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ISOKINETIC PERFORMANCE CAPACITY OF TRUNK MUSCLES. PART I: THE EFFECT OF REPETITION ON MEASUREMENT OF ISOKINETIC PERFORMANCE CAPACITY OF TRUNK MUSCLES AMONG HEALTHY CONTROLS AND TWO DIFFERENT GROUPS OF LOW-BACK PAIN PATIENTS

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ABSTRACT. The aim of this investigation was to assess the reproducibility of the isokinetic trunk muscle performance measurement among patients with different degrees of low-back pain. Twenty-two healthy volunteers, 20 patients with mild and 18 patients with severe low-back pain participated in isokinetic measurements. Lidoback® isokinetic dynamometer was used. The measurements were performed with the subjects standing, using velocities of 60, 90 and 120°/second. Five repetitions were performed at each velocity. All subjects were tested three times with a 1-week interval between the tests. Peak torque, average peak torque, coefficient of variation, total work done and peak torque to body weight ratio were calculated for each velocity for both flexion and extension. The results showed that in every measurement peak torque, average peak torque, peak torque to body weight ratio and total work done correlated with each other very strongly both in flexion and extension ($r \geq 0.9$). The average peak torques increased in further measurements. The change had a strong correlation with the severity of the back problem, which was evaluated by means of the Oswestry disability index. The critical value was found to be 20% in the Oswestry index: values above this meant big changes between measurements and values below this meant small changes between measurements.

Key words: isokinetic measurements, low-back pain, repetition.

INTRODUCTION

Measurements of muscle strength have been commonly used for the assessment of the severity of musculoskeletal disorder, disability and impairment. Standards for healthy individuals have been collected (24). Several studies have documented an association between trunk muscle strength weakness and low-back pain (1, 5, 11, 14, 17, 19, 22, 26). Functional muscle tests are reported to reflect the integrated activity of both the central and peripheral motor systems and are considered useful for screening and describing the patient's general motor ability (2). Ratings of disability are considered more meaningful if they are based on objective measurements rather than on subjective impressions (27). The developments in the quantification of true trunk muscle performance were assumed to bring a new dimension to low-back assessment (16).

Some researchers argue that chronic low-back pain patients have, due to prolonged inactivity, self-protection and fear of pain, fallen into a deconditioning state (16) which can be measured with novel dynamometric devices. Isokinetic dynamometers can also be used to steer the rehabilitation efforts, in which case the success is gauged by improvement in function. However, in some studies, only weak correlations have been found between physical measurements and present or future disability and treatment outcome (20).

It is assumed that the weakness of trunk muscle strength of low-back pain patients is due to disuse imposed by pain or fear of pain. However, performance changes in serial dynamometry testing might be due to motor learning or other behavioural factors, such as familiarity with the measurement situation, improved technique, decreased pain level and increased mood (3, 7, 18). Several studies have shown strong evidence of a learning effect between the first and second test sessions, and a single testing session may seriously underestimate the trunk function (23). It has also been reported that a session of education and exposure to functional restoration principles on an outpatient basis 2–6 weeks before the beginning of the main programme resulted in a large increase in the level of performance on lumbar dynamometry at the time of admission compared to patients who did not have such a pre-admission programme (12).

It has been concluded that in low-back pain patients with a high score in Waddell tests, serial lumbar dynamometry reveals a progressive improvement in performance. This improvement is greater than what would be expected from natural history of physical recovery and also greater than any learning effect related to the test procedure (4).

The purpose of this study was to determine the reproducibility of the isokinetic trunk muscle performance measurement among subjects with different degrees of low-back pain without any influence from rehabilitation or additional activity in the study period. We also studied a control group of anamnestically healthy subjects.

MATERIAL AND METHODS

Twenty-two healthy volunteers, 20 patients with mild low-back pain and 18 patients suffering from moderate to severe and long-lasting low-back pain, participated in the study. For the healthy control group the criteria for the admission included being asymptomatic of all low-back pain at the time of admission and in the previous 6 months. The classification into mild and severe low-back pain groups was based on the Oswestry disability ratings index (9), which is a sum-index of ten different situational items including troubles, e.g. in sitting, standing, sleeping, travelling, social activities and everyday living. The result of the index is reported as a per cent-value (scale 0% = no disability to 100% = maximum disability). Other separating factors were the pain reported on the visual analogue scale (21) at the time of the investigation, the impairment the back problems caused to the working and functional capacity and the subject's own estimate about his health and the severity of the back problem (filling in a questionnaire with six items) during the past 6 months. Also the anamnestically back-healthy reported some disability associated with certain tasks, such as lifting a burden and prolonged sitting or standing, but at the time of admission they were pain-free. The characteristics of the subjects are shown in Table I.

The subjects filled in a questionnaire before the isokinetic testing. The details of the study were explained to each subject before the test. A Lidoback® (Loredan Biomedical Inc., Davis, TX) isokinetic dynamometer was used to measure the trunk muscle performance (Fig. 1). The subjects were in a standing position, with the pelvis fixed by an adhesive belt below crista iliaca anterior superior. The knees were in slight flexion and the centre of rotation was set at the spine

Table I. *Background information about the subjects (mean ± SD)*

	Healthy ($n = 22$)	Low-back pain: Mild ($n = 20$)	Low-back pain: Severe ($n = 18$)
Age	43.5 ± 61.1	44.3 ± 7.1	45.1 ± 8.4
Weight (kg)	73.9 ± 10.9	71.7 ± 12.6	76.4 ± 12.5
Height (cm)	176.6 ± 9.8	173.4 ± 8.1	175.4 ± 8.4
Oswestry (%)	3.0 ± 5.0	13.0 ± 8.0	35.0 ± 14.0
Pain (VAS)	0.7 ± 2.0	26.7 ± 16.0	95.0 ± 36.0

iliaca posterior superior-level (corresponding to about L4-level). All subjects had to be able to perform a range of movement of 80° flexion and 5° extension in the fixed position in the device. Platform height and other information of the position of the dynamometer components were recorded for each participant. Torque measurements were not corrected for the effect of gravity.

The testing protocol is shown in Table II. The isokinetic angular velocity of 180°/second was not used due to the

Fig. 1. An isokinetic trunk muscle test by means of Lidoback.

Table II. *The testing protocol*

1.	5 minute warm-up by biking with ergometric
2.	three trials without resistance
3.	five submaximal trials (60°/second)
4.	five submaximal trials (90°/second)
5.	three submaximal trials (120°/second)
6.	3 minutes of rest
7.	seven maximal trials (60°/second) from which the last five were recorded
8.	3 minutes of rest
9.	seven maximal trials (90°/second) from which the last five were recorded
10.	3 minutes of rest
11.	seven maximal trials (120°/second) from which the last five were recorded

increased variability of the test–retest results associated with higher velocities (6). All subjects were tested three times with a 1-week interval between the tests. The tests were all performed at the same time of the day and by the same physiotherapist.

Peak torque, average peak torque, peak torque to body weight ratio, total work done and coefficient of variation, which shows the variability of subsequent repetitions, were chosen as the measures of performance.

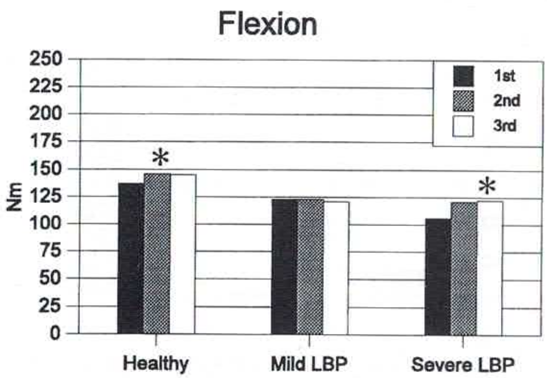
The statistical significances of the differences within and between the groups were evaluated with the aid of paired and unpaired *t*-tests. The correlations were analysed with Pearson's correlation analysis.

RESULTS

The results show that in every measurement the most common performance parameters of isokinetic trunk strength measurement, (peak torque, average peak torque, peak torque to body weight ratio and total work done) correlated very strongly ($r \geq 0.90$ with all parameters) with each other both in flexion and extension muscle strength. Because the different angular velocities in this study correlated also very strongly with each other, we mainly used the average peak torque with angular velocity of 60°/second for further analysis. The correlation coefficients of average peak torques between different measurement periods were also remarkably high among both men ($r = 0.80$–0.84) and women ($r = 0.84$–0.89).

The means of the average peak torques are presented in Fig. 2. Among the healthy controls, both the flexion and extension strengths increased statistically significantly ($p < 0.05$) between the first and second measurements. Between the first and third measurements, an increase was noted especially in extension strength ($p < 0.01$). There were no statistically significant changes among the subjects with mild low-back pain. Among the subjects with severe low-back pain, the changes of both flexion and extension strengths were statistically significant between the first and third measurements ($p < 0.05$).

The subjects with severe low-back pain had statistically significantly lower extension strength than the healthy controls in each measurement ($p < 0.05$). There was a trend towards the severe low-back pain subjects also having lower flexion strengths than the healthy controls, but the differences did not reach statistical significance. The differences between the healthy controls and those with severe low-back pain decreased somewhat in further measurements. This was caused especially by the increase in average performance capacity level among the subjects with severe low-back pain. There were no statistically significant differences between the mild low-back



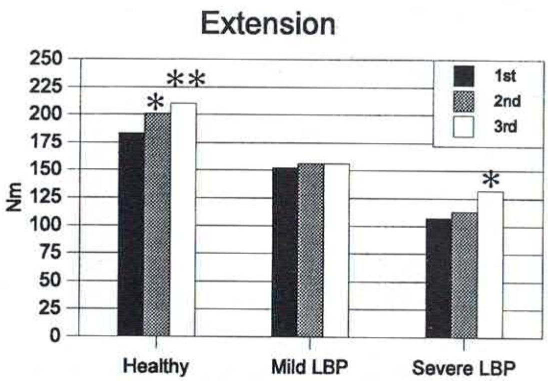


Fig. 2. The mean values of the average peak torques (60°/second) and the statistical significance of the differences between 1st and 2nd and between 1st and 3rd measurements (* $p < 0.05$, ** $p < 0.01$); LBP, low-back pain.

pain group and the healthy controls either in flexion or in extension strengths.

The changes in the muscle strengths among the subjects with low-back pain became particularly evident when the subjects were observed individually (and not in groups as in Fig. 2). The average percentage of individual changes between the first and second and the second and third measurements are shown in Fig. 3. In the group with severe low-back pain, the percentage changes were 43–50%. In the other two groups the changes remained at or below 15%.

Because the average change in isokinetic measurements had a strong association with the severity of the low-back illness, we tried to determine the critical value with the aid of the Oswestry index. It was noted that if the Oswestry index score was below 20% (low-back problems causing mild disability), the average increases in torques between measurements were 3–11%. If the Oswestry index score was above 20%, the average changes were 26–51%. The biggest changes were noted at fast angular velocities (90 and 120°/second).

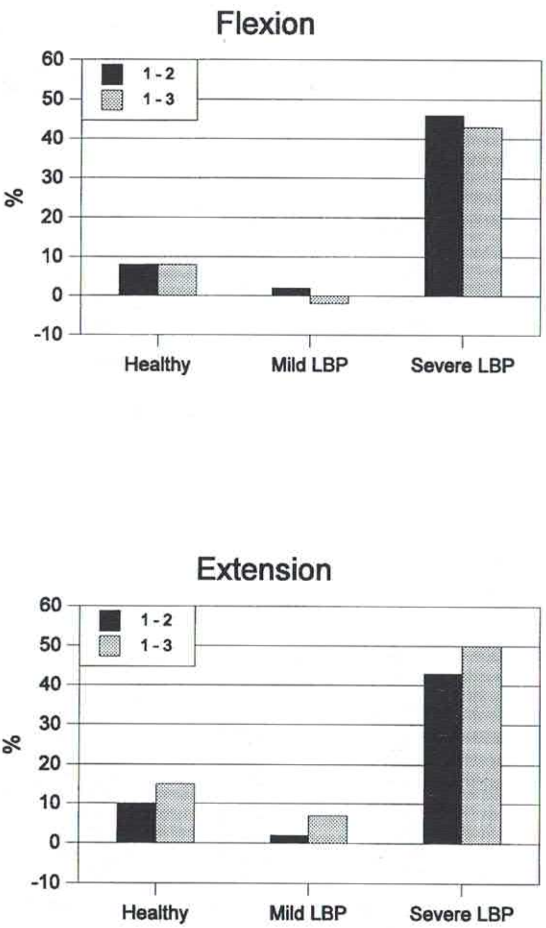


Fig. 3. The percentage changes in the average peak torques between 1st and 2nd measurements and between 1st and 3rd measurements. The changes have been calculated from the individual changes of the subjects; LBP, low-back pain.

We also studied the coefficients of variation in the different groups. A performance is usually considered maximal if the coefficient of variation is below 15%. It was noted that in groups of healthy controls and mild low-back pain, the average coefficients of variation remained under 15% in every measurement. There were no significant changes in the coefficients of variation between measurements, either. Among the subjects with severe low-back pain, the coefficients of variation remained above 15% even on the third measurement. On the whole, the coefficients of variation of the group with severe low-back pain differed very significantly from those of the two other groups in all the measurements ($p < 0.001$).

In order to assess the pain related to the test situation, the subjects were asked to estimate their low-back and lower limb pain on the visual analogue scale (VAS) before and after every test. A sum index was calculated (range 0–200 mm). It was noted that the subjects with severe low-back pain reported significantly more pain both before and after the test than the other two groups, but no group showed an increase of perceived pain related to the test situation.

In examining the associations of the flexion and extension torques with the crucial background variables, it was noted that they correlated highly, as expected, with age ($r = -0.42$–-0.48, $p < 0.001$), weight ($r = 0.48$–0.63) and, especially, height ($r = 0.71$–0.77). The torque strengths did not correlate significantly with professional status or the level of education.

DISCUSSION

In clinical work (in the follow-up of treatment and rehabilitation and in assessing disability) and in research, there are several different result variables in use in the isokinetic measurements (e.g. peak torque, average peak torque, total work done and peak torque to body weight ratio). However, the correlations between the different measurements are very high ($r \geq 0.9$), and this makes the use of many very similar result variables questionable. In this study, we used the average peak torque of five repetitions, which is frequently used in literature.

This study concentrated mainly on the changes in average peak torque between the measurements. The changes were most evident and statistically significant in healthy subjects and subjects with severe low-back pain. Individually, the changes were greatest among subjects with severe low-back pain.

It was somewhat surprising that among subjects with mild low-back pain, there were fewer changes in consecutive measurements than among healthy controls. On the whole, the results of the subjects with mild low-back pain and the healthy subjects were very similar in the isokinetic measurements, and the critical value turned out to be the Oswestry value of 20%: values above this mean strong changes between measurements and values below this mean small changes between measurements. This result has an evident practical clinical significance.

The trunk muscle strength test of the low-back pain patients measures perhaps more the pain threshold and the ability to bear pain (3) than mere performance capacity of the back as regulated by muscles and other physiological mechanisms. This is true especially if one single measurement is used to determine the base line. The test itself did not significantly increase the pain even among the subjects with severe low-back pain. Therefore the changes observed in the performance capacity cannot in any group be explained by the pain caused by the measurement done in the previous week.

The coefficient of variation, which shows the variability of subsequent repetitions, varied very much according to the illness status of the subjects. In general, the values of the coefficients of variation were high among the subjects with severe low-back pain. A critical value of 15% is often used, although the literature does not clearly support its use. The manufacturers of the measurement devices often recommend more strict critical values (usually 10%). Among the subjects with severe low-back pain, the perceived pain in the measurements can explain the variations in the results to some degree. The realiable level of the coefficient of variation is studied more closely in the second part of our study (15).

When assessing the treatment results of patients with low-back pain, it is important to consider how the base level of isokinetic performance capacity has been determined (8). If it is based on one measurement only, the change in performance capacity can be mainly due to a learning effect. The significance of this effect would decrease if the measurement is repeated. The effect of repetition on isokinetic models is a well-known phenomenon (13). It has also been assumed that the lower the performance, the easier it is to get an increase in performance, and this should be considered when reporting treatment effects (8). Also, biological factors have not very often been found to be the determinants of disability in patients with low-back pain (25) but, on the contrary, it has been shown that poor performance in biomechanical testing in a low-back pain group correlated strongly with abnormal illness behaviour (10).

We are concluding that healthy subjects and subjects with mild low-back pain should be measured twice to reach a reliable base-line measurement of isokinetic performance capacity of trunk muscles. Among subjects with severe low-back pain (Oswestry index value more than 20%), not even two measurements are always enough to get close to a reliable performance level of the subject.

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