

Isometric Back Extension Endurance Testing: Reasons for Test Termination

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Study Design: Cross-sectional study.

Objective: The self-reported reasons for terminating isometric back extension endurance testing and their associations with test performance and other factors were investigated to gain insight into determinants of test performance.

Background: Factors limiting isometric back extension endurance performance remain unclear. Better understanding the reasons for termination of isometric extension endurance testing could provide insights into what the test actually reflects.

Methods and Measures: Lifetime work, leisure activities and back pain questionnaire data, isometric back extension endurance testing (holding time, as measured in seconds), and reasons for test termination were obtained for a population-based sample of 544 working-age men.

Results: The most common reason for test termination was fatigue (62.5%), followed by pain in various parts of the lower extremities (12.6%) and back (3.2%). A history of daily low back pain over the prior 12 months and greater pain intensity of the worst back pain episode over the same period were associated with a greater likelihood of termination due to back pain. In a regression analysis, longer holding time was associated with stopping due to fatigue rather than low back pain, with a trend of 19 seconds (95% confidence interval [CI], -2-40) longer holding time. After controlling for low back pain history, those previously involved in competitive sports were 2.6 times more likely to stop due to pain. Those with a competitive sport history had 14 seconds (95% CI, 5-23) greater holding time than those without such a history.

Conclusions: Isometric back extension endurance testing is most commonly reported to be terminated due to muscle-related capacity as indicated by fatigue. Back pain is more likely to decrease performance time in men with a history of significant (frequent, intense) low back symptoms. *J Orthop Sports Phys Ther* 2005;35:437-442.

Key Words: fatigue, low back pain, lumbar spine, muscle

Interest in isometric extension endurance testing grew after Biering-Sørensen³ found this test to have prognostic value for first-time occurrence of low back pain (LBP) in men. These findings were supported by Alaranta et al,¹ who also found test performance to be predictive of first-time LBP.¹ It has also been suggested that isometric back extension endurance testing discriminates between subjects with and without LBP.^{8,14,20-21,25} Poorer test performance has been associated with greater pain severity among patients with LBP,^{10,15,17} but not with degree of LBP-related disability.^{6,22}

Back pain history also has been found to have an influence on isometric back extension endurance in a general population sample of men.⁴ Anthropometric factors, such as height, body mass, lean body mass, body fat percentage, and body mass index, have been inconsistently associated with test performance.^{4,12} A comparison of test performance both with and without encouragement¹² indicates that isometric back extension endurance may be highly dependent on subject motivation among healthy subjects and patients with LBP. Kankaanpää et al¹² have questioned the validity of the isometric back extension endurance test as a measure of back muscle

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function, based on their results of fatigability by electromyography, which indicated load sharing between the back and hip extensor muscles during testing. An influence of physical activity, age, health, body mass, height, and occupation has been found in several earlier studies in which age^{4,8,12-13,16,21} and physical activity^{4,8,16,18} have explained modest amounts of the variance in isometric back extension endurance both among patients with LBP and healthy subjects. As shown by Simmonds et al,²⁵ the isometric back extension endurance test was subjectively felt to be a difficult test for subjects with or without LBP.

We found only 2 studies that reported the reasons for terminating isometric back extension endurance testing and these had partly conflicting findings. In Moreland et al's study¹⁹ of healthy workers, 1 subject stopped due to discomfort in the upper back and another due to lower extremity cramps; the other 37 subjects ended the test due to fatigue. In the second study, subjects with current or previous nonspecific LBP (n = 43) were more likely to end testing due to fatigue, and asymptomatic subjects (n = 20) more often ended due to pain in the low back area.¹⁴ The association between the reason for ending the test and test performance, as judged from holding time (the time the upper body was held unsupported at horizontal level), was not assessed in either of these studies,^{14,19} and factors limiting holding time, in large part, remain unclear.

We found that, unlike some strength measures, where genetic influences have been substantial, among the present sample genetics played an exceptionally small role in isometric back extension endurance test performance and explained only 5% of the variance.²⁴ Environmental factors accounted for most of the variance in isometric back extension endurance performance. Fatigue as a reason for termination explained a similar proportion (5%) of variance, as did other factors identified earlier, such as physical activity and health.²⁴ In another previous analysis, which included a subsample of the present sample, holding time in isometric extension endurance testing was also modestly associated with age, current health, body fat, and physical loading activities, in addition to back pain history. However, in a multivariable regression model, all these factors explained only 23% of the variance in test performance.⁴ Overall, it remains quite unclear what isometric extension endurance testing measures, which is of particular interest, considering that this test is one of the few predictors of first-time back symptoms. A better understanding of the underlying factors of isometric extension endurance performance could also provide insight into the genesis of spinal disorders.

The primary purpose of this study was to specifically investigate reasons given for terminating isomet-

ric back extension endurance testing in a large population-based sample of men, so as to gain additional insight into factors influencing test performance. We were interested in determining if the reasons for test termination, such as fatigue or LBP, vary by test performance (holding time, as measured in seconds) or by other influential factors like age, health, physical activity, history of LBP, pain-related conditions, or participation in competitive sports. We hypothesized that the test would more likely elicit pain or discomfort in the low back area in those with a history of LBP, limiting test performance.

METHODS

Subjects

A population-based sample of 600 males, 35 to 69 years old, was drawn from the Finnish Twin Cohort (Table 1). The population-based Finnish Twin Cohort consists of all same-sex twins born before 1958. This study is a part of the Twin Spine Study project, in which data on suspected determinants related to spinal function and disorders were collected through a comprehensive structured interview and clinical examination. Selection criteria were based solely on within-pair differences in occupational materials handling, sedentary work, exercise, driving history, or cigarette smoking, as has been reported earlier in detail.² Those who had polio, heart malfunction (angina pectoris, cardiac arrhythmia, or other severe heart conditions), had alcohol the night before, high blood pressure (very high or repetitively high systolic blood pressure over 140 mmHg or diastolic blood pressure over 90 mmHg), vertigo, paralysis, recent back surgery (within a year), cerebral palsy, tremor, or a mental condition preventing them from understanding instructions, or could not assume the test starting position due to obesity or restricted range of motion, were excluded from isometric back extension endurance testing. Altogether, 56 subjects (9%) were not tested due to the above-mentioned reasons, leaving 544 for inclusion in the study. The study was approved by the Ethical Committees of the Department of Public Health at the University of Helsinki and the Health Research Ethics Board at the University of Alberta, and informed consent was obtained prior to data collection.

Interview

Information on lifetime work and exercise histories, other regularly performed activities involving physical loading, and a detailed history of neck and back pain and other health problems were gathered in a structured interview by 5 trained female interviewers.

LBP History Subjects were asked if they were currently experiencing LBP and if they had ever had an

TABLE 1. Characteristics of the subjects (mean and range, or proportion).

Characteristics	Mean (SD)	Range	N (%)
Age (y)	49.4 (7.3)	35-70	
Height (cm)	175.6 (6.2)	153-196	
Body mass (kg)	79.5 (11.4)	48-120	
Education			
Less than middle school			399 (73)
Middle school			69 (13)
High school			72 (13)
Back problems today			105 (19)
Frequency of low back pain in the past 12 mo			
None			179 (33)
Once			61 (11)
2-3 times			114 (21)
Several times			51 (9)
At least once a mo			54 (10)
At least once a wk			47 (9)
Daily			38 (7)
Current smoker			162 (30)
Frequency of exercise per wk for the past 5 y	2.9 (3.1)	00.0-25.1	
Mean-weighted occupational physical loading since age 20 (score on a scale of 1 to 4)*	2.5 (0.9)	1-4	

* 1, light; 2, light mixed; 3, heavy mixed; 4, heavy.

episode lasting more than 1 day. In addition, data were gathered on the frequency of LBP over the past year using a scale from 1 to 7, with 1 representing daily LBP and 7 representing none. Pain intensity of the worst episode over the past year was rated on a 0- to 100-point numeric scale, with 0 representing no pain and 100 the worst pain imaginable.

Leisure-Time Physical Activity The subject's lifetime histories of exercise and other leisure-time physical activities regularly performed during at least 3 months in a year were reviewed. Mode, length of time of participation (years during lifetime, months per year), duration (minutes per session), frequency (times per week), intensity (light, moderate, or strenuous), and associated injuries were recorded for each exercise or activity. The overall repeatability of the structured interview of lifetime exercise using a 5-year test-retest interval has been previously reported.²³ Weekly exercise hours and years of participation were found to be the most reliable variables, with intraclass correlation coefficients (ICC) of 0.63 to 0.90.²³

Isometric Back Extension Endurance Test Endurance was evaluated by timing (holding time measured in seconds) how long the subject was able to hold the upper part of the body horizontal, while lying prone, with no support beyond the upper border of the iliac crest. The hands were kept behind the neck and the thighs and ankles were fixed to the table by 2 wide straps. Subjects were instructed to hold the position as long as they could. During testing, subjects received encouragement once if their position fell

under the horizontal level. The position was indicated by a plumb bob hanging from the ceiling that was adjusted to contact the back when the horizontal position was maintained (Figure). If the position was not immediately corrected, or if the subject claimed that the position could no longer be held due to fatigue or discomfort, the test was ended and the holding time was recorded. The subject was then asked with an open-ended question, "Why did you stop the test?" To clarify the answer, the subject was encouraged to name the main reason why he stopped the test. The answers given for the reasons of test termination were recorded (see Table 2). Coefficients of intertester repeatability for holding time have ranged from 0.66 to 0.89 in earlier studies,^{11,28} but the repeatability for the reason given for test termination has not been examined.

Data Analysis

Statistical analysis was done in Stata, Release 8.2 (Stata Corporation, College Station, TX). Variables associated with stopping due to fatigue, rather than LBP, were assessed using logistic regression in Stata.²⁷ Odds ratios and 95% confidence intervals (CIs) were calculated, with the standard errors adjusted for clustering by twin pair to account for any correlation that may exist within the pairs. Linear regression, adjusted for twin pair, was used to estimate the difference in length of holding times for the 2 groups. Thus, in these analyses, only subjects citing fatigue or LBP as a reason for test termination were included.

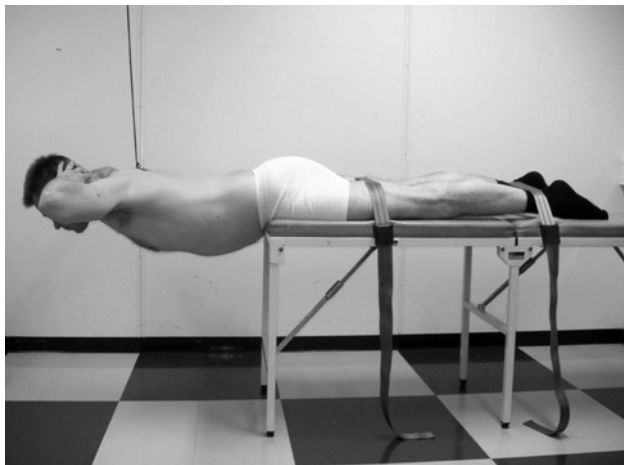


FIGURE. The test position of the isometric back extension endurance test.

RESULTS

Of the 544 eligible subjects, fatigue was the main reason (62.5%) given for stopping the isometric back extension endurance test, followed by acute pain in the lower extremities (12.6%), and LBP (3.2%) (Table 2). Presence, frequency, and intensity of LBP were all associated with the reported reason for terminating isometric back extension endurance testing ($P < .001$), with subjects who stopped due to fatigue reporting less back pain (Table 3). Those with daily LBP in the past year were also more likely to terminate the test due to LBP (odds ratio, 0.12; 95% CI, 0.04-0.36); $P < .001$) than fatigue. None of the other variables studied was associated with reason for test termination, as indicated by univariate analyses.

The best multivariate model for reason for test termination (fatigue versus LBP) consisted of history of competitive sports and intensity and frequency of LBP during the past year (Table 4). Those with higher pain intensity and frequency over the past year were significantly more likely to stop due to LBP. Once LBP was controlled for, those with a history of competitive sports were also more likely to stop due to LBP.

In a regression analysis, longer holding time was associated with stopping due to fatigue rather than LBP, with a trend of 19 seconds (95% CI, -2-40) longer duration. Those with a competitive sport history had on average 14 seconds (95% CI, 5-23) greater holding time than those without a history of participation in competitive sport.

DISCUSSION

The results showed that those with daily LBP were much more likely to stop the test due to pain. The clinical implication would be that the isometric back extension endurance test might reflect current back symptoms and pain tolerance of those with daily LBP

history more than it serves as a measure of physical capacity such as isometric back extension endurance.

The large population-based sample of men in this study reported a range of LBP histories, which is one of the strengths of this study. Those with medical problems other than LBP that could have affected their performance were excluded. We also had the benefit of a thorough interview regarding history of LBP and other factors and explicitly asked the reason for ending the isometric back extension endurance test. Measures taken to enhance isometric back extension endurance test reliability included following a standardized protocol in a controlled test environment, using only 2 trained female testers to conduct the test on all subjects. However, because earlier studies have indicated only moderate to good test reliability ($r = 0.89$; ICC, -0.77-0.88), measurement error may have been a limitation of this study.^{11,26}

Our study results are limited to men. Women were not included in the Twin Spine Study because heavy occupational physical loading and occupational driving—2 of the suspected determinants for spine degeneration and function—are rare among women. The earlier studies^{14,19} of reasons for isometric back extension endurance test termination did not study the effect of sex, which remains unknown. The relatively small numbers of subjects who reported back pain as their reason for stopping limited the power to detect significant predictors. While we had sufficient power to detect moderate differences (0.65 SD) between fatigue and LBP, we may have failed to detect effects that were smaller yet clinically relevant.

The reasons for subjects terminating their isometric back extension endurance testing have rarely been sought; yet the test is widely used for patients with LBP where motivation and pain-related factors might

TABLE 2. Reasons for test termination in the study sample, with mean (SD), range) holding times (in seconds).

Reasons	Frequency (%)	Holding Time
Fatigue	386 (62.5)	77 (41), 3-235
Acute pain in lower extremities	78 (12.6)	75 (37), 4-200
Low back pain during the test	20 (3.2)	59 (48), 6-141
Motivation	18 (2.9)	60 (31), 9-100
Table caused pain/pressure to anterior superior iliac spines	14 (2.3)	65 (30), 16-110
Out of breath	11 (1.8)	91 (43), 33-145
Pain or discomfort in upper extremities	7 (1.1)	83 (80), 3-225
Pain or discomfort in head area	6 (1.0)	42 (21), 20-68
Fear	5 (0.8)	25 (27), 5-68
Feeling of loose straps	2 (0.3)	70 (31), 48-92
Reaching the limit of 240 s	2 (0.3)	240 (0.0), 240-240

TABLE 3. Univariate odds ratios (OR) for stopping due to fatigue rather than low back pain (LBP).

Reason for Stopping	OR (95% CI)
Holding time (1 min longer)	2.12 (0.80-5.63)
Age (10 y older)	0.80 (0.46-1.40)
More frequent LBP past y (1/7 points)	0.61* (0.47-0.79)
Higher LBP intensity past y (10/100 points)	1.24* (1.10-1.39)
LBP today	0.33 [†] (0.13-0.85)
More tired than usual on the test day	1.03 (0.33-3.20)
Health currently normal on the test day	1.90 (0.60-6.01)
History of competitive sports	0.55 (0.22-1.37)
Years of aerobic exercise (10 y) [*]	1.15 (0.87-1.53)

Abbreviations: OR, odds ratio; CI, confidence interval; LBP, low back pain.

* $P < .001$

[†] $P < .05$

^{*} Years of aerobic activity are age adjusted.

TABLE 4. Multivariate model for stopping the test due to fatigue rather than low back pain (LBP) during testing.

Factor	OR (95% CI)
LBP frequency (daily LBP over prior year)	0.16 (0.05-0.54)
LBP intensity (10/100 points)*	0.84 (0.74-0.95)
History of competitive sports	0.38 (0.15-0.98)

Abbreviations: OR, odds ratio; CI, confidence interval.

* LBP intensity of worst episode of back symptoms over the prior year.

both play an important role. The question, "Why did you stop the test?" resulted in a variety of responses in this population-based sample of men. Familiarity with the types and frequencies of various responses to the test in a general population sample is important background knowledge when observing and interpreting the frequency of responses in a patient population. Also, some of the less frequent reasons for stopping, that were related to motivation and insecurity or discomfort with the test position, suggest that it may be important to inform the subject properly of the requirements of the test and to ensure that the testing position is well secured and as comfortable as possible. Fatigue was by far the most common reason for terminating the isometric back extension endurance test, which is consistent with the results of an earlier study on healthy subjects.¹⁹ Pain in the lower extremities was the second most common reason for stopping the test. Termination due to LBP was relatively rare, claimed by only 3% of subjects. As expected, those who stopped the isometric back extension endurance test due to LBP were more likely to have a history of frequent or intense LBP, and had shorter holding times than those who stopped due to fatigue. Conversely, those who terminated the test due to lower extremity pain had similar holding times as those who claimed fatigue as the cause. These findings support our hypothesis that the

test would be more likely to elicit pain or discomfort in the low back area in those with a history of LBP problems and thus limit test performance. Our results conflict with Latimer et al's¹⁴ findings, in which subjects with LBP were less likely to end testing due to LBP than subjects without LBP. However, several studies, including Latimer et al's, have found that isometric back extension endurance testing can discriminate between subjects with and without LBP.^{14,25}

As might be expected, stopping due to fatigue was associated with a holding time 19 seconds longer than the holding time when stopping due to LBP. The shorter holding time in persons with a history of LBP problems may reflect, in part, test fear-avoidance²⁹ or a transient exacerbation of symptoms from an underlying back condition, as well as lower isometric back extensor muscle endurance. LBP problems may have an even greater influence on test performance in patients undergoing evaluation and care for such problems. This difference in holding time between those who terminated the test due to fatigue and back pain could explain, in part, how the test discriminates between subjects with and without LBP.^{8,14,20-21,25} It could be speculated that also considering the reason for test termination may enhance the predictive value of holding time for future LBP episodes.³ Several studies have shown that a history of back pain problems is a predictor of future pain.^{4,26} As those who terminated the test due to LBP were more likely to have had past episodes of LBP, they may be more prone to have LBP episodes in the future. In addition, those with a history of competitive sports were more likely to stop due to pain than were those without such a history. People with a history of competitive sports are accustomed to pushing the limits of their physical capacities to the point of pain or discomfort, which could be one explanation for this finding. Consistent with this explanation, those with a competitive sport history had a holding time 14 seconds longer on average than those with no competitive-sport history.

CONCLUSIONS

Our findings suggest that in the general adult male population isometric back extension endurance test performance reflects some muscle-related capacity, as indicated by fatigue being the dominant reason for test termination. Pain-related factors influence performance in a minority of men, such as those with a history of frequent or intense LBP. These individuals were more likely to limit holding time due to LBP elicited by testing. It may be important to be aware of such effects in a patient population where transient exacerbation of LBP or fear-avoidance may have an influence on test results. Psychological factors, perhaps related to a competitive nature or motivation, as reflected by a history of competitive-sport involvement, may also play a role in performance. It could

be speculated that the reason for test termination could enhance the predictive value of holding time of isometric back extension endurance testing for future LBP episodes.

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