

ISOKINETIC PERFORMANCE CAPACITY OF TRUNK MUSCLES. PART II: COEFFICIENT OF VARIATION IN ISOKINETIC MEASUREMENT IN MAXIMAL EFFORT AND IN SUBMAXIMAL EFFORT

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ABSTRACT. It has been claimed that with the aid of isokinetic trunk strength measuring devices it is possible to distinguish true muscular weakness from submaximal effort in the test. This proposition is based on the presumption that in the isokinetic trunk strength test identical performances can only be reproduced by maximal effort. The purpose of this study was to investigate whether it is possible to distinguish maximal effort from submaximal with the aid of the coefficient of variation (CV) in an isokinetic trunk muscle strength test. The study group included 35 (21 male and 14 female) subjects of whom 12 were healthy, 10 had a mild low-back pain and 13 had a more severe chronic low-back pain. The subjects performed five consecutive bendings both with maximal (100%) and submaximal (50%) efforts at a speed of 90°/second. In maximal effort only healthy subjects reached an average level of CV close to 10% both in extension and in flexion. In the chronic low-back pain group the average CV was close to 20%. The difference in CV was statistically significant ($p < 0.05-0.02$) between the healthy and the chronic low-back pain subjects. In the submaximal effort all health groups had a CV of approximately 20% or more and no significant differences were found. The group of slightly variable measurements (CV = 11-20%) was remarkably large in both the maximal and submaximal effort. The results suggest that an effort with a CV of 11-20% cannot be classified as definitely submaximal or maximal. When the CV is less than 10% the effort can be fairly certainly classified as maximal.

Key words: isokinetic test, low-back pain, maximal effort, submaximal effort.

INTRODUCTION

The trunk muscle strength tests are widely used in

guiding back rehabilitation. The actual performance level depends, however, on individual effort, which may be affected by many factors such as pain, unconscious pain behaviour and even conscious choice to show certain weakness in muscle performance. It has been claimed that with the aid of isokinetic trunk strength measuring devices it is possible to distinguish true muscular weakness from submaximal effort in the test. This proposition is based on the presumption that in the isokinetic trunk strength test identical performances can only be reproduced by maximal effort.

To measure the performance capacity of trunk musculature, the isokinetic devices produce, for example, flexion and extension curves. If the performance is repeated the device can draw all the curves on the same screen. It is thus possible to compare the different performances visually. Usually the curves are graded as consistent, slightly variable, or variable. Some isokinetic devices count the variability of the repeated performances and report it as the coefficient of variation (CV, %). The problem is that we do not know the upper limit of a normal physiological variation of the performance in an isokinetic test. The literature does not give us a clear and unambiguous answer on this question. One upper limit often used for the CV is 15%, even though clear support on this usage cannot be found from the literature, either. The device manufacturers usually recommend even lower CV (usually under 10%).

Hazard et al. (4) tested 30 normal subjects on the Cybex trunk extension/flexion machine during maximal (100%) and submaximal (50%) efforts. The performance variability on each test was graded visually. In this study, the maximal effort correlated strongly with consistent curves and submaximal effort with variable curves. However, there was still quite a

high percentage of slightly variable curves in both the maximal and submaximal efforts. The final conclusion on these results was that intercurve variability can distinguish maximal from submaximal effort quite accurately (80–90%) in normal subjects.

The purpose of this study was to investigate if it is possible to distinguish maximal effort from submaximal with the aid of the CV in an isokinetic trunk muscle strength test separately for symptom-free and low-back pain subjects. Our hypothesis was that in the submaximal effort the CV are much higher than in the maximal.

MATERIAL AND METHODS

The study group included 35 (21 male and 14 female) subjects of whom 12 were healthy, 10 had a mild low-back pain and 13 had a more severe chronic low-back pain. This status of health classification into mild and severe low-back pain groups was based on the Oswestry disability index (3) and the pain reported on the visual analogue scale (VAS) at the time of the investigation (5).

This study was a part of a larger study in which three sets of isokinetic trunk muscle strength measurements were conducted at 1-week intervals (5). The present study was done on the 3rd week. A Lidoback (Loredan Biomedical Inc., Davis) isokinetic device was used. The subjects performed five consecutive bendings with maximal (100%) effort at the speed of 90°/second. After a 3-minute rest the subjects were asked to repeat the test with the effort they thought was 50% of their maximal effort.

The statistical significance of the intergroup differences was analyzed with the help of unpaired *t*-test and χ^2 -test.

RESULTS

Figure 1 shows the average peak torques (APT) of the maximal and submaximal efforts. The subjects were

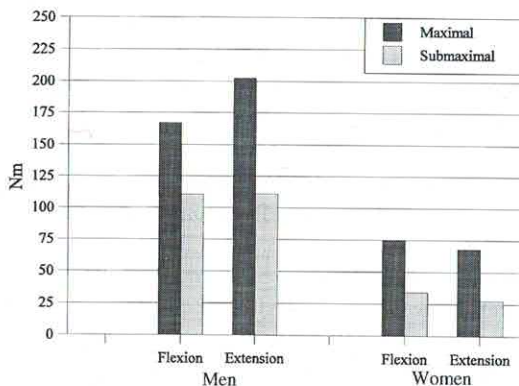


Fig. 1. The mean values of the average peak torques of the maximal (100%) and submaximal (50%) effort measurements.

able to estimate their 50% effort fairly well. The men performed slightly over (54.8–66.1%) and the women slightly below (40.9–45.7%) their 50% effort.

The CV in the three groups in both maximal and submaximal effort are shown in Fig. 2. In maximal effort only healthy subjects reached an average level of CV close to 10% both in extension and in flexion. In the severe low-back pain group the average CV was close to 20%. The difference was statistically significant ($p = 0.05$ – 0.02) between the healthy and the severe low-back pain subjects. In the submaximal effort all groups had a CV of approximately 20% or more and no significant differences were found.

The subjects were classified into three groups in both the maximal and submaximal effort tests. In the first group were those who had a low coefficient of variation (CV = 0–10%). In the second group were those with medium CV (11–20%) and in the third group those with high CV (over 20%). Table I shows how the subjects grouped according to these limits.

The results show that there is a trend towards low CV being connected with maximal (100%) effort and a high CV being connected with submaximal (50%) effort both in flexion and in extension. The trend is stronger among men. However, despite the clear trend the differences in CV between the maximal and submaximal measurements remained just below statistical significance. Both men and women had remarkably high percentages of medium (11–20%) CV. Of the maximal effort performances, this group was among men 24–33% and among women 50–64%. Of the

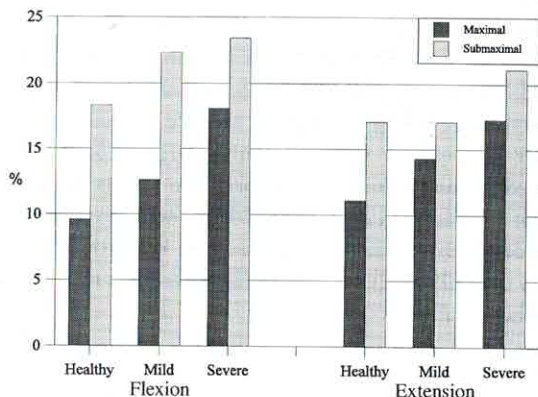


Fig. 2. Coefficient of variation of the maximal (100%) and submaximal (50%) effort measurements. Mean values of flexion and extension for the three groups (healthy, mild and severe low-back pain).

Table I. The grouping of the subjects according to the coefficient of variation in both the maximal and submaximal effort (number and percentage)

	Flexion			Extension		
	below 10%	11–20%	over 20%	below 10%	11–20%	over 20%
All (<i>n</i> = 35)						
100%	17 (49%)	12 (34%)	6 (17%)	13 (37%)	16 (46%)	6 (17%)
50%	3 (9%)	20 (57%)	12 (34%)	2 (6%)	22 (63%)	11 (31%)
Men (<i>n</i> = 21)						
100%	13 (62%)	5 (24%)	3 (14%)	13 (62%)	7 (33%)	1 (5%)
50%	3 (14%)	10 (48%)	8 (38%)	2 (10%)	11 (52%)	8 (38%)
Women (<i>n</i> = 14)						
100%	4 (29%)	7 (50%)	3 (21%)	0 (0%)	9 (64%)	5 (36%)
50%	0 (0%)	10 (71%)	4 (29%)	0 (0%)	11 (79%)	3 (21%)

submaximal effort performances the corresponding percentages were among men 48–52% and among women 71–79%. Medium CV were thus found more during the submaximal than during the maximal effort.

We also studied how well the subjects were able to maintain their level of the CV (Table II). If the difference in the CV between the maximal and submaximal tests was less than 5% it was considered that the subject was able to maintain the level. In both flexion and extension, 46% of the subjects were able to repeat their performance submaximally so that the CV did not change more than 5%. This "ability" seems to focus on the group with medium CV in both flexion and extension strength.

DISCUSSION

Our results support the observations Hazard et al. (4) made about consistent measurements being connected to maximal effort, and, respectively, variable measurements being connected with submaximal effort. The phenomenon does not seem to depend largely on the back health of the subjects, as our observations are similar to Hazard's despite the differences in the back condition of the subjects.

We used the coefficient of variation (CV) instead of visually analysing the curves because of its more practical use in clinical work. Coefficient of variation can be achieved when standard deviation is divided by the mean value, if the isokinetic device does not calculate it automatically. CV is given as percentile value and it is used when one wants to compare the variation in a certain group of subjects.

The measurement changes in serial isokinetic tests may be due to motor learning or other behavioural factors, such as familiarity with the measurement situation and improved technique (1, 2). This study was part of a larger study (5) in which three isokinetic trunk muscle strength measurements were conducted at 1-week intervals so that at the time of the present study every subject had been tested twice earlier. The results can thus be assumed to reflect true differences between maximal and submaximal efforts.

The group of slightly variable measurements (CV = 11–20%) is remarkably large in both the maximal and submaximal effort. The ability to repeat the performance submaximally after the maximal measurement without major changes in the CV also seems to be connected with this group. These results would seem to suggest that an effort of a CV of

Table II. The grouping into variation classes (number and percentage of all the 35 studied subjects) of such subjects who were able to maintain their coefficient of variation (difference between the tests less than 5%) regardless of the effort

Flexion				Extension			
Below 10%	11–20%	over 20%	Total	below 10%	11–20%	over 20%	Total
5 (14%)	9 (26%)	2 (6%)	46%	5 (14%)	9 (26%)	2 (6%)	46%

11–20% cannot be classified as definitely submaximal or maximal.

We conclude that only the efforts of the consistent (CV less than 10%) group can be fairly certainly classified as maximal. We consider it possible to reach this CV level although less than 50% of our subjects did. In order to reach the motivation needed for maximal effort, the subjects need feedback about their performance. Feedback was not used in our study, which is probably the reason for the low percentage of subjects reaching the CV level of less than 10%. It should also be remembered that a small percentage of subjects is capable of reaching a low CV level even with submaximal effort. We suggest that the repetition of isokinetic trunk muscle strength tests should be done until the CV level of less than 10% is reached.

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