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The Dubousset Functional Test is a Novel Assessment of Physical Function and Balance

Bassel G. Diebo MD, Vincent Challier MD, Neil V. Shah MD, MS, David Kim BS, Daniel P. Murray MD, John J. Kelly MS, Renaud Lafage MS, Carl B. Paulino MD, Peter G. Passias MD, Frank J. Schwab MD, Virginie Lafage PhD

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Abstract

Background Currently, the functional status of patients undergoing spine surgery is assessed with quality-of-life questionnaires, and a more objective and quantifiable assessment method is lacking. Dr. Jean Dubousset conceptually proposed a four-component functional test, but to our knowledge, reference values derived from asymptomatic

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
This work was performed at the Department of Orthopaedic Surgery and Rehabilitation Medicine, State University of New York, Downstate Medical Center, Brooklyn, NY, USA.

B. G. Diebo, N. V. Shah, D. Kim, D. P. Murray, C. B. Paulino, Department of Orthopaedic Surgery and Rehabilitation Medicine, State University of New York, Downstate Medical Center, Brooklyn, NY, USA

V. Challier, Unité de Pathologie Rachidienne, Clinique Francheville, Périgueux, France

J. J. Kelly, State University of New York, Upstate Medical University, School of Medicine, Syracuse, NY, USA

R. Lafage, F. J. Schwab, V. Lafage, Spine Service, Hospital for Special Surgery, New York, NY, USA

P. G. Passias, Department of Orthopaedic Surgery, New York University Langone Orthopedic Hospital, New York, NY, USA

B. G. Diebo (✉), Department of Orthopaedic Surgery and Rehabilitation Medicine, State University of New York (SUNY), Downstate Medical Center, 450 Clarkson Avenue, MSC 30, Brooklyn, NY, 11203, Email: dr.basseldiebo@gmail.com

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individuals have not yet been reported, and these are needed to assess the test's clinical utility in patients with spinal deformities.

Questions/purposes (1) What are the reference values for the Dubousset Functional Test (DFT) in asymptomatic people? (2) Is there a correlation between demographic variables such as age and BMI and performance of the DFT among asymptomatic people?

Methods This single-institution prospective study was performed from January 1, 2018 to May 31, 2018. Asymptomatic volunteers were recruited from our college of medicine and hospital staff to participate in the DFT. Included participants did not report any musculoskeletal problems or trauma within 5 years. Additionally, they did not report any history of lower limb fracture, THA, TKA, or patellofemoral arthroplasty. Patients were also excluded if they reported any active medical comorbidities. Demographic data collected included age, sex, BMI, and self-reported race. Sixty-five asymptomatic volunteers were included in this study. Their mean age was 42 ± 15 years; 27 of the 65 participants (42%) were women. Their mean BMI was 26 ± 5 kg/m^2. The racial distribution of the participants was 34% white (22 of 65 participants), 25% black (16 of 65 participants), 15% Asian (10 of 65 participants), 9% subcontinental Indian (six of 65 participants), 6% Latino (four of 65 participants), and 10% other (seven of 65 participants). In a controlled setting, participants completed the DFT after verbal instruction and demonstration of each test, and all participants were video recorded. The four test components included the Up and Walking Test (unassisted sit-to-stand from a chair, walk forward/backward 5 meters [no turn], then unassisted stand-to-sit), Steps Test (ascend three steps, turn, descend three steps), Down and Sitting Test (stand-to-ground, followed by ground-to-stand, with assistance as needed), and Dual-Tasking Test (walk 5 meters forwards and back while counting down from 50 by 2). Tests were timed, and data were collected from video recordings to ensure consistency. Reference values for the DFT were determined via a descriptive analysis, and we calculated the mean, SD, 95% CI, median, and range of time taken to complete each test component, with univariate comparisons between men and women for each component. Linear correlations between age and BMI and test components were studied, and the frequency of verbal and physical pausing and adverse events was noted.

Results The Up and Walking Test was completed in a mean of 15 seconds (95% CI, 14-16), the Steps Test was completed in 6.3 seconds (95% CI, 6.0-6.6), the Down and Sitting Test was completed in 6.0 seconds (95% CI, 5.4-6.6), and the Dual-Tasking Test was performed in 13 seconds (95% CI, 12-14). The length of time it took to complete the Down and Sitting ($r = 0.529$; $p = 0.001$), Up and Walking ($r = 0.429$; $p = 0.001$), and Steps ($r = 0.356$; $p = 0.014$) components increased with as the volunteer's age increased. No correlation was found between age and the time taken to complete the Dual-Tasking Test ($r = 0.134$; $p = 0.289$). Similarly, the length of time it took to complete the Down and Sitting ($r = 0.372$; $p = 0.005$), Up and Walking ($r = 0.289$; $p = 0.032$), and Steps ($r = 0.366$; $p = 0.013$) components increased with increasing BMI; no correlation was found between the Dual-Tasking Test's time and BMI ($r = 0.078$; $p = 0.539$).

Conclusions We found that the DFT could be completed by asymptomatic volunteers in approximately 1 minute, although it took longer for older patients and patients with higher BMI.

Clinical Relevance We believe, but did not show, that the DFT might be useful in assessing patients with spinal deformities. The normal values we calculated should be compared in future studies with those of patients before and after undergoing spine surgery to determine whether this test has practical clinical utility. The DFT provides objective metrics to assess function and balance that are easy to obtain, and the test requires no special equipment.

Introduction

Spinal deformities in adults do not only manifest as structural bony malalignment of the spine in one or more planes, they may also be associated with deterioration of the muscles of the spine, pelvis, or lower limbs, as well as with overall body-balance compromise [1, 7, 11, 27]. Although standardized patient-reported outcome questionnaires are helpful in gauging some endpoints patients feel are important, they fall short in terms of objective measurements of function or disability [36]. Therefore, using a simple clinical tool that simultaneously evaluates multiple domains contributing to spinal alignment, muscle integrity, and body balance may be helpful in stratifying the risk of deformities in adult patients, tracking surgical outcomes, and perhaps anticipating complications.

Recently, in personal communication with the second author of this paper (VC), Dr. Jean Dubousset conceptually proposed a practical four-component global functional assessment test—the Dubousset Functional Test (DFT)—to objectively quantify the functional capacity of adults with spinal deformities [7, 8]. The DFT includes the following components: getting up from a chair that does not have arms and walking 5 meters forward and 5 meters backward, climbing steps, sitting down on the floor from a standing position, and a dual-tasking test, in which the participant walks while simultaneously counting down from 50. We believe measuring objective functional endpoints this way is important because our current methods of assessment lack a quantifiable measure of functional performance, instead relying upon correlations between patient-reported functionality and measures of static alignment. We also believe that the specific metrics

Dr. Dubousset proposed are likely good to measure because they evaluate the functionality of spinopelvic muscle groups that are directly involved in maintaining global alignment of the trunk. Adding a dual-tasking component enables us to evaluate coordination and balance, which are necessary elements for patients undergoing corrective procedures for deformities and who are expected to adapt to a new alignment. However, normative values in patients without spinal conditions have not been reported for the DFT. Having such values and determining whether patient factors such as age or BMI influence these normative values is important if we ultimately seek to evaluate the value of the test in patients with spinal deformities.

We therefore asked (1) What are the reference values for the DFT in asymptomatic people? (2) Is there a correlation between demographic variables such as age and BMI and performance of the DFT among asymptomatic people?

Materials and Methods

Study Design and Setting

We performed this prospective study at a single institution from January 1, 2018 to May 31, 2018. We obtained institutional review board approval (Study #1111613-2).

Participants

Asymptomatic adult volunteers (older than 18 years) were recruited from our college of medicine and hospital staff to complete all four components of the DFT in a single session. Volunteers provided consent before any component of this study was conducted. Asymptomatic volunteers were defined as those without any of the following: recent musculoskeletal trauma (within the past 5 years); neurologic impairment; current neck or back pain that affected activities of work, daily living, or participation in social activities or for which narcotic medication was given; and history of spine surgery, THA or TKA, pregnancy, inflammatory arthritis, congenital anomalies, active infection, primary or metastatic tumor, end-stage organ damage, and uncontrolled diabetes mellitus or cardiovascular disease. Before performing any single component of the DFT, volunteers were given an instructional session in a controlled setting that incorporated detailed verbal instruction and a personal demonstration of the DFT component we expected them to perform.

Description of Experiment, Treatment, or Surgery

The four components of the DFT included (1) the Up and Walking Test: participants rose without assistance from a seated position in a chair that did not have arms, walked 5 meters (500 cm) forward before stopping, walked backwards 5 meters, and sat again without assistance; (2) the Steps Test: from a starting position 50 cm away, volunteers climbed three stairs, turned around on the third step (top), and walked down the three steps; (3) Down and Sitting Test: from a standing position, participants sat on the ground and stood up again, using assistance as needed; (4) Dual-Tasking Test: participants walked 5 meters forward, turned around, and walked 5 meters back to the starting position while performing a working memory test (counting down from 50 by intervals of 2).

The rationale for using the Up and Walking and Steps Tests is that they were found to correlate with functional impairment and predict surgical outcomes [21, 22, 28]. The Down and Sitting Test may help evaluate the patient's ability to rise to an erect, bipedal, and balanced posture. Dr. Dubousset thought the Dual-Tasking Test was important because any interference between mental activity and postural control may be related to global body capacity [30, 31]. We believe that timing each of these tests is important (as opposed to, for example, seeing whether a patient can simply complete them or complete them in a reasonable amount of time) because it helps adjust performance by demographic variables such as age, gender, and comorbidities. It also enables us to investigate improvements before and after treatments as well as study minimal clinically important differences in future studies.

Equipment for the DFT components included a three-step apparatus that was designed and built in our institution's carpentry workshop to perform the Steps Test (Fig. 1). In the Up and Walking Test, a chair was precisely placed 30 cm away from two lines of bright blue marking tape set 5 meters apart (Fig. 2). This same set of markers was used for the Dual-Tasking Test. In the Down and Sitting Test, we used a foam pad (Gopher Sport, Owatonna, MN, USA) (Fig. 3).

Variables, Outcome Measures, Data Sources, and Bias

We obtained data on patient demographics, including age, height, weight, and self-reported race. Sixty-five asymptomatic volunteers met the requirements for inclusion in this study. The mean age of the volunteers was 42 ± 15 years, and 27 of the 54 volunteers (42%) were women. The mean BMI was 26 ± 5 kg/m^2. The racial distribution of the participants was 34% white (22 of 65 participants), 25% black (16 of 65 participants), 15% Asian (10 of 65 participants), 9% subcontinental Indian (six of 65 participants), 6% Latino (four of 65 participants), and 10% other (seven of 65 participants).

All volunteers were only provided with verbal instructions and a physical demonstration by the observer or rater

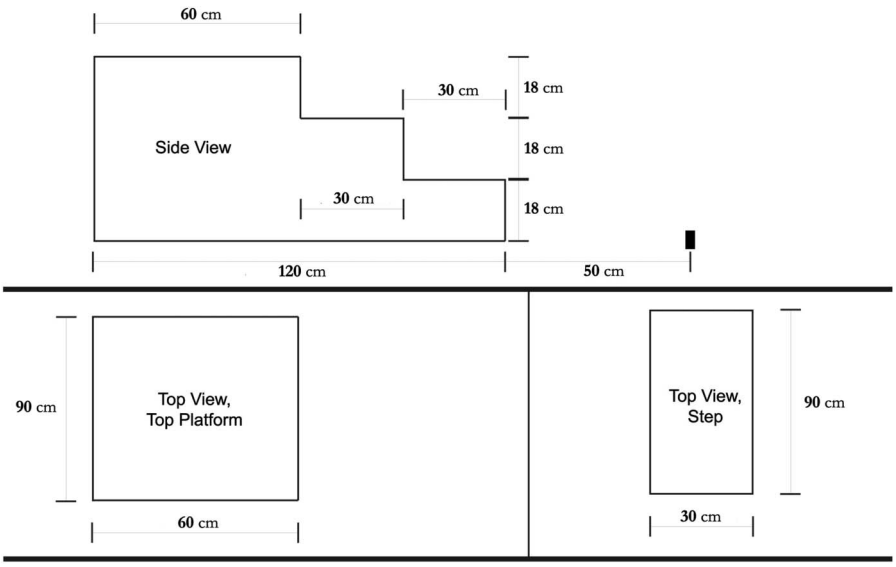


Fig. 1 A three-step apparatus was designed and built for the Steps Test. Depicted is a side view of all steps (top), along with a birds-eye view of the top platform (left) and first and second step (right).

before each DFT component. All participants performed each test component in a single attempt. We video recorded volunteers as they performed the components of the DFT, and we analyzed the videos to collect data and assess for consistency in sequential performance of the test protocol (verbal instruction followed by physical demonstration, and subsequent test performance by the volunteer for each test component).

The primary outcomes included the time it took to complete each test, including the time it took to perform various factors in each test. In addition, we analyzed the video recordings for any mistakes made by the volunteers while performing the tests, including, but not limited to, errors in countdown or passing the blue markers and boundary lines. Two of the coauthors (BGD and NVS) independently analyzed the video recordings and calculated means for all outcomes. In the Dual-Tasking component, we evaluated physical and verbal pauses that occurred during testing, and the time of their occurrence was determined by quartile range in the test cycle. In addition, for the Dual-Tasking Test, we documented the counting rhythm and final count after the test was

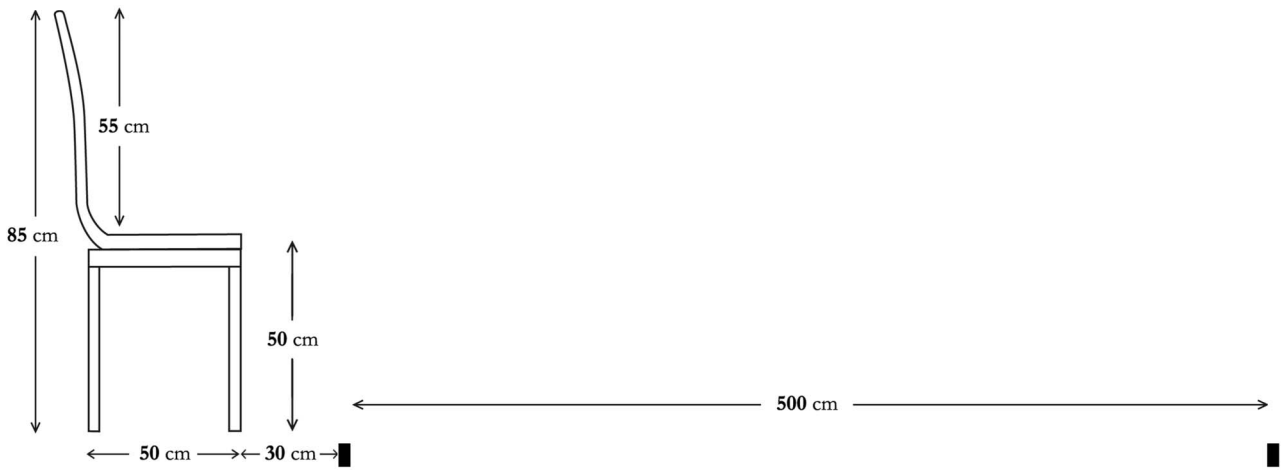


Fig. 2 A lateral view of the testing setup for the Up and Walking Test and Dual-Tasking Test is shown. A chair was placed 30 cm away from the starting marker. A second marker was placed 5 meters (500 cm) away from the first marker. Volunteers rose unassisted from the chair to complete the Up and Walking Test. For the Dual-Tasking Test, volunteers started from a standing position behind the first marker. For both tests, participants were instructed to not pass the second marker.

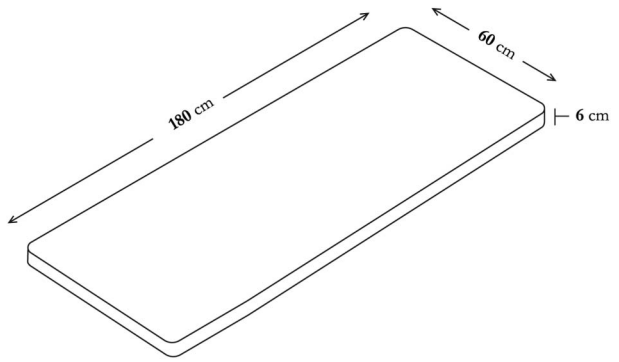


Fig. 3 This image shows the foam pad used in the Down and Sitting Test.

completed. Lastly, we recorded adverse events such as loss of balance (with or without falling) or difficulty performing the tests.

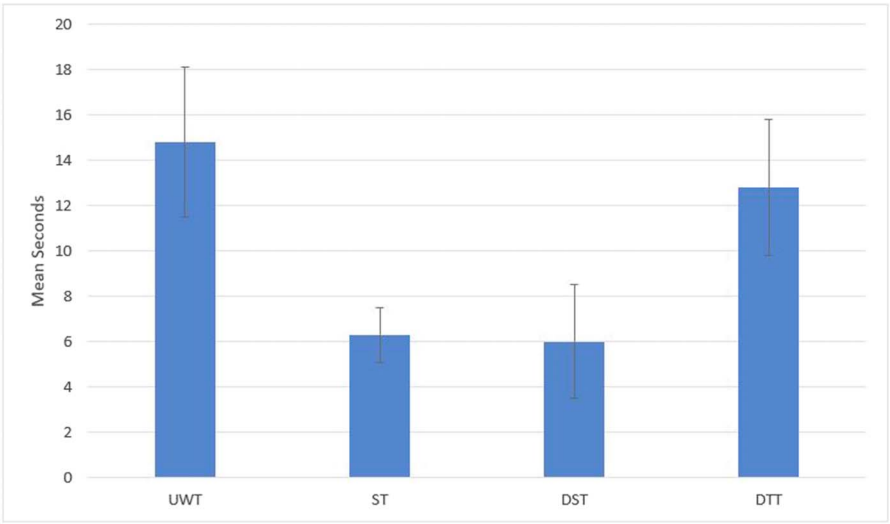
Statistical Analysis, Study Size

Data were organized in spreadsheets using Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA). Statistical and descriptive analyses were conducted using SPSS software version 24.0 (IBM Corp., Armonk, NY, USA). A univariate analysis included descriptive means, SDs, 95% CIs, and the median and range for the time it took for participants to perform each component of the DFT. A t-test was used to compare DFT performance between men and women. Pearson's correlation analysis was used to investigate linear correlations between age and BMI and DFT components. Specific to the Dual-Tasking Test, we determined the frequency of verbal and physical pauses. We also reported the frequency of adverse events. A p value less than 0.05 was the threshold for statistical significance.

Results

What are the Reference Values for the DFT in Asymptomatic People?

The Up and Walking Test was completed in a mean of 15 seconds (95% CI, 14-16), the Steps Test was completed in 6.3 seconds (95% CI, 6.0-6.6), the Down and Sitting Test was completed in 6.0 seconds (95% CI, 5.4-6.6), and the Dual-Tasking Test was completed in 13 seconds (95% CI 12-14) (Fig. 4).



Test	Mean Duration (Seconds)	95% CI	Std. Error Mean	Median	Range
UWT	14.8	13.99-15.64	0.413	14.0	17 (10 to 27)
ST	6.32	6.02-6.63	0.154	6.0	6 (4 to 10)
DST	6.0	5.39-6.61	0.306	5.0	12 (3 to 15)
DTT	12.8	12.05-13.57	0.380	12.0	21 (4 to 25)

Fig. 4 The mean and SD for the duration, in seconds, of each component of the DFT are visually depicted, with expanded descriptive statistics below.

Table 1. Comparison between men and women in the performance of each component of the DFT

Parameter	Up and Walking Test		Steps Test		Down and Sitting Test		Dual-Tasking Test	
Gender	Men	Women	Men	Women	Men	Women	Men	Women
Mean duration of test ± SD (s)	15 ± 3.5	15 ± 3.1	6.3 ± 1.2	6.4 ± 1.4	5.9 ± 2.3	6.2 ± 2.7	13 ± 3.4	13 ± 2.5
p value	0.411		0.798		0.614		0.677	

Is there a Correlation Between Demographics and Performance of the DFT Among Asymptomatic People?

The time it took to complete all four components did not differ between men and women (Table 1). The length of time taken to complete the Down and Sitting ($r = 0.529$; $p = 0.001$), Up and Walking ($r = 0.429$; $p = 0.001$), and Steps ($r = 0.356$; $p = 0.014$) test components of the DFT increased as the volunteer's age increased. No correlation was found between age and the time taken to complete the Dual-Tasking Test ($r = 0.134$; $p = 0.289$). Similarly, the length of time it took to complete the Down and Sitting ($r = 0.372$; $p = 0.005$), Up and Walking ($r = 0.289$; $p = 0.032$), and Steps ($r = 0.366$; $p = 0.013$) test components of the DFT increased as the BMI of the volunteer increased, yet no correlation was found between the Dual-Tasking Test's time and BMI ($r = 0.078$; $p = 0.539$).

Other Relevant Findings

An analysis of the Dual-Tasking Test revealed that patients stopped verbally counting downward from an average of 50 to a mean of 30 ± 5.3 by the time they finished the test. During the Dual-Tasking Test, eight of the 65 participants (12%) physically paused, with 56 (88%) of these pauses occurring during the turning phase. A verbal pause, stutter, or error in counting was seen in 21 of the 65 participants (32%), with 40 (62%) of these verbal errors also occurring during the turning phase of the cycle. Two participants (3%) lost their balance without falling during the Dual-Tasking Test, and one (2%) abruptly landed while finishing the Down and Sitting Test.

Discussion

Recent advances in the radiographic analysis of spinal deformities in adults have led to the establishment of parameters that can explain more than 25% of patients' reported health-related quality of life (HRQOL) outcomes [2, 6, 32–34, 40]. Although proposed realignment targets resulting from this work represent a remarkable step in the management of spinal deformities, factors such as patient frailty, muscle integrity, and neurosensory function that correlate with HRQOL have not been systematically assessed in spine care [1, 25–27, 35, 38, 39]. Current methods of assessing functional status are largely subjective and rely on patient-reported outcome questionnaires [5, 12, 14, 24, 37, 42]; thus, a new model of testing proposed by Dr. Jean Dubousset may offer a more objective approach to assessing physical function, trunk and lower-limb muscle integrity, balance, and dual-tasking, elements that are difficult to capture in questionnaires. The present study prospectively evaluated the DFT in asymptomatic volunteers, finding that it could be implemented in a timely manner with no specialized equipment, with all test components completed in an average of 40 seconds, excluding transition time. Older patients and those with a higher BMI required longer times to complete all test components aside from the Dual-Tasking Test. The combination of these four testing components into a single functional assessment offers a unique tool compared with other physical function tests described in previous studies [3, 9, 10, 15, 17, 19–21, 28, 41].

A limitation to the present study was the selection method to recruit volunteers. Participation relied on volunteerism among individuals from our college of medicine and hospital staff, introducing a potential selection bias by limiting participation to individuals from specific institutions. However, Ganguli et al. [13] evaluated selection methods and found that the volunteer method of recruitment was more likely than a randomized recruitment method to include educated women who used health care services infrequently. Our findings may not be generalizable to populations that differ markedly from the one we assessed in terms of age, sex, race, and BMI. We recommend that future studies seek to replicate or refute our findings in other populations to refine the normative data for later comparisons with populations of patients with spinal deformities. In addition, we believe the sample size used in this study was a limitation to the study's generalizability; with a sample size of 65, we were unable to make comparisons across the various subgroups of demographic parameters we chose to study, including age, sex, race, and BMI. Although it would be useful to define parameters for this test across these groups, it is important to remember that this is the first study to use this combination of specific functional tests, serving as a pilot study upon which to build. We sought to perform the DFT in a demographically diverse population; we believe we were successful in that

regard, and we will continue to enroll more asymptomatic participants to establish normative reference values in various subgroups. In line with this concern, the sample size was not large enough to establish the safety of this test [23]. Given the occurrence of imbalance during testing as well as a drop to the ground towards the end of the Down and Sitting Test, it is important to further enroll participants to better study the safety of this test, especially when considering the potential difficulties patients with spinal deformities may encounter during testing.

Another limitation of this study was the use of a single observer or rater in performing the test. Therefore, inter-rater and intra-rater reliability were not determined. Although we ensured consistency in the sequence of instructions and tests and checked it with video, the lack of test reproducibility for a single rater or across different raters is important, and we are actively addressing this issue.

We found that asymptomatic volunteers could complete the DFT in less than 1 minute, and the test did not require specialized equipment. This test is a powerful and efficient assessment method that can easily be incorporated into any practice setting, given its low cost and quick nature. This test could build on established functional assessments and complement validated patient-reported outcome tools to provide a more complete assessment of patients with spinal deformities. The Timed Up and Go test is similar to the Up and Walking component of the DFT. It has been proven to be a more sensitive measure of preoperative status and predictor of postoperative course than patient-reported outcome measures, including the VAS and EuroQol 5D [15, 17, 19, 21]. Moreover, it has been used to identify patients who might use an assistive device 6 months after THA [29]. The Steps Test resembles the stair climb test used in patients with hip and knee osteoarthritis [3, 9, 10]. Among the few who have studied preoperative stair climbing in patients undergoing spine surgery, Nakashima et al. [28] performed a 10-second "step" test and demonstrated that the number of steps climbed reflected surgical outcomes and predicted lower limb function. Sit-to-stand and stand-to-sit tests assess spinal balance and functional mobility, paralleling the Down and Sitting Test; the sit-to-stand test has been shown to be reliable in assessing functional instability in patients with degenerative lumbar spinal conditions [41]. Similar to the Dual-Tasking component of the DFT, Hemmati et al. [20] demonstrated that patients with chronic low back pain had impaired static and dynamic balance when performing the test. The Dual-Tasking Test also reflects coordination and balance, which are closely linked to spinal alignment and proprioceptive control of new posture [20]. In this component of the DFT, physical and verbal pausing was reported in one of 10 and one of three of participants, respectively, and most pauses occurred during the turning phase. Similarities between the four DFT components and other studied functional assessment methods support the idea that this all-encompassing assessment tool may improve the outcomes of surgery in adults with spinal deformities. Moreover, its multifaceted nature, compared with established functional assessments, combined with its low cost, limited use of space, and short time requirements may improve its utility as a comprehensive tool for a busy spinal care practice. Future studies should assess its safety as well as the correlation between test components, HRQOL measures, and patient-reported outcome questionnaires in patients with spinal conditions.

We found that older patients and patients with higher BMIs completed the DFT more slowly than younger patients and patients with lower BMIs, but we found no differences between men and women. This is an important finding because it demonstrates that the DFT components overcome sex bias in their functional assessment of asymptomatic participants. In studies of patients with degenerative disc disease, Gautschi et al. [16, 18] demonstrated that unlike HRQOL measures such as the VAS, Oswestry Disability Index, EuroQol-5D, and SF-12, the Timed Up and Go test did not demonstrate sex differences when assessing for the presence and degree of objective functional impairment. The findings related to age are supported by previous functional assessment studies. Butler et al. [4] evaluated age and sex differences in seven functional mobility tests, including stair ascent/descent and 6-meter walk tests, and showed that older asymptomatic participants performed worse than younger participants did in all seven tests. Their subanalysis by age demonstrated that older women performed worse than older men, while this difference was not observed between younger men and women [4]. The present study integrated four functional assessments with similarities to established tests, and the trends observed in the data are supported by previous studies, although the correlation between increased BMI and lengthier test performance have not been reported. Echoing this study's limitations, it will be important for future studies of the DFT to stratify groups by age, sex, race, and BMI to identify any differences across these groups in reference values before it is used for assessing patients with spinal conditions.

The DFT is a novel functional test that can be completed in normal volunteers in approximately 1 minute, although it took longer in older patients and patients with a higher BMI. Further research will determine if using preoperative functional scores such as the DFT may become protocol for detecting differences between healthy people and patients with a variety of spinal disorders that are not easily captured using traditional radiographic parameters or patient-reported outcome measures. Future research is underway to investigate this test's utility in predicting the surgical and clinical outcomes of patients with spinal conditions.

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