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Research article

QUANTIFICATION OF LUMBAR ENDURANCE ON A BACKUP LUMBAR EXTENSION DYNAMOMETER

Staci M. Hager [1]✉, Brian E. Udermann [1], David M. Reineke [2], Mark H. Gibson [1], John M. Mayer [3] and Steven R. Murray [4]

[1] Department of Exercise and Sports Science, University of Wisconsin-La Crosse, La Crosse, WI, USA
[2] Mathematics Department, University of Wisconsin-La Crosse, La Crosse, WI, USA
[3] U.S. Spine and Sport Foundation, San Diego, CA, USA
[4] Department of Kinesiology, Mesa State College, Grand Junction, CO, USA

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ABSTRACT

We evaluated the reliability of static and dynamic lumbar muscle endurance measurements on a BackUP lumbar extension dynamometer. Sixteen healthy participants (8 male; 8 female) volunteered for this investigation. Fifty percent of each participant's body weight was calculated to determine the weight load utilized for the static (holding time) and dynamic (repetitions) lumbar extension endurance tests. Four separate tests (2 static, 2 dynamic) were conducted with at least a 24-hour rest period between tests. Test-retest intraclass correlations were shown to be high (static lumbar endurance, ICC = 0.92 ($p < 0.0005$); dynamic lumbar endurance, ICC = 0.93 ($p < 0.0005$) for both of the performed tests. Our results demonstrated that static and dynamic lumbar endurance can be assessed reliably on a BackUP lumbar extension dynamometer.

KEY WORDS: Reliability, low back, static, dynamic.

INTRODUCTION

Low back pain (LBP) is a prevalent and costly health problem that stresses the healthcare systems of industrialized societies. Numerous risk indicators can cause and contribute to LBP, including spinal and musculoskeletal impairments, psychological factors, lack of fitness, obesity and muscular dysfunction (Andersson, 1999; Jorgensen and Nicolaisen, 1987; Taimela et al., 2000).

The endurance capability of the lumbar muscles is important in the prevention and rehabilitation of LBP (Udermann et al., 2003). For instance, LBP is more common in individuals with low-static-lumbar endurance and patients with recurrent LBP have considerably shorter trunk muscle endurance times than healthy individuals (Biering-Sorensen, 1984; Hultman et al., 1993; Jorgensen and Nicolaisen, 1987; Nicolaisen and Jorgensen, 1985). Furthermore, decreased low back endurance is a significant risk factor in the development of future incidence of LBP (Biering-Sorensen, 1984). Exercise training that focuses on trunk muscle endurance movements is effective in reducing pain and disability in patients with LBP (Chok et al., 1999; Kankaanpää et al., 1999; Moffroid et al., 1993).

Because of the magnitude of the problem of LBP, new devices are often added to the marketplace since they may offer distinct advantages over current technologies. A variety of instruments and procedures have previously been used to evaluate the reliability of lumbar endurance capabilities. The results of these studies have varied considerably when reporting reliability levels (Alaranta et al., 1994; Jorgensen and Nicolaisen, 1986; Mayer et al., 1995; Udermann et al., 2003). Reliability is defined as a measure of the consistency of repeated observations for an individual on a particular performance outcome.

The BackUP™ dynamometer (Priority One Equipment, Grand Junction, CO) is a relatively low cost dynamometer (approximately $8,000 US) that is designed to effectively isolate the paraspinal muscles while performing dynamic lumbar extension exercises through a 72° range of lumbar flexion. It has been shown to reliably assess isometric lumbar extension strength through the full range (Udermann et al., 2004). While other currently available lumbar dynamometers have been studied extensively and have been validated, the exorbitant cost of these devices (approximately $40,000-60,000), hinders their widespread use in clinical, athletic, and fitness settings (Dreisinger and Nelson, 1996; Udermann et al., 2004). The purpose of our investigation was to examine the reliability of static and dynamic lumbar endurance measurements using the BackUP lumbar extension dynamometer.

METHODS

Participants

Sixteen healthy volunteers, 8 male (age = 20.6 ± 1.8 years; height = 1.86 ± 0.10 m; weight = 82.2 ± 19.5 kg) and 8 female (age = 19.9 ± 1.2 years; height = 1.69 ± 0.05 m; weight = 72.4 ± 11.4 kg) were recruited by word of mouth from a midwestern university campus. All participants reported no previous back surgery or low back pain in the past 6 months. Written informed consent was obtained from all participants, and the procedures for this research study were approved by the sponsoring university's Institutional Review Board.

Instrumentation

The BackUP lumbar extension dynamometer was used to test dynamic and static lumbar endurance. This machine is designed to allow dynamic lumbar extension through a 72º range of lumbar flexion. A range of motion stop on the dynamometer controls the degree of extension during dynamic exercise if limited movement is necessary because of back pain or injury. The pelvic stabilization system on this device provides user operated restraint mechanisms at the feet, shins, thighs, lower and upper back (see Figure 1).

Procedures

The participants completed a 5-minute warm-up on a cycle ergometer (to reduce the risk of injury) prior to testing. Before positioning the participants in the BackUP dynamometer, the range of motion stop was set to 0º of lumbar flexion. Participants were then seated in a position where their feet were placed on a footrest with their lower legs against the shins pads and the knees and hips flexed to approximately 90º. Next, the lumbar support height was adjusted both horizontally and vertically to ensure a neutral position where the fulcrum point of the movement arm passed through the frontal plane of the back in line with the hip joints. The lumbar pad permitted the primary pressure to occur on the pelvis at or slightly above the posterior superior iliac spines, below the fifth lumbar vertebrae. The back pad height on the movement arm was adjusted where the pad was located in the middle region of the thoracic spine at the level of the shoulder blades. The thigh restraint was then set so that the pads were resting on the thighs. Finally, a hydraulic lever was engaged to raise the footrest (knees and hips remaining at 90°), which caused the femurs to be driven toward the pelvis, securing the pelvis against the lumbar support pad. All pelvic restraint settings were recorded for each individual, and the same positions were used on subsequent tests.

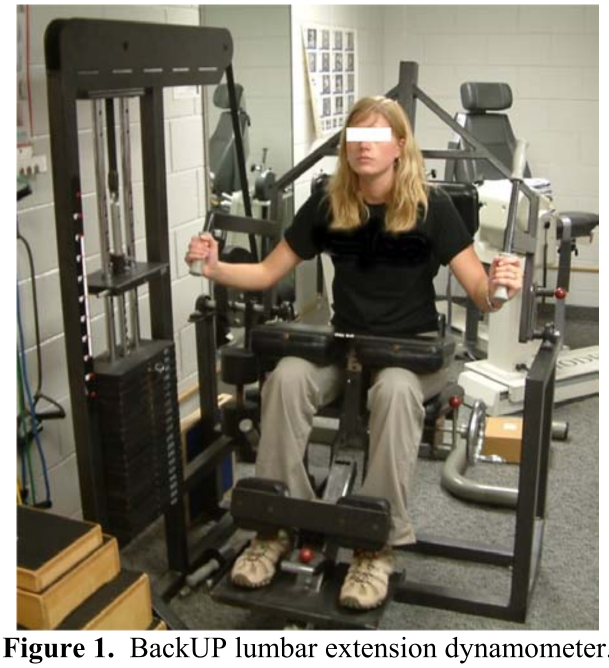

Figure 1. BackUP lumbar extension dynamometer.

Once the pelvic stabilization procedures were completed, proper instruction was given to the participants and a practice test was performed to familiarize the participants with the dynamometer. Prior to testing, 50 percent of each participant's body weight was calculated to determine the weight load utilized for the static and dynamic lumbar extension endurance tests. Four separate tests (2 static, 2 dynamic) were conducted with at least a 24-hour rest period between tests to reduce the possibility of a fatigue effect. This rest period has been used in similar studies (Udermann et al., 2003; 2004). Participants were not allowed to test if they were experiencing delayed onset muscle soreness. Testing order was balanced across participants using a Latin square design to minimize a training effect. Static lumbar endurance was tested by having the participants hold the calculated load at 36° (mid-range of lumbar flexion) for as long as possible. The test was stopped when the participant could no longer maintain this position. The dynamic lumbar endurance tests were performed through 0-72° lumbar range of motion. The participants completed as many repetitions as possible moving through the concentric contraction (lumbar extension) in 4 seconds and the eccentric contraction (lumbar flexion) in 4 seconds. The test was terminated when participants could not complete a full repetition in 8 seconds.

Data analysis

Means and standard deviations were calculated for both static and dynamic lumbar endurance tests. Reliability was measured by correlating values for each endurance test for tests 1 and 2 using intraclass correlation coefficients (ICC). The measures for test 1 and test 2 for static and dynamic endurance were also compared visually to 95% limits of agreement using a Bland-Altman plot. A significance level of 5 percent was used for all hypothesis testing.

RESULTS

The means and standard deviations of tests 1 and 2 for static lumbar endurance were 161.2 ± 38.6 seconds and 169.2 ± 43.3 seconds, respectively. The means and standard deviations of tests 1 and 2 for dynamic lumbar endurance were 17.4 ± 4.9 repetitions and 16.6 ± 3.9 repetitions, respectively. The test-retest ICC for static lumbar endurance was 0.92 ($p < 0.0005$) and 0.93 ($p < 0.0005$) for dynamic lumbar endurance, indicating a high level of agreement between test 1 and test 2 measurements. The Bland-Altman plots are shown in Figures 2 and 3 for the static and dynamic tests, respectively. For both measures the sample differences tend to be bigger when the average endurance measure is high, noting that the only two values falling outside of the 95% limits of agreement occur at higher means values for both static and dynamic tests (note: the values falling outside the limits in Figure 2 are not the same participants for which the values fall outside the limits in Figure 3).

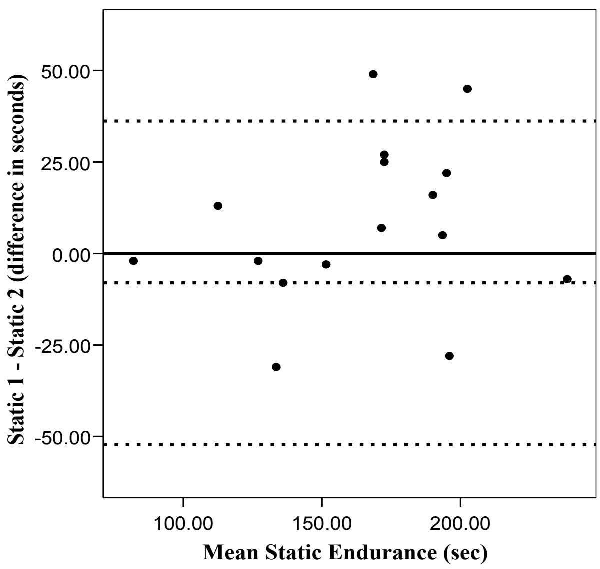

Figure 2. Bland-Altman plot for static endurance with 95% limits of agreement and bias line.

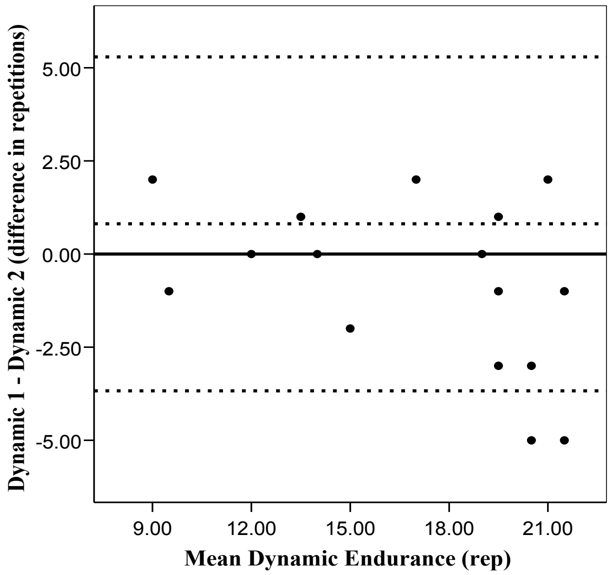

Figure 3. Bland-Altman plot for dynamic endurance with 95% limits of agreement and bias line.

DISCUSSION

This is the first study to report reliability measures of static and dynamic lumbar endurance on a BackUP lumbar extension dynamometer. The results suggest that both static and dynamic lumbar endurance can be assessed reliably on this machine in apparently healthy individuals. Previous research has tested the reliability of isometric lumbar extension strength on the BackUP lumbar extension dynamometer, resulting in high reliability coefficients (r = 0.92 - 0.97) at multiple joint angles (Udermann et al., 2004).

Unfortunately, reliability studies that test lumbar endurance on machines that effectively stabilize the pelvis and isolate the lumbar extensors are limited. To the best of our knowledge, only one other study has reported static and dynamic lumbar endurance measurements on a pelvic stabilizing lumbar extension dynamometer (Udermann et al., 2003). In that study, eight healthy participants completed 4 lumbar endurance tests (2 static, 2 dynamic) on a MedX dynamometer, each separated by a 24-hour resting period. The authors reported high reliability coefficients for static (r = 0.95) and dynamic (r = 0.91) endurance tests.

When pelvic stabilization is not employed, as is the case with the Sorensen test or repetitive arch-ups, conflicting results have been reported (Alaranta et al., 1994; Latimer et al., 1999; Mayer et al., 1995; McGill et al., 1999; Moffroid et al., 1994). Alaranta et al. (1994) found the Sorensen test to be moderately reliable (r = 0.66), while repetitive arch-ups had a high reliability coefficient of 0.83. Mayer et al. (1995) demonstrated unacceptably low test-retest correlations of 0.20 on the Sorensen test. Conversely, McGill et al. (1999) showed a reliability coefficient of 0.99, and Latimer et al. (1999) found high interclass correlation coefficients (ICC) ranging from 0.77 to 0.88 on the Sorensen test for participants who had current, previous, or asymptomatic nonspecific LBP. Latimer et al. also demonstrated that activity level does not appear to affect the reliability of the Sorensen test (ICC = 0.86 for active participants, ICC = 0.82 for inactive participants). Furthermore, Moffroid et al. (1994) demonstrated an excellent correlation coefficient of 0.96 for active individuals, but a poor correlation coefficient of 0.39 for inactive individuals. Reasons for this inconsistency may be the variety of ways examiners have performed the tests and the ability of the pelvis and hips to rotate freely, allowing contributions of additional muscle groups.

Although these tests have been shown to be reliable, have predicted first time occurrences of LBP, and have demonstrated that individuals with current or previous LBP have shorter endurance times than healthy individuals (Alaranta et al., 1994; Hultman et al., 1993; Luoto et al., 1995), the validity of these tests in measuring lumbar endurance has to be questioned. Without stabilizing the pelvis, the lumbar muscles cannot be isolated effectively because of the contributions from the hip extensors. Moffroid et al. (1994) indicated that the Sorensen test fatigued the hip extensors more than the lumbar extensors. Kankaanpää et al. (1998) also found the Sorensen test to be influenced by an individual's body weight. Factors like weight and body proportions that are not directly associated to lumbar endurance capacity must not manipulate the test results (Jorgensen and Nicolaisen, 1986). With these non-dynamometric tests, the weight of the upper body cannot be accurately measured. Relative load applied to the lumbar extensors must be known because endurance time is primarily dependent on the relative load on the muscles (Jorgensen, 1970). The weight of the upper body may be too heavy of a load for postsurgical individuals or for those experiencing LBP or injury. With the BackUP dynamometer, the resistance load can be set to as little as five pounds and can be incrementally increased as the patients progress through treatment and rehabilitation programs.

Our study was conducted with volunteers in good general health, so direct generalizations to patients with low back pain cannot be made. A variety of factors that may be present in clinical populations (e.g. pain inhibition, level of motivation) may impact reliability levels in this population.

One limitation of the tests described in this study is that they are performed in a seated position. This raises questions in regards to the specificity of the tests in relationship to the variety of activities, postures and positions that individuals are in as they perform activities of daily living and tasks possibly related to occupation. This is a common limitation of many standardized physical tests. However, previous research has shown that isometric strength in the seated position is related to lifting capacity in the standing position (Matheson et al., 2002).

These tests provide simple and reliable assessments of lumbar muscle endurance. Given the strong relationship between poor endurance of the lumbar muscles and an increased risk of future low back pain (Biering-Sorensen, 1984; Luoto et al., 1995), the findings of this study have practical applications. For example, clinicians, athletic trainers, fitness specialists, and occupational risk managers can use these tests to assess lumbar muscle endurance of patients, athletes, and workers to provide baseline measurements of function to help guide intervention strategies. Future research is needed, however, to assess the reliability of the endurance tests in patient populations and validity (e.g. responsiveness, concurrent validity) in various settings.

CONCLUSION

The data from this investigation suggest that static and dynamic lumbar endurance testing on a BackUP lumbar extension dynamometer, which uses a variety of pelvic stabilization mechanisms, is highly reliable in apparently healthy individuals.

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KEY POINTS

- Reliability studies that test lumbar endurance on machines that effectively stabilize the pelvis and isolate the lumbar extensors are limited.
- This is the first study to report reliability measures of static and dynamic lumbar endurance on a BackUP lumbar extension dynamometer.
- Static and dynamic lumbar endurance on a BackUP lumbar extension dynamometer, which uses a variety of pelvic stabilization mechanisms, can be reliably assessed in apparently healthy individuals.
- Future research is necessary to examine the reliability of lumbar extension endurance on the BackUP dynamometer in patient populations and validity in various settings.

AUTHORS BIOGRAPHY

Staci M. HAGER

Employment

Certified Athletic Trainer, Sports Medicine Department, Aurora Health Center, USA.

Degrees

MS, ATC

Research interests

Low back pain, musculoskeletal assessment of the low back.

E-mail: staci.hager@aurora.org

Brian E. UDERMANN

Employment

Assoc. Prof., Department of Exercise and Sport Science, University of Wisconsin-La Crosse, USA.

Degrees

PhD, ATC, FACSM

Research interests

Musculoskeletal assessment of the low back

E-mail: udermann.bria@uwlax.edu

David M. REINEKE

Employment

Assoc. Prof., Depart. of Mathematics, Univ. of Wisconsin-La Crosse, USA.

Degree

PhD

Research interests

Lifetime data analysis, hypothesis testing, applied statistics.

E-mail: reineke.davi@uwlax.edu

Mark H. GIBSON

Employment

Ass. Prof., Department of Exercise and Sport Science, University of Wisconsin-La Crosse, USA.

Degrees

MSEd., MS, PT

Research interests

Athletic Training education, clinical practice validation, cardiovascular health.

E-mail: gibson.mark@uwlax.edu

John M. MAYER

Employment

Research Director, U.S. Spine and Sport Foundation, USA.

Degrees

PhD, DC, CCRP

Research interests

Clinical outcomes for spinal disorders.

E-mail: jmmayer@mail.sdsu.edu

Steven R. MURRAY

Employment

Chair, Department of Kinesiology, Mesa State College, Grand Junction, CO, USA.

Degree

DA

Research interests

General Fitness, Low back health.

E-mail: smurray@mesastate.edu

✉ **Staci M. Hager**

2845 Greenbrier Road, Green Bay, WI 54311, USA.