**Brief Report**

Reliability of the Box and Block Test of Manual Dexterity for Use With Patients With Fibromyalgia

Mark L. Canny, Jeffrey M. Thompson, Mikel J. Wheeler

**OBJECTIVE.** The aim of this study was to determine the reliability of the Box and Block (B&B) Test of Manual Dexterity for upper-extremity function in patients with fibromyalgia and to compare their results with those of healthy control participants.

**METHOD.** We assessed reliability of the B&B Test within and between testers using the intraclass correlation coefficient (ICC). We compared fibromyalgia patient \((n = 30)\) and control group \((n = 30)\) scores using analysis of variance and population-based normative data.

**RESULTS.** The B&B Test was reliable with ICCs of .90 to .85. Fibromyalgia patients' B&B Test scores were significantly lower (more impaired) than those of the control group and standardized norms.

**CONCLUSIONS.** The B&B Test is a reliable measure of upper-extremity function in fibromyalgia patients and is able to reveal a reduction in upper-extremity function in these patients compared with both healthy control participants and normative scores.


**KEY WORDS**
- disability evaluation
- fibromyalgia
- hand
- motor skills
- reproducibility of results

**Fibromyalgia syndrome (FMS)** is characterized by widespread musculoskeletal pain, multiple tender points, easy fatigue, and exacerbation of pain with activity. The etiology of the muscular pain has yet to be conclusively determined, and hypotheses are moving away from peripheral causes, such as local muscle ischemia and microtrauma (Simms, 1998), toward etiologies that may involve central sensitization and lowered pain thresholds (Bennett, 1996; Crofford & Demitrack, 1996; Weigent, Bradley, Blalock, & Alarcon, 1998). Nevertheless, some investigators still hold fast to the belief that muscle dysfunction plays a central role in the development and continuance of some symptoms associated with FMS (Veierstad, Westgaard, & Andersen, 1993).

Among the various symptoms associated with FMS, stiffness is one of the most common complaints, after pain and fatigue (Mannerkorpi, Svantesson, Carlson, & Ekhdal, 1999). No joint pathology that would explain this stiffness, however, has ever been found in patients with FMS. What is its source? One could consider stiffness to be a result of central sensitization and altered somatic sensation. Conversely, one could consider it to result from resistance to movement in the muscles or other connective tissues. Investigators have pointed to poor muscle-firing patterns as a possible source of this resistance to movement (Madeleine, Lundager, Voigt, & Arendt-Nielsen, 1999; Sterling, Jull, & Wright, 2001); a common clinical observation is that FMS patients exhibit multiple muscle co-contraction patterns resulting in nonsmooth movements and reduced range of motion (ROM; Donaldson, Snelling, MacInnis, Sella, & Mueller, 2002). This

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Mark L. Canny, OTR, is Staff Therapist, Department of Physical Medicine and Rehabilitation, Mayo Clinic, Rochester, MN.

Jeffrey M. Thompson, MD, is Associate Professor of Physical Medicine and Rehabilitation, Mayo Clinic College of Medicine, Rochester, MN 55905; thompson.jeffrey@mayo.edu

Mikel J. Wheeler, COTA, is Staff Therapist, Department of Physical Medicine and Rehabilitation, Mayo Clinic, Rochester, MN.
poor coordination of muscle firing may be the result of chronic pain, or it may be an important factor in the initiation of muscle pain.

Our purpose in this study was not to provide verification for one theory over another but rather to evaluate the reliability and concurrent validity of a tool that may aid researchers and clinicians who work with patients with FMS. Finding a way to reliably and objectively measure upper-extremity function may lead to a better understanding of the role of muscular dysfunction in musculoskeletal pain, and it could potentially lead to more effective treatment for those experiencing FMS.

Historically, various assessments have been used to measure functional capacities of patients with FMS; the assessments vary in their approach. Some have focused on performance of activities of daily living (ADLs); others have examined component performance, targeting strength and endurance at the muscular level; and still others have combined both task performance and component performance. Panton et al. (2006) compared 29 women with FMS to those without FMS using the Continuous-Scale Physical Functional Performance Test (Cromwell, 1976). This assessment includes performance of tasks such as pouring water from a jug to a cup, putting on and removing a jacket, putting a Velcro strap over a shoe, and picking up scarves. In this study, patients with fibromyalgia were found to have lower functionality scores than age- and weight-matched controls. Mannerkorpi et al. (1994) found the combined 6-min walk test, chair rising, component testing of hand grip strength, upper-extremity active ROM, and shoulder endurance to be a valid measure of upper-extremity muscular performance. Gowans, deHueck, Voss, and Richardson (1999) defined an increase in function using the 6-min walk test and measured change in function after 6 and 12 months of exercise. The protocol of examining specific activity performance and muscular components together seems a logical approach to assessing function, given the close relationship each has to the other.

Despite the tools already used by clinicians for assessing function, an extensive search of the literature did not identify any specific assessments targeting muscle coordination dysfunction in FMS. The Box and Block (B&B) Test of Manual Dexterity (Cromwell, 1976) has been used to measure upper-extremity coordination in clients with functional impairments (Desrosiers, Hebert, Dutil, & Mercier, 1994; Paltamaa, Sarasoja, Wikstrom, & Malkia, 2005; Svensson & Häger-Ross, 2006) and, when paired with other tools focused on task performance, could potentially be used to provide clinicians with valuable information regarding function in patients with FMS. The advantages of the B&B Test are that it has been standardized, is quick to administer (requiring <5 min), and is inexpensive to purchase or can even be handmade (Mathiowetz, Volland, Kashman, & Weber, 1985). The test involves grasping and moving 1-in. square wooden blocks from one side of an 8-in. square box to the other by passing them over a wooden partition 5 in. high. The patient is scored according to the number of blocks passed from one side to the other in 1 min. Lower scores correspond to greater upper-extremity impairments.

Normative data for the B&B Test have been documented for adults on the basis of 628 people without disabilities between ages 20 and 70+ years (Mathiowetz et al., 1985). Test–retest reliability was established at a 6-month interval and found to be 0.95 for the left hand and 0.98 for the right hand (Cromwell, 1976). Convergent validity was supported using a Minnesota Rate of Manipulation Test subtest (Cromwell, 1976). Further validation of the test targeted more specific clients, including elderly adults (Desrosiers et al., 1994), patients with multiple sclerosis (Paltamaa et al., 2005), and patients with Charcot–Marie–Tooth disease (Svensson & Häger-Ross, 2006). Svensson and Häger-Ross (2006) was the only study that compared patient scores with documented norms, with patient scores being significantly lower than the norms. We found no studies, however, describing the use of the B&B Test in patients with FMS.

Method

Research Design

This study was an inter- and intratester, test–retest design reliability study with the addition of comparisons between a control group and an experimental group consisting of FMS patients. We assessed the reliability of the B&B Test within and between testers using the intraclass correlation coefficient (ICC) and compared control and experimental group scores using analysis of variance and population-based normative data. A convenience sample of 30 women with FMS and 30 women in good health without FMS participated in this study in the Mayo Clinic’s biofeedback clinic. The B&B Test data used in this study were collected as part of a larger study examining surface electromyography information.

Participants

We recruited 30 female patients from the Fibromyalgia Treatment Program at the Mayo Clinic. Patients attending the program had the diagnosis of FMS confirmed by a physician using the American College of Rheumatology 1990 criteria (Wolfe et al., 1990) before enrollment in the program. Thirty-two participants were identified and agreed to take part; however, 2 were not able to complete the testing because of scheduling conflicts. The healthy control group was a convenience sample consisting of staff members working in Mayo Clinic’s Fibromyalgia Treatment Program and Pain Rehabilitation Center. All volunteers were pain free, had no musculoskeletal pain requiring medication in the previous month, and had no history of neuromuscular disease. Baseline data collected included age, height, and weight. This study was approved by the Mayo Clinic Institutional Review Board, and all participants completed a consent form before enrollment in the study.

Procedure

Each participant was asked to sit comfortably at a table and complete the B&B Test using the dominant upper extremity. The raw score was recorded as the number of blocks passed over the divider within 1 min.
Each participant performed the test three times—twice on the same day with the same examiner and once the next day with a second examiner. We calculated ICCs within examiner (ICC[2]) and between examiners (ICC[1]) for the 30 patients with FMS and the 30 control participants (Fleiss, 1981). Each participant’s mean score for the three trials was determined and used in the between-groups comparison using an unpaired t test. Finally, we compared both groups’ scores to normative data collected by Mathiowetz et al. (1985), using each participant’s average score.

Results

Demographics

The average age of patients was 46.9 years (range = 20–68). The average age of healthy control participants was significantly younger at 41.2 years (range = 29–52). Of the 30 participants in each group, 29 were right-hand dominant. Groups showed no statistically significant differences on weight or body mass index (see Table 1).

Reliability

For this study, we defined fair reliability as an ICC of .4 to .6, good reliability as an ICC of .6 to .75, and excellent reliability as an ICC of .75 to 1.00. We found ICCs for the raw score on the B&B Test to be excellent, ranging from .80 to .98 for both within- and between-examiner trials (see Table 2).

Between-Group Comparisons

The average B&B Test score for the FMS patients was significantly lower than that for the control group (61.8 and 71.1, respectively; unpaired t = 5.2154, df = 58, p = .0001). When compared with the normative values provided by Mathiowetz et al. (1985), the FMS patients’ average score was 3 standard deviations below and the control group’s average score was 1.9 standard deviations below the age-matched mean. Table 3 shows the raw score comparisons between the two groups.

Discussion

Patients with FMS often experience loss of function as a result of the variety of symptoms associated with the syndrome. These symptoms include widespread musculoskeletal pain, more fatigue than usual, activity intolerance, and joint stiffness. The symptom of stiffness has not been studied in any detail. Marques et al. (2004) described morning stiffness; however, they focused their evaluation on flexibility testing and quality of life via the Fibromyalgia Impact Questionnaire. Adams and Sim (2005) identified principal rehabilitative approaches to FMS, finding that exercise combined with a psychologically based treatment such as cognitive–behavioral therapy is becoming more frequently used without any specific mention of treatments for stiffness. When rehabilitation efforts include occupational therapy, emphasis is placed on improving the patient’s ability to perform functional activities (Lindberg, 2002).

A key issue leading to the initiation of this study was that FMS patients attending our treatment program often complain of decreased upper-extremity function, including complaints of slowed fine motor performance and “dropping things,” yet we have not adopted any formal testing procedures to assess muscle coordination. Unfortunately, we found no studies specifically targeting assessment or treatment of muscle incoordination in FMS. This lack of focus on upper-extremity coordination may result from several reasons, including lack of attention to upper-extremity function during the evaluation process. Hints that the problem exists come from findings on some assessment tools that identify difficulty with ADLs (Lindberg, 2002) and from studies of more localized muscle pain syndromes such as neck and shoulder pain (Madeleine et al., 1999).

Although many forms of evaluative tools for measuring gross and fine motor coordination can be found in the literature, they have not been used in patients with FMS. Our purpose in this study was to determine whether the B&B Test, chosen because of its ease of administration with minimal equipment, can be used to measure the upper-extremity performance of patients with FMS.

The authors of a study establishing reliability and validity of the B&B Test with elderly people underscored the importance of “measuring the reliability of an instrument with the targeted clientele” (Desrosiers et al., 1994, p. 754). The B&B Test as described by Mathiowetz et al. (1985) was shown in our study to be reliable in both healthy control participants and FMS patients whether repeated by the same examiner or a different examiner, thus supporting its use in patients with FMS.

The B&B Test also successfully discriminated between FMS patients and the control group, lending some credence to the common patient complaint of upper-extremity dysfunction and to the use of the B&B Test to measure upper-extremity dysfunction in FMS patients.

Limitations and Future Research

This study was completed in a clinical treatment setting in which clinical concerns were given priority over research. Consequently, some errors in data collection may have occurred that would not occur in a laboratory-based research project. Because the study did not include

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**Table 1. Patient and Control Participant Demographics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patients (n = 30)</th>
<th>Control participants (n = 30)</th>
<th>t</th>
<th>df = 58</th>
<th>p &lt; .05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years, mean (SD)</td>
<td>46.9 (11.8)</td>
<td>41.2 (6.6)</td>
<td>2.33</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>Weight in kilograms, mean (SD)</td>
<td>72.3 (12.6)</td>
<td>68.3 (10.8)</td>
<td>1.32</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>Body mass index, mean (SD)</td>
<td>25.9 (3.7)</td>
<td>25.7 (3.8)</td>
<td>0.27</td>
<td>.78</td>
<td></td>
</tr>
</tbody>
</table>

*Note. SD = standard deviation; df = degrees of freedom.*
male participants, it is not clear whether the B&B Test would have the same reliability with them.

Our control group consisted of a convenience sample of health care workers recruited from the tertiary clinical setting where this study was conducted. Because this sample may not be representative of the normal population, its accuracy must be considered before judgments can be made. In the same way, the FMS patients referred to the treatment program may not represent the population seen in a community-based setting. The information for this research project was gathered as a part of a larger project that included measurement of muscle activity using biofeedback electromyography while participants engaged in a variety of tasks. This project’s sample size was consequently restricted; however, we still found a statistically significant difference between the control and patient groups. The possibility of uncontrolled variables influencing the results, however, is greater with a small sample size. The patient group members were significantly older than the control group members (46.9 vs. 41.2), which may have influenced their performance, although they also scored much worse than controls when compared with age-matched norms.

The control participants and patients both scored significantly below the published norms by 1.9 and 3 standard deviations, respectively. The reason for this result is not clear. One possibility is that the presence of surface electromyography electrodes attached to cervical paraspinals, upper trapezius, and lumbar paraspinals as part of a different study may have influenced the participants’ speed of movement (although there was no mechanical impedance to movement). Another possibility is a difference in the level of encouragement provided in this study during data collection compared with that provided in the study that established normative data. Because the instructions provided for this test are not scripted, it is unknown how the original researchers provided instructions. Variations in wording between facilitators may have influenced the intensity provided by the participants. These issues should be addressed in a larger study using a more representative control group rather than a convenience sample.

As mentioned, the B&B Test was one of the activities used in a larger study. For this reason, we made no direct comparison to other upper-extremity coordination tests; therefore, we can make no convergent validity judgments. Other tests in the literature used to evaluate this population are more functionally based; there does not appear to be a gold standard assessment tool for measuring coordination problems in people with FMS. Construct validity is supported by the success in distinguishing between the control group and patients with FMS using the B&B Test.

Another variable that may have influenced outcomes was the motivation to succeed at a performance test rather than a functional test. Moving blocks from one place to another may not have the same inherent reward offered by other functional tasks. Related to this, the B&B Test requires rapid movements, which may add a stress component not found in more routine tasks. We selected the B&B Test for this study because of its ease and speed of delivery in contrast to other tests that require increased time and effort to administer. Further research comparing the validity of this test to that of a variety of other tests of upper-extremity coordination in patients with FMS is recommended.

### Conclusion

FMS is characterized by multiple subjective symptoms. The B&B Test appears
to represent a reliable and objective measure of one of those symptoms, decreased upper-extremity function. Future work should seek to correlate the findings from the B&B Test with other measures of severity and with treatment outcomes. Ideally, the test would aid in directing more specific and appropriate treatment for those with FMS.

Acknowledgments

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References


