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table with their right hand holding the table’s edge to stabilize their trunk (Figure 1). The right limb was fully extended and the left knee was flexed to 90°. To ensure proper positioning of the test limb, the tester moved the participant’s right limb through maximum hip and knee flexion, then hip abduction followed by hip and knee extension. The limb was then lowered to 0° hip abduction guided by an inclinometer. This provided a consistent frontal plane hip position across participants, which may not be achieved by placing the foot at a fixed height, as done in previous protocols.4-6 Transverse plane rotation in the test limb was minimized by ensuring that the lateral border of the foot was parallel with the table’s surface. Standardized verbal instructions were given prior to each trial to “maintain this leg position using as much leg strength as you have until your leg reaches the table.” First, a matching adduction force was applied to the test limb by the tester to elicit a maximum isometric contraction for approximately 2 seconds. Afterward, the tester gradually increased the adduction force until the test limb reached the table while contracting eccentrically. Three trials were recorded with at least 1 minute for rest after each test. Participants returned to the lab at least 1 week later and the protocol was repeated. The same tester collected all data during each visit for every participant.

The peak force and time to peak force during the test were recorded by the handheld dynamometer (Lafayette Instrument, Lafayette, IN). Limb motion was recorded at 100 Hz via an 8-camera motion capture system (Vicon, Oxford, UK), which tracked a retroreflective marker on the right tibial tuberosity. The handheld dynamometer made an audible signal when it began recording force to mark the start of each trial. After hearing the signal, the tester immediately remote-triggered the motion capture system to start recording.

Data were processed to determine the dependent variables for each participant. Peak force was multiplied by the moment arm to calculate torque, then divided by height and weight (%BWh). The start of the lowering phase, when the limb began descending, was determined from the marker’s vertical position using custom MATLAB software (MathWorks, Natick, MA). The start of the lowering phase was identified by first connecting the initial and lowest vertical marker positions with a straight line. Then, the perpendicular distance from this line to the marker position was determined at each time point. The lowering phase began where the perpendicular distance was greatest (Figure 2). The start of the lowering phase was subtracted from the time to peak force to determine the peak force offset for each trial. A positive peak force offset indicated the peak force occurred during the lowering phase. Negative offsets indicated that the peak force occurred during the static phase.

### Table 1 Participant Demographic Information

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>26 (6)</td>
<td>22–50</td>
</tr>
<tr>
<td>Height, m</td>
<td>1.66 (0.06)</td>
<td>1.58–1.88</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>62.0 (7.8)</td>
<td>45.0–76.1</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>22.4 (2.0)</td>
<td>18.1–24.8</td>
</tr>
</tbody>
</table>

Abbreviation: BMI, body mass index.

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### Results

The mean peak hip abduction torque was 12.4 (2.7) %BWh at the first visit and 13.2 (2.5) %BWh at the second visit. The hip abductor eccentric strength test had substantial intrarater reliability, indicated by an ICC of .88 (95% confidence interval, .65–.95). Additionally, the test had a SEM of 0.9 %BWh and MDD of 2.5 %BWh. Construct validity was established for the hip abductor eccentric strength test with an average peak force offset of 2.1 (0.6) seconds (range: 0.7–3.7 s; \( P \leq .001 \)). Notably, the peak force offset was positive for all trials across all participants.

### Discussion

The purpose of this study was to determine intrarater reliability and construct validity of the hip abductor eccentric strength test. We hypothesized that the test would have substantial intrarater reliability and construct validity.
reliability and that the peak force would occur during the lowering phase. Both hypotheses were supported by the results. Objective strength tests must be reliable to be useful for clinical decision making. Our results are similar to the previously reported substantial intrarater reliability for another hip abductor eccentric strength test.\(^4\) Thus, we suggest using the MDD values from the present study with a general population. Objective measurements should quantify the intended construct to be valid and useful for clinical decision making. For a measurement of eccentric muscle strength to be valid, it must quantify muscle strength during an eccentric contraction. Maximum muscle force occurs during eccentric rather than isometric contraction.\(^11\) Therefore, peak hip abduction torque during a hip abductor eccentric strength test should occur during the lowering phase. A previous descriptive study suggested that this was the case.\(^4\) Our findings objectively confirmed those of the previous descriptive study and established construct validity for the hip abductor eccentric strength test.

We intentionally collected data in healthy participants to avoid the effects of injury or pain as potential confounding variables. We acknowledge that the MDD may not apply to populations with specific pathologies. Thus, future studies should determine the MDD of this test in other populations. It was a limitation of this study that the handheld dynamometer and motion capture system were not digitally synchronized. However, the tester’s reaction time indicated that the motion capture collection was delayed approximately 0.25 seconds relative to the dynamometer data. This delay between equipment was much smaller than the mean peak force offset of 2.0 seconds. Furthermore, the delay would have shortened the resulting peak force offset. Thus, if anything, the delay between equipment makes our findings more conservative.

In conclusion, the hip abductor eccentric strength test has substantial between-day intrarater reliability in healthy adults. We also established construct validity by demonstrating that peak force occurred during the lowering phase of the test. For clinical decision making, it is important to note that eccentric hip abductor muscle strength differences greater than 2.5 %BWh reflect a true difference in eccentric muscle strength between measurements. Differences less than 2.5 %BWh cannot be identified as a true difference because they fall within the error of measurement. For example, the MDD can be used in a clinical setting to determine if a true difference in eccentric hip abductor muscle strength occurred after an intervention. If the difference between the preintervention and postintervention peak hip abduction torque during the hip abductor eccentric strength test exceeded 2.5 %BWh, then a true change occurred. The clinician can then determine whether the change is clinically meaningful. We recommend the hip abductor eccentric strength test using a handheld dynamometer for clinical use.

References