Which Patients With Low Back Pain Benefit From Deadlift Training?

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Abstract

Berglund, L, Aasa, B, Hellqvist, J, Michaelson, P, and Aasa, U. Which patients with low back pain benefit from deadlift training? *J Strength Cond Res* 29(7): 1803–1811, 2015—Recent studies have indicated that the deadlift exercise may be effective in decreasing pain intensity and increasing activity for most, but not all, patients with a dominating pattern of mechanical low back pain. This study aimed to evaluate which individual factors measured at baseline could predict activity, disability, and pain intensity in patients with mechanical low back pain after an 8-week training period involving the deadlift as a rehabilitative exercise. Thirty-five participants performed deadlift training under the supervision of a physical therapist with powerlifting experience. Measures of pain-related fear of movement, hip and trunk muscle endurance, and lumbopelvic movement control were collected at baseline. Measures of activity, disability, and pain intensity were collected at baseline and at follow-up. Linear regression analyses were used to create models to predict activity, disability, and pain intensity at follow-up. Results showed that participants with less disability, less pain intensity, and higher performance on the Biering-Sørensen test, which tests the endurance of hip and back extensor muscles, at baseline benefit from deadlift training. The Biering-Sørensen test was the most robust predictor because it was included in all predictive models. Pain intensity was the next best predictor as it was included in 2 predictive models. Thus, for strength and conditioning professionals who use the deadlift as a rehabilitative exercise for individuals with mechanical low back pain, it is important to ensure that clients have sufficient back extensor strength and endurance and a sufficiently low pain intensity level to benefit from training involving the deadlift exercise.

Key Words motor control, resistance training, Biering-Sørensen test, pain intensity, prediction

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Introduction

The barbell deadlift exercise is a free weight exercise in which a barbell is lifted from the floor in a continuous motion by extending the knees and hips. When performing the deadlift, the spine should maintain its neutral alignment, which requires the extensibility of muscles around the hip (11) and the activation of stabilizing muscles (8). Although the deadlift was originally an exercise used exclusively in competitive powerlifting, many strength and conditioning professionals (7) and high-school athletes (5) also use the deadlift in their weight-training regimen to enhance their hip, thigh, and back strength. In healthy individuals, the deadlift exercise has been shown to activate the trunk muscles, specifically the longissimus and multifidus muscles, to a greater extent than exercises commonly performed with a Swiss ball do (22). Because patients with low back pain reportedly have decreased strength and endurance in their back extensor muscles compared with healthy individuals (16), exercises that focus on improving back strength might be effective as rehabilitative exercises.

Recently, a case study (14) and randomized controlled trial (1) indicated that deadlift training with an individualized progression in intensity and volume might be effective in reducing pain and disability in patients with a dominating pattern of mechanical low back pain. The randomized controlled trial (1) showed that two-thirds of the patients achieved a clinically meaningful improvement (>30% change (24)) in pain intensity and activity after an 8-week training period (1). The patients also increased their trunk muscle strength and endurance (1). Still, the finding that one-third of patients did not achieve a clinically meaningful improvement in pain intensity and activity raises the question of whether and in what aspect these patients differ from those who benefitted from deadlift training. Because the results of the aforementioned studies might encourage strength and conditioning professionals to suggest training involving the deadlift exercise to individuals with low back pain, it is important to establish which factors characterize patients who benefit from using the deadlift as a rehabilitative exercise.

Low back pain is a multifaceted condition, and results concerning which factors might be associated or could predict the outcome of rehabilitation remain inconclusive.

Earlier studies have shown that pain intensity (2,3), disability (2,3), pain-related fear of movement (2), and nonoptimal movement patterns of the lumbopelvic region (11) are associated with low back pain and can predict outcomes of low back pain rehabilitation programs. For example, Beneciuk et al. (2) showed that patients with high pain intensity at baseline did not benefit from physical therapy treatment. Yet, the number of studies investigating potential predictive variables of treatment success after exercise interventions remains limited. The present study thus aimed to evaluate which individual factors measured at baseline could predict activity, disability, and pain intensity in patients with mechanical low back pain after an 8-week training period using the deadlift as a rehabilitative exercise. This will provide information to strength and conditioning professionals about which patients can benefit from deadlift training.

Methods

Experimental Approach to the Problem

Deadlift training has been shown to decrease pain and increase both activity and physical performance in patients with a dominating pattern of mechanical low back pain at a group level (1,14). However, evidence regarding which individual factors affect activity, disability, and pain intensity following a training period involving the deadlift exercise remains scarce. To understand which patients with low back pain can benefit from deadlift training, this study aimed to identify which variables could predict activity, disability, and pain intensity after an 8-week training period involving the deadlift as a rehabilitative exercise. Such information is vital for physical therapists and strength and conditioning professionals when selecting exercises for individuals with low back pain.

The present study is a secondary analysis of a randomized controlled trial (Clinical trial registration NCT01061632) involving 70 participants with a dominating pattern of nociceptive mechanical low back pain with duration for at least 3 months (1). The intervention in one group ($n = 35$) consisted of the deadlift exercise, which was performed 12 times during an 8-week period. Participants answered questionnaires and completed a physical performance test battery before and after the intervention. The first weeks of deadlift training emphasized the correct lifting technique, and thereafter, the intensity and volume of training was individually increased. In statistical analyses using multiple linear regression, predictive models were built to show which individual factors measured at baseline could predict activity, disability, and pain intensity after the 8-week period.

Subjects

Participants were recruited by 2 physical therapists from 2 occupational health care services that consecutively enrolled patients seeking care for mechanical low back pain with a duration of at least 3 months. All included participants fulfilled the inclusion and exclusion criteria. In total, 70 participants were included in the randomized controlled trial investigating the efficacy of low load motor control exercises and deadlift training (1). For this secondary analysis, the group receiving the deadlift intervention consisted of 35 participants (15 men and 20 women). Descriptive statistics of individual characteristics and test performance are presented in Table 1. The youngest participant was 26 years old and the oldest was 60 years. Two participants were experienced in resistance training, whereas all others were not. Most recruited participants were on industrial jobs; some worked on assembly lines, whereas others had more administrative duties. No participant was currently on full-time sick leave.

All participants provided their written consent and were informed that they could at any time end their participation without further explanation. Risk of harm or injury to participants was minimized by encouraging participants to report any discomfort or pain during or between sessions. The study protocol received ethics approval from the Regional Ethical Review Board in Umeå, Sweden (nr 09–200 M).

Procedures

The procedures used in this study have been described in detail in a previous article (1). Participants randomized to the deadlift intervention met with the physical therapist who supervised them when performing the deadlift exercise 12 times during an 8-week period. The physical therapist had used the deadlift as a rehabilitative exercise in his clinical practice with patients, was experienced in coaching the deadlift exercise for more than 10 years, and was both an instructor for the Swedish Powerlifting Federation and an active powerlifter at the international level. The collection of outcome variables was performed before (baseline) and after the 8-week training period (follow-up values) by 2 specially trained and blinded investigators.

Outcome Measures

In this study, the follow-up values for activity, disability, and pain intensity were used as outcome measures. To measure activity, the Patient-Specific Functional Scale was used (31), whereas the Roland-Morris Disability Questionnaire was used (15) to measure disability and a visual analog scale to measure pain intensity during the last 7 days (6). These questionnaires are considered to be valid and reliable outcome measures in rehabilitation studies for patients with low back pain (6,15,31). Separate predictive models were built for each outcome measure with the follow-up values used as dependent variables.

Predictive Variables

Eight measures were used as possible predictive (i.e., independent) variables. These measures were chosen for being earlier identified as predictors of outcomes of low back pain rehabilitation programs. Apart from the baseline values of activity, disability, and pain intensity, the baseline values of pain-related fear of movement, 3 tests of trunk muscle endurance, and

Table 1. Descriptive statistics, mean ± *SD* (first and third quartile), of participants at baseline.*

	All participants (n = 35)	Men (n = 15)	Women (n = 20)
Age (y)	42 ± 10 (32, 49)	44 ± 10 (34, 53)	41 ± 10 (32, 48)
Height (cm)	174 ± 8 (167, 180)	181 ± 5 (179, 185)	169 ± 6 (164, 172)
Weight (kg)	74 ± 13 (65, 84)	84 ± 12 (75, 93)	66 ± 7 (63, 71)
BMI ($kg \cdot m^{-2}$)	24 ± 3 (22, 26)	26 ± 2 (23, 28)	23 ± 2 (21, 25)
PA ($min \cdot wk^{-1}$)	179 ± 148 (60, 270)	245 ± 139 (120, 380)	129 ± 137 (30, 203)
Activity: PSFS (0–10)	5 ± 1 (4, 6)	5 ± 1 (4, 7)	4 ± 1 (4, 5)
Disability: RMDQ (0–24)	7 ± 4 (4, 10)	6 ± 4 (4, 9)	8 ± 4 (4, 12)
Pain intensity: VAS (0–100 mm)	43 ± 24 (22, 60)	38 ± 22 (20, 60)	46 ± 24 (32, 63)
TSK (17–68)	32 ± 7 (26, 36)	34 ± 8 (26, 41)	30 ± 6 (26, 35)
MC test battery (0–7)	4 ± 2 (3, 5)	4 ± 1 (3, 5)	4 ± 2 (3, 6)
Prone bridge test (s)	72 ± 46 (34, 118)	82 ± 46 (46, 120)	64 ± 45 (26, 103)
Side bridge test (right side) (s)	45 ± 28 (17, 67)	60 ± 21 (51, 68)	34 ± 29 (13, 58)
B-S test (s)	87 ± 43 (57, 118)	85 ± 38 (71, 114)	89 ± 48 (56, 129)

*BMI = body mass index; PA = physical activity at moderate intensity; PSFS = Patient-Specific Functional Scale; RMDQ = Roland–Morris Disability Questionnaire; VAS = Visual Analogue Scale; TSK = Tampa Scale of Kinesiophobia; MC = movement control; B-S = Biering-Sørensen.

a movement control test battery were included. Age, sex, and body mass index were also included as potential predictors.

Activity was measured with the Patient-Specific Functional Scale, an activity-specific questionnaire in which the patient is asked to list 3 activities that he or she cannot perform due to low back pain. For each listed activity, the patient is also asked to rate on a 0–10 scale their current level of difficulty in performing each activity due to low back pain, in which a score of 10 signifies the level of activity "pre-injury" and 0 signifies a total inability to perform the activity (31). In the analysis, the mean score of the 3 activities was calculated. The Patient-Specific Functional Scale has been evaluated for test-retest reliability (intraclass correlation coefficient [ICC] = 0.97) and exhibits good concurrent validity compared with the Roland-Morris Disability Questionnaire (31) for patients with mechanical low back pain.

Disability was measured with the Roland-Morris Disability Questionnaire, a condition-specific questionnaire consisting of 24 statements regarding activities relevant to patients with low back pain (e.g., "Because of my back, I try not to bend or kneel down") to be responded to affirmatively or negatively. Each affirmative response equals one point on the 0–24 point scale, for which a higher total score indicates greater disability. The Roland-Morris Disability Questionnaire has been tested for test-retest reliability (ICC = 0.88) and for convergent validity and divergent validity (15) for patients with low back pain lasting at least 4 weeks.

Pain intensity during the last 7 days was measured on a 0–100 mm visual analog scale in which 0 signifies "no pain at all" and 100 signifies "worst imaginable pain." The visual analog scale for measuring pain intensity is used extensively in chronic pain research (6) and is considered to be both a reliable and valid measurement (23).

Pain-related fear of movement was measured with the Tampa Scale of Kinesiophobia, which consists of 17 statements to be rated on a scale of 1–4 in which 1 signifies "strongly disagree" and 4 signifies "strongly agree." The statements (e.g., "I'm afraid that I might injure myself if I exercise") are constructed to reflect different aspects of fear of movement, fear of injury and/or reinjury, and pain catastrophizing. The scores range from 17 to 68, and a higher total score indicates a higher degree of pain-related fear of movement. The Tampa Scale of Kinesiophobia is considered to be both a reliable and valid measurement and has been evaluated for face, content, and construct validity and reliability (ICC = 0.91) (17).

The movement control test battery included 7 tests of patients' ability to dissociate lumbar spine movements from hip movements (i.e., each patient's ability to keep the lumbar spine in its neutral position while moving in the hips and knees). For example, the test called the waiter's bow involves standing upright and bending forward via hip flexion while preventing flexion movements in the lumbar spine (19). The movement control test battery included the waiter's bow (to evaluate flexion control), and the sitting knee extension performed bilaterally and unilaterally (to evaluate flexion control and/or rotation control) and the prone lying active knee flexion performed bilaterally and unilaterally (to evaluate extension control and/or rotation control) (18). Patients performed 3 trials of each exercise; 2 correctly performed trials indicated an ability to prevent lumbar spine movements while performing the test. Test results were added together in a range from 0 (no correct test) to 7 (all correct tests). Dissociation tests have been evaluated for reliability with good results (18), have been shown to differentiate patients with and without low back pain (19), and have proven useful as predictors of low back and knee pain in dancers (27).

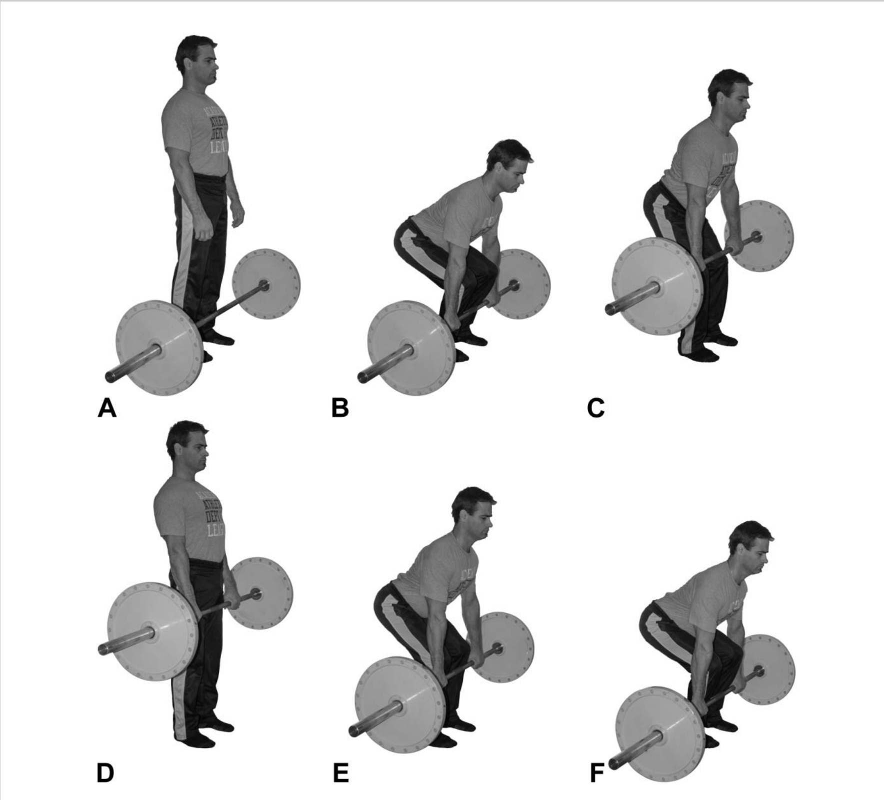

Figure 1. A–F Execution of the deadlift exercise. The person shown in Figures 1 A–F has given full permission to be included in the figures of this submission to Journal of Strength and Conditioning Research. Reprinted with permission from Aasa et al. Individualized low-load motor control exercises and education versus a high-load lifting exercise and education to improve activity, pain intensity, and physical performance in patients with low back pain: a randomized controlled trial. *J Orthop Sports Phys Ther*. 45: 77–85, 2015. http://dx.doi.org/10.2519/jospt.2015.5021. Copyright ©Journal of Orthopaedic & Sports Physical Therapy®

The 3 tests of trunk muscle endurance focused on the isometric endurance of the trunk and hip muscles and included the Biering-Sørensen test, the prone bridge test and the side bridge test (16,21,29). All tests were performed in standardized positions with an emphasis on maintaining a neutral lumbar spine and the described test position for as long as possible, as measured in seconds (1 trial). The test position for the Biering-Sørensen test is a prone position on a bench, upon which the half of the body below the superior iliac spines is strapped over the lower legs and thighs, whereas the upper body remains unsupported in the air, to produce a flexion moment on the lumbar spine (16). The Biering-Sørensen test has been evaluated for test-retest reliability (ICC = 0.77) in patients with nonspecific low back pain and can also differentiate patients with and without low back pain (16). For the prone bridge test, the patient is positioned prone on a thin rubber mat with support only from the toes and forearms, which produces an extension moment to the lumbar spine (29). The toes are positioned closely to each other yet without touching, whereas the forearms and elbows are positioned shoulder-width apart. For the side bridge test, the patient is positioned on a thin rubber mat on the right side, with support only from the lateral aspect of the right foot and the ulnar aspect of the right forearm. The forearm and elbow are placed directly under the shoulder. The prone and side bridge tests have been evaluated for test-retest reliability on healthy subjects with excellent results (Pearson correlation of 0.78 for the prone bridge test; reliability coefficient of 0.99 for the side bridge test) (21,29).

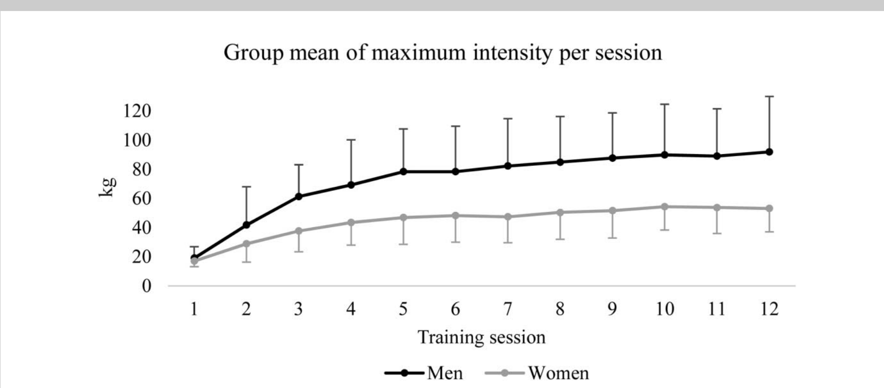

Figure 2. The progression of the group mean of maximal intensity per session during the intervention period.

Deadlift Exercise

Training took place in an exercise facility with resistance training barbells and weight plates with a diameter of 45 cm. For all lifts, participants stood in front of a barbell with

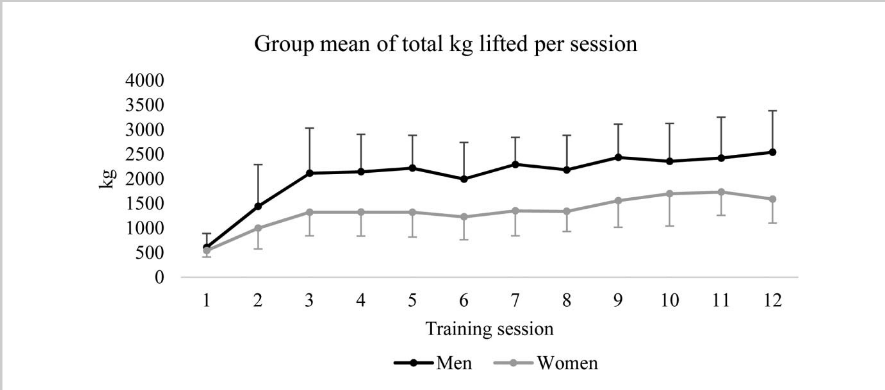

Figure 3. The progression of the group mean of training volume during the intervention period.

weights (Figure 1A). Participants were first taught to find a neutral position of the lumbar spine and then to stabilize the spine by taking a deep breath and contracting the stabilizing muscles (i.e., bracing). This was done so that the participants would maintain the lumbar spine in a neutral position throughout the entire lift. Participants were next instructed to squat with the knees at approximately 90°, have the lumbar spine in a neutral position, suspend their arms straight down, and grasp the barbell (Figure 1B). A simultaneous extension of the knee and hip was performed (Figure 1C) to complete the concentric phase of the movement (Figure 1D) and to come to an erect position.

The eccentric phase of the lift was initiated by lowering the barbell through hip flexion and keeping the bar close to the thighs until it passed the knee cap (Figure 1E), whereupon knee flexion concluded the descent (Figure 1F). The eccentric phase took roughly twice as long as the concentric phase. Between repetitions, participants let go of the barbell and paused in a standing position before initiating the next repetition. The rest between each set lasted 5–10 minutes, or as long as it took to change the weights on the barbell and to ensure that the participant had recovered from the set and could perform the next set with optimal technique. During the initial 4 weeks of the training period, participants trained twice weekly with 2–3 days between sessions. During the final 4 weeks, participants trained weekly with 5–7 days between sessions. Participants did not receive any special instructions regarding activities beyond the deadlift training, other than that they should attempt to use the lifting technique learned during deadlift training in their everyday activities.

The first sessions of the training period focused on both controlling spinal alignment throughout the exercise and optimizing the movement pattern, including the activation

Table 2. Linear regression modeling including dependent and significant independent variables, number of participants, unstandardized coefficient *B* values for each variable and 95% confidence interval, adjusted R^2, individual *p* values, model *p* values and equation for final models.*

Dependent variable	Independent variable	*n*	*B* value (95% CI)	Adjusted R^2	*p*
Activity at follow-up	B-S test	33	0.02 (0.01 to 0.04)	0.2	0.01
	VAS	33	−0.04 (−0.07 to −0.01)	0.18	0.01
	RMDQ	33	−0.19 (−0.37 to −0.00)	0.1	0.05
	Prone bridge test	33	0.02 (0.00 to 0.03)	0.09	0.05
Predictive model for activity = 6.45 + 0.02 × (B-S test) − 0.03 × (VAS)		33	0.02 (−0.00 to 0.3) −0.03 (−0.06 to 0.01)	0.23	0.01
Disability at follow-up	VAS	31	0.07 (0.01 to 0.12)	0.15	0.02
	B-S test	31	−0.04 (−0.07 to −0.01)	0.14	0.02
	RMDQ	31	0.36 (0.03 to 0.7)	0.11	0.04
Predictive model for disability = 4.19 + 0.05 × (VAS) − 0.03 × (B-S test)		31	0.05 (−0.02 to 0.11) −0.03 (−0.06 to 0.01)	0.17	0.03
Pain intensity at follow-up	RMDQ	31	2.54 (0.85 to 4.24)	0.22	0.01
	B-S test	31	−0.23 (−0.4 to −0.06)	0.19	0.01
	VAS	31	0.35 (0.05 to 0.64)	0.14	0.02
Predictive model for pain intensity = 23.81 + 1.87 × (RMDQ) − 1.16 × (B-S test)		31	1.87 (0.07 to 3.68) −1.16 (−0.33 to 0.02)	0.28	0.00

*CI = confidence interval; B-S test = Biering-Sørensen test; VAS = Visual Analogue Scale; RMDQ = Roland-Morris Disability Questionnaire.

of the stabilizing muscles. All participants started with 10–20 kg. When the lifting and lowering phases could be performed with control of the movement pattern, spinal and hip-knee alignment, the volume and intensity were gradually increased by number of lifts per session and/or weight on the bar. Initially, 3–5 sets with 10 repetitions per set were performed. As training intensity progressed, to emphasize an increase in maximal strength, yet to ensure that every lift was performed with the correct technique, repetitions were gradually reduced to 3–5 per set, whereas sets increased from 5 to 8 per session. As a result, training volume increased along with intensity during the first weeks of the training period, but thereafter volume was kept at a more constant level, whereas intensity increased until the end of the training period (Figures 2 and 3). The precise number of sets and repetitions for each patient was left to the discretion of the physical therapist supervising the training.

As training progressed beyond the initial sessions, cognitive behaviors that influenced the pain behavior were also targeted (35). Participants who experienced pain-related fear of movement and were apprehensive about stressing their low back by lifting weights were individually reassured that, by maintaining the neutral position of the spine during daily activities, the risk of aggravating their symptoms would be minimized and the progression of strenuous activities made possible.

Statistical Analyses

Means, standard deviations, and quartiles were used for descriptive statistics. To evaluate which individual factors could predict activity, disability, and pain intensity in patients with mechanical low back pain after 8 weeks of deadlift training, separate predictive models were constructed using linear regression with the follow-up values of activity, disability, and pain intensity as dependent variables. First, for each predictive model, univariate linear regression analysis was performed by testing each independent variable separately. The independent variables were the baseline values of activity, disability, pain intensity, pain-related fear of movement, the movement control test battery, the Biering-Sørensen test, the prone bridge test, the side bridge test, age, sex, and body mass index. Second, multiple linear regression analyses were performed that included the variables from the univariate analysis with $p \leq 0.05$. The independent variable with the highest adjusted R^2 from univariate analysis was first entered into the multiple regression models. Thereafter, the remaining significant independent variables from univariate analysis were added one at a time in order of relevance to gauge whether they could increase the explained variance (adjusted R^2) and form a significant ($p \leq 0.05$) regression model.

Results

There was a high degree of adherence to training among participants ($n = 35$), 33 of whom completed the 8-week training period and attended 11.6 ($SD = 0.8$) of the 12 planned sessions. Two participants reported adverse effects, one of whom withdrew from the study. Another participant withdrew from the study without explanation. Both participants who withdrew reported baseline activity scores of 4.3 and 5, disability scores of 7 and 8, and pain intensity scores of 57 and 54 mm, respectively. For activity and disability, these scores were similar to the mean score of the group, whereas the score for pain intensity was considerably higher. Generally, activity scores increased from 4.8 ($SD = 1.3$) to 6.8 ($SD = 2.2$) (1), disability scores decreased from 7.1 ($SD = 4.1$) to 3.8 ($SD = 3.9$), and pain intensity scores decreased from 42.6 ($SD = 23.5$) to 22.2 ($SD = 21.1$) (1).

Prediction of Follow-up Scores for Activity (Patient-Specific Functional Scale)

The univariate regression models with the follow-up value of activity as the dependent variable showed associations with 4 independent variables: disability, pain intensity, the Biering-Sørensen test, and the prone bridge test (Table 2). The Biering-Sørensen test was entered first in the multiple regression model. No other variable except pain intensity could significantly increase the explained variance (adjusted $R^2 = 0.23$) (Table 2).

Prediction of Follow-up Scores for Disability (Roland-Morris Disability Questionnaire)

The univariate regression models with the follow-up value of disability as the dependent variable showed associations with 3 independent variables: disability, pain intensity, and the Biering-Sørensen test (Table 2). Pain intensity was entered first into the multiple regression model. No other variable except the Biering-Sørensen test could significantly increase the explained variance (adjusted $R^2 = 0.17$) (Table 2).

Prediction of Follow-up Scores for Pain Intensity (Visual Analog Scale)

The univariate regression models with the follow-up value of pain intensity as the dependent variable showed associations with 3 independent variables: disability, pain intensity, and the Biering-Sørensen test (Table 2). Disability was first entered into the multiple regression model. No other variable except the Biering-Sørensen test could significantly increase the explained variance (adjusted $R^2 = 0.28$).

Discussion

This study aimed to evaluate which individual factors that could predict the activity, disability, and pain intensity after 8 weeks of deadlift training in patients with mechanical low back pain. The main result was that measures of disability, pain intensity, and performance on the Biering-Sørensen test at the beginning of the training period could predict activity, disability, and pain intensity at 8 weeks' follow-up (i.e., after the training period). The higher the disability and pain intensity and the lower performance on the Biering-Sørensen test, the less likely that participants were to benefit from deadlift training. These findings suggest that pain intensity, disability, and performance on the

Biering-Sørensen test should be considered before recommending an individual with low back pain to start deadlift training. A rough estimate of values corresponding to high pain intensity and low performance on the Biering-Sørensen test could be pain intensity above 60 mm on the visual analog scale (i.e., above the third quartile in this study) (Table 1) and an ability to hold the Biering-Sørensen test position for less than 60 seconds (i.e., below the first quartile in this study) (Table 1).

Baseline performance on the Biering-Sørensen test was a predictor in all 3 models, indicating that it can be a more robust predictive variable (32) than pain intensity and disability. The underlying mechanism of the relevance of the Biering-Sørensen test is arguably that it reflects an ability to activate the stabilizing hip and back extensors for a sustained period, which is also important in deadlift training. An inability to optimally activate the stabilizing hip and back extensors during deadlift training can lead to sustained tissue stress and ongoing pain (28). To increase muscle strength and avoid stress on passive tissues, the physical therapist instructed all participants to brace the trunk muscles to stabilize the lumbar spine during lifts. However, we cannot assure that all lifts for every participant were performed with optimal activation of the stabilizing hip and back extensors. Earlier research has shown an association between poor performance on the Biering-Sørensen test and high pain intensity (16,26). The fact that both the Biering-Sørensen and pain intensity were associated with activity, disability, and pain intensity at follow-up confirms this association in our study.

In the predictive models, baseline pain intensity was a predictor for activity and disability, which implies that participants with high pain intensity at baseline should not use the deadlift as a rehabilitative exercise. There could be several reasons for this. First, it has been proposed that the adaptation to pain in motor behavior involves a redistribution of muscle activity and changes in mechanical behavior (13). Participants with high pain intensity might therefore have had nonoptimal muscle activation patterns while performing the deadlift exercise. An altered activation due to pain might explain why pain intensity was associated with performance on the Biering-Sørensen test. Second, regarding the execution of the deadlift exercise, although the physical therapist instructed the participants to contract their trunk muscles to stabilize their lumbar spine in a neutral position, their deep stabilizing muscles might not have been optimally activated. Tsao and Hodges have shown that, to optimally retrain the feed-forward mechanism of the transversus abdominis muscle, isolated retraining, not general trunk strengthening with a sit-up exercise, is most effective for patients with recurrent low back pain (34). However, to ensure optimal performance regarding muscle activation during deadlift training, more advanced equipment (e.g., electromyography) would have been needed. Third, pain not only inhibits optimal muscle recruitment patterns but can also influence motor learning (13). More specifically, it has been suggested that pain may disturb motor learning due to its interference in the quality of performing a task that is being practiced (e.g., the deadlift exercise) (12). It might have therefore taken more time for participants with high pain intensity to learn how to perform the deadlift with the proper technique. Fourth, participants with high pain intensity might have needed treatment for pain alleviation, as suggested by Widerström et al. (36), before starting the deadlift training to enhance their potential to perform the exercise properly. Altogether, to benefit from deadlift training, participants with low endurance in the hip and back extensors and high pain intensity might need isolated retraining in activating local and global stabilizing muscles and/or pain alleviation before initiating training with the deadlift exercise.

Disability at baseline was included as a predictor in the predictive model for pain intensity at follow-up. The questionnaire used for measuring disability, the Roland-Morris Disability Questionnaire, is designed to measure disability during a fairly wide range of activities commonly impaired in patients with low back pain (e.g., bending or kneeling down) (15). However, it also addresses aspects of how the patients' mood and/or behavior are affected by their low back pain (15). Participants in this study were classified with a dominating pattern of mechanical low back pain, defined as pain that can be aggravated or relieved by different movements or postures (30). Because high pain intensity is reflected in many movements, postures, and behaviors, a correspondingly high score on the Roland-Morris Disability Questionnaire is natural. However, in accordance with previously mentioned consequences of high pain intensity, participants who scored high on the Roland-Morris Disability Questionnaire might have been impaired in such an extensive way in various activities demanding a wide range of body functions that they were simply unable to reap the benefits of the deadlift training.

In univariate analysis, the prone bridge test was significant ($p \leq 0.05$) in predicting the follow-up value of activity, yet showed a low degree of explained variance (adjusted $R^2 = 0.09$). Furthermore, the side bridge (i.e., right side) and movement control tests could not significantly explain any variance in the final predictive models. It therefore seems that these tests do not measure any dimensions that are important to predicting which patients can benefit from deadlift training. The results indicate that the prone bridge, side bridge, and movement control tests might not reflect the ability to control the lumbar neutral position during deadlift training to the same extent as the Biering-Sørensen test. Control of the neutral position of the lumbar spine during a flexion load and the strength and endurance of the hip and back extensors as measured with the Biering-Sørensen tests seem to be important aspects in deadlift training.

The baseline variables of age, sex, and body mass index were also unable to predict activity, disability, or pain intensity after deadlift training. The initial pilot study of the deadlift exercise (14) included physically active, middle-aged men. Our results show that women and men aged 26–60 years, with a dominating pattern of mechanical low back pain, can benefit from deadlift training, if not restricted by the significant predictors of disability and pain intensity or performance on the Biering-Sørensen test.

Generally, participants in the present study reported less disability and pain-related fear of movement and higher levels of activity than those with low back pain in previous studies (4,9,20), possibly because this study included only participants with a dominating pattern of mechanical low back pain. The low values for pain-related fear of movement might explain the nonsignificant influence of these independent variables due to floor effects in the models. Regarding activity, the Patient-Specific Functional Scale measured the degree of limitations in activities that each participant reported to be most affected by his or her low back pain. Deadlift training might thus benefit participants who report activities such as bending forward or lifting, but not activities that involve sitting or standing, which might explain why the baseline values of activity did not become a significant predictor in any of the predictive models.

Some important methodological considerations in this study should be discussed. The design of this study (i.e., a secondary analysis of a randomized controlled trial) is not optimal for creating predictive models. However, we chose this design to generate possible predictive variables for further prospective studies. Furthermore, the relatively small sample size ($n = 35$) could have affected the predictive models. According to Tabachnick and Fidell (33), regarding cases relative to each independent variable in regression analysis, a ratio of 20:1 is recommended to achieve valid results, although Field (10) recommends a ratio of 10:1 or 15:1. In the present study, all 3 predictive models had a ratio of 16:1, which clearly meets Field's (10) criteria, yet poses a slight power issue in relation to the recommendations of Tabachnick and Fidell (33). The models have adjusted R^2 values ranging from 0.17 to 0.28. Compared with previous studies' ranges of 0.41–0.62 (3), 0.17–0.48 (2), and 0.15–0.55 (25), the explained variance in our models might be deemed somewhat weak. However, we consider that the predictive variables were found to be reasonable for and representative of the selected group of participants, although we might not have targeted all potential predictors. This topic could be an area for future studies.

We chose the follow-up values of the Patient-Specific Functional Scale, the Roland-Morris Disability Questionnaire, and a visual analog scale to represent activity, disability, and pain, respectively, at the end of the training period. We chose these domains because pain and disability are the most common reasons why individuals with low back pain seek care. Moreover, it has been suggested that different aspects of related outcome measures should be included in predictive modeling because such aspects reduce the chance of identifying single false-positive predictors (i.e., type 1 errors) (3).

In conclusion, the results of the analyses suggest that, in patients with mechanical low back pain, endurance of hip and back extensors (Biering-Sørensen test), pain intensity, and disability are important factors to assess before initiating deadlift training, if the goal in training is a high score in activity, low scores of disability and pain intensity. Further research should test the results presented in this study with a larger sample to examine whether the variables found in the present study can be confirmed as predictors.

Practical Applications

Strength and conditioning professionals should not hesitate to use the deadlift exercise in their everyday practice, but before considering deadlift training for individuals with mechanical low back pain, our results suggest that pain intensity and the endurance of the hip and back extensors should be evaluated. For example, if low endurance of the hip and back extensors and high pain intensity are found in an individual with mechanical low back pain, then other interventions should be considered before initiating deadlift training. However, regardless of patients' age, sex, body mass index, pain-related fear of movement, movement control, and activity, the deadlift exercise seems to be an effective intervention. Finally, we stress the importance of strength and conditioning professionals' being skilled in technique instructions and providing feedback when instructing the deadlift exercise and progressing training for individuals with mechanical low back pain.

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