physical strenuousness of work had only a minor relationship to results [13, 26, 31, 89, 92]; however, this is at odds with other studies that have reported much poorer results in patients with heavy work [14, 78]. The conflict may be partly based on difficulty in classifying the strenuousness of work from traditional job descriptions instead of the perceived strenuousness of work, which Hurme and Alaranta found correlated well with the results [31]. When comparing their results with an earlier study by Tunturi et al., which dealt with the predictive factors in lumbar fusion operation for spondylolisthesis, it was found that age had more importance, the heaviness of work no relation, and social class was of less predictive value in Hurme's study than in Tunturi's fusion patients [85, 86].

Weber compared operative versus non-operative treatment of patients' HNP and found the average sick leave after surgery to be 12 weeks [89], whereas Long recommended that patients with sedentary jobs return to work 2–4 weeks after surgery, and that others with heavier demands refrain from work for 6–12 weeks or more [42]. McCulloch [54] and Kahanovitz et al. [33] commended the benefits of early mobilization, but the average sick time after surgery was more than 2 months in most studies. The results of Carragee et al. have shown that early return to vigorous activities was clearly possible in 98% of the patients [4]. Preparing the patients by clear educational materials before surgery for early return to activities is essential. Patients should be encouraged to return to activities to tolerance (i.e., up to the limits appropriate to their specific situation) and should not be told to wait until most pain has gone before returning to normal activities. Instead, they should be given physiotherapy and informed that deconditioning of the tissues is not recommended.

An important criterion of success is increased activity following surgery, since CLBP patients have reduced most physical activity. Peters et al. examined activity levels of patients following treatment. Prior to rehabilitation and surgical treatment, 78% of the patients were classified as inactive. At the re-evaluation 2–18 months following treatment, this number was reduced to 25%. In comparison, 33% of the untreated patients were inactive prior to treatment, and this number increased to 58% inactive by the time of the follow-up [65]. Flor et al. reported the results of a meta-analysis indicating dramatic increases in activity levels for treated versus untreated patients [11]

There is a basis for the concern that the FSU may be weakened post surgery. There is also no doubt that the muscles will be less effective in the post-surgical patient and thus, as stated above, rehabilitation should concentrate on the key muscle groups. As Crisco and Panjabi pointed out, the muscles are vital to the stabilization of the motion segment [7]. Because of the reduced stability provided by the disc and the facets after surgery, specific stabilizing training of the multifidus muscles should be prescribed. There is, however, no scientific basis for current lifting restrictions. The restrictions are not consistent for the same surgery and are not even consistent between surgeons for the same patients. To restrict lifting by a certain permitted weight is senseless, as we have a poor ability to discern the weights of objects.

It is clear that most post-surgical patients have poor paraspinal musculature. Activity and physiotherapy as stated above should be encouraged. In healthy subjects, isometric trunk extensor strength is greater than flexion strength [10, 24, 37, 76, 77, 80, 83]. The ratio of the two has been used to determine abnormalities in patients [1, 38, 55, 80, 83, 84]. Mayer et al. found a significant loss of both flexor and extensor muscle strength in chronic back patients compared to healthy controls, and also found that the main loss of strength was in the extensor muscles [48–50]. Hemborg and Holmstrom et al. reported a drop in the ratio of extension to flexion when comparing healthy workers to those with CLBP [25, 28]. Marras and Wongsam found that LBP patients reduce the speed by which they move the trunk, and suggest that this is one of the first functional losses caused by pain [46]. Shirado et al. reported that while eccentric trunk strength was greater than concentric in normals, this was not always the case in patients. CLBP patients always had weak extensors [73]. In addition, CLBP patients cannot recruit their muscles as quickly [43]. Thus, conditioning of the muscles is a vital part of the postoperative care. Finneson recognized the poorer results of overweight (and probably somewhat deconditioned) women [9]. We recommend concentrating on extensor strength and endurance as well as exercises that improve the reaction time of the dorsal muscles.

Lifting restrictions will undoubtedly inhibit return to work [35]. Nachemson stated that for idiopathic LBP "the deleterious effects" of long-term absence from activity and work are well known [59]. Information is available regarding the healing time and properties of possibly diseased tissues and the actual loads on the lower back in various positions of activity and work; data are also available regarding the perception of pain, and how it can be affected by muscle activity [17, 56]. This information may well serve as a basis for a new type of treatment for back pain – early, gradual, biomechanically controlled return to activity and work [59]. Perhaps the same is true for patients post surgery.

It is clear that prolonged inactivity post surgery will lead to psychosocial problems and deconditioning and may even inhibit fusion healing. Cyclic axial loads may induce hydrostatic pressure changes that provide a stimulus for bone graft revascularization and incorporation. This speaks strongly for staged loading of the graft. Clinicians should visit workplaces to see what can be done to encourage early return to work (i.e., job modification [44], work rotation [45], resting for brief periods, etc. [41]). Physiotherapy should emphasize strengthening, endurance and improved reaction time of the muscles. Advice to patients should include how to avoid high stress lifts and other risk factors. A patient information sheet or video would be helpful.

The surgeons, as a group, estimated the weights of common objects to be heavier than the other groups. Does this mean that unconsciously the surgeons are really expecting the patients to lift less than their recommendations? In any case, merely specifying the weight, even if it could be estimated, without the other parameters of lifting has no scientific basis.

A pragmatic approach would seem to be to encourage activity to tolerance, but to avoid postures that would increase loads on the spine. In the clinic the ability to lift can be easily evaluated. The simplest and most practical method is the Progressive Isoinertial Lifting Evaluation described by Mayer et al. In this protocol, the subject lifts a crate with increasingly heavy loads from floor to waist until a maximum is reached or they report inability to continue [52].

In a companion paper [67], we make suggestions for a means of considering all important aspects of lifting (weight, position, lifting rate, asymmetry) and the decreased mechanical properties due to surgery. This may prove to be a useful approach to scientifically based lifting restrictions.

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