

Countermovement Jump (CMJ) Testing on Force Plates

Test Protocol Document

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1. Introduction

1.1 Objective / Rationale

1. **Measuring maximal lower body dynamic force expression**
 - Performance testing / profiling (cross-sectional / entry & exit)
 - Longitudinal performance adaptation tracking
2. **Monitoring acute, transient variations in force expression**
 - Continuous assessment (high-frequency longitudinal)
 - e.g.; Performance fatigue monitoring, neuromuscular readiness monitoring
3. **Monitoring return-to-play variables in cases of lower body injury**
 - Recurring monitoring (ongoing, longitudinal)

1.2 Traceability

| Protocol Name | Date (yyyy-mm) | Changes Made | Changes Made by |
|---|----------------|---|---|
| Force Plate Countermovement Jump Test SOP | 2025-04 | Version 1 - Creation of SOP | Nicola Bourrel, Andrew Cochran, Amarah Epp-Stobbe, Mary Claire Geneau, Scott Willgress, Bryan Yu |
| Force Plate Countermovement Jump Test SOP | 2025-09 | Reviewed By: | Lachlan James, Matt Jordan |
| Force Plate Countermovement Jump Test SOP | 2026-01 | Edits made from reviewers suggestions | Nicola Bourrel, Andrew Cochran, Mary Claire Geneau, Scott Willgress, Bryan Yu |

2. Equipment

2.1 Equipment Recommendations

- **Dual force plate system**
 - Recommended for all testing.
 - **Required** for asymmetry assessment.
- **Sampling Frequency: Minimum 1000Hz**

| <i>Type</i> | <i>Quality</i> | <i>Pros</i> | <i>Cons</i> |
|------------------------------------|----------------|---|---|
| AMTI Floor Mounted Force Platforms | Gold | <ul style="list-style-type: none"> ● Research-grade hardware ● Most accurate, reliable ● Allows for custom processing and analysis | <ul style="list-style-type: none"> ● Requires custom software for processing, visualization and analysis ● Not portable ● Expensive |
| VALD Performance ForceDecks | Silver | <ul style="list-style-type: none"> ● Portable ● Accessible software ● Accessible customer support ● Very popular in sport science globally ● More affordable | <ul style="list-style-type: none"> ● Hardware performance can be affected by floor or set up (when portable) ● The processing and analysis of data cannot be adjusted in the software |
| Hawkin Dynamics Force Platforms | Silver | <ul style="list-style-type: none"> ● Portable ● Accessible software ● Accessible customer support ● Very popular in sport science globally ● More affordable | <ul style="list-style-type: none"> ● Hardware performance can be affected by floor or set up (when portable) ● The processing and analysis of data cannot be adjusted in the software |
| Other (e.g., Pasco) | NA | <ul style="list-style-type: none"> ● Most affordable | <ul style="list-style-type: none"> ● Poor durability and reliability |

2.2 Equipment Calibration Setup

1. **Verification (Appendix A).**
 - **Conduct accuracy verification quarterly.**
 - Perform a static load assessment of up to 300 kg per plate to ensure accuracy.
2. **Surface Requirements**
 - Strive for a **level, hard, consistent** surface type for every collection. Avoid compliant surfaces (e.g ; turf or poured rubber)
3. **Force Plate Positioning**
 - Ensure dual force plates are connected to each other.
 - Ensure **no object** (e.g., protective surround) is in contact with the plates.
 - Zero the plates before each use (see above comment)
 - Confirm left/right plate orientation is correct.
 - Maintain a **minimum 1 cm gap** between plates and keep it consistent.
 - Ensure plates are level relative to each other and individually.
 - Manually press the corners of each plate to confirm they are solid and level.

4. Force Plate Warm-Up

Follow manufacturer recommendations for hardware warm-up time (e.g., 1 hour for AMTI plates).



Figure 1. A photo of the force plates ensuring nothing is in contact with the force plates, and the plates are leveled on their own and with each other.

3. Pre-testing Instructions

1. Medical Clearance and Informed Consent

- Confirm the athlete is medically cleared to perform a maximal CMJ testing and can do so competently.
- Athletes have consented to participate in testing and sharing of data.

2. Equipment Setup Verification

- Refer to Section 2.2.
- If the force plates have been moved, repeat the setup and calibration procedure.

4. Warm-Up

1. **Athlete's Usual Pre-Session Warm-Up (approx. 10 minutes)**
 - The athlete performs their regular warm-up routine.
2. **Pre-Test CMJs (approx. 5 minutes)**
 - Perform 3 maximal CMJs.
 - Rest for 2 minutes.
 - Perform another 3 maximal CMJs.
 - Rest for 2 minutes before the official testing trial.

5. Testing Procedure

5.1 Key Instructions / Test Regulations

- **Hand Placement:** Hands on hips throughout the test.
- **Jump Emphasis:** Jump fast and high. If asked, maximal jump height is the priority.
- **Stance Width:** Self-selected, between shoulder and hip width
- **Countermovement Depth:** Self-selected
- **Consistent Footwear:** Maintain the same footwear across testing sessions.
- **Minimal Cueing:** No additional coaching cues beyond the test instructions.

5.2 Running the Test (approx. 3-5 minutes per athlete)

1. **Pre-Test Preparation**
 - Zero the plates, ensuring nothing is on or touching the plates
 - Select the correct athlete and test (e.g., CMJ) in the software.
2. **System Weight Collection** (depending on software)
 - Ask the athlete to stand still on the plates with hands on hips for 5–10 seconds (quiet standing). **A small (even 1 N) error here can result in large outcome error**
 - Verify that the recorded system weight is within an expected range.
3. **Test Instructions**
 - Provide a demonstration while explaining the expectations.
 - Use a **clear, direct tone:**
 1. “Place your hands on your hips and stand as still as you can.”
 2. “I am going to count down from three, and when I say ‘jump,’ You are free to jump. Jump fast, and as high as possible while keeping your hands on your hips.”
 - Optional external cue: “Try to put your head through the ceiling.”
 - If asked for priorities: **1) Height, 2) Speed.**
 3. “Please stay as still as possible during the countdown and land in a soft, stable, athletic position at approx. ¼ squat depth.”

- Emphasize correct landing (especially if using landing metrics).

4. “Ready — stand still — 3-2-1-Jump.”

- If there is movement during the countdown, restart the countdown.

4. Repetitions and Rest

- Perform **3–5 repetitions** (minimum 3).
- Rest **10–15 seconds** between each jump (minimum 10).
 1. Stillness***
- Repeat instructions for each jump: “**Ready — stand still — 3-2-1-Jump.**”

5. End of Test

- Press “Stop Recording” once the set of trials is complete, after adequate quiet starting period
- Inspect force tracing for technical violations
- **Invalid trials** should be repeated and excluded from final analysis (see Section 6.2).
- If valid, ensure data collection is saved

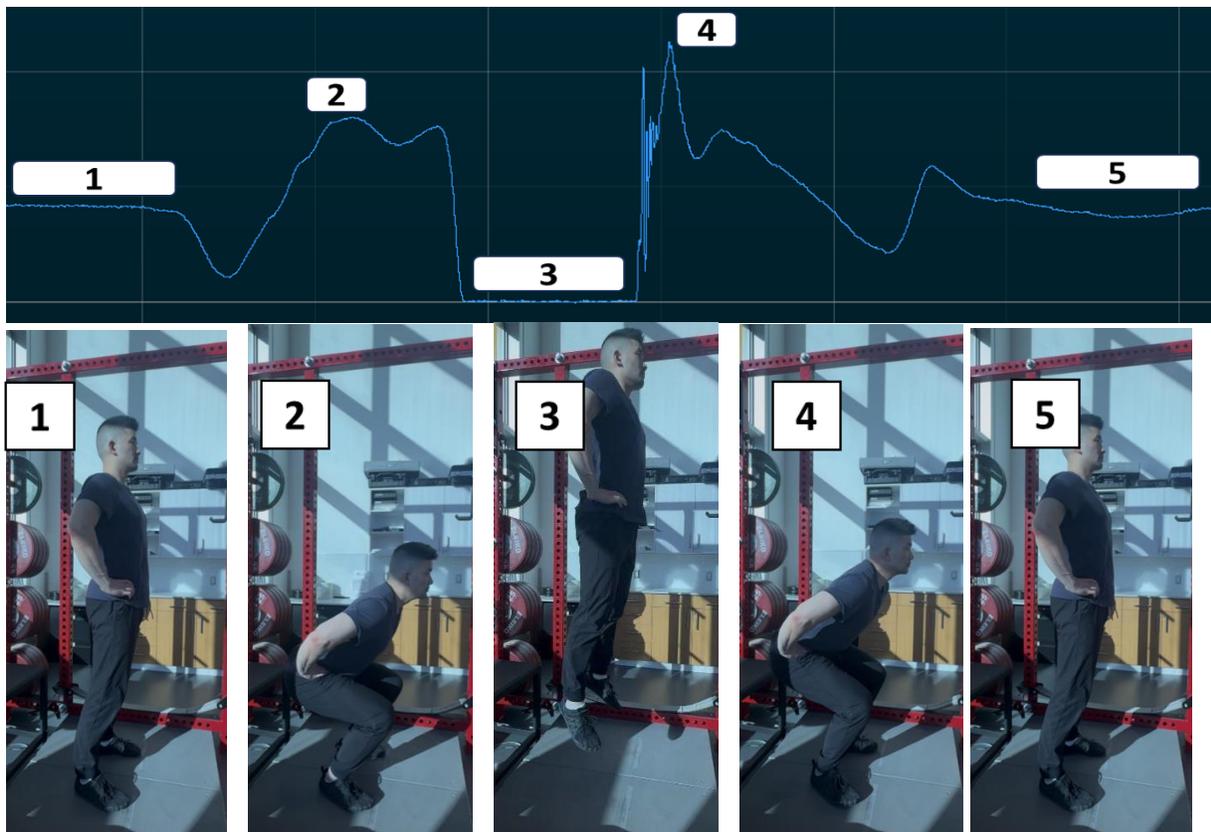


Figure 2. Force trace of a typical counter movement jump. 1) Quiet standing phase. 2) Bottom of the eccentric phase. 3) Flight. 4) Landing phase. 5) Return to the quiet standing phase.

6. Technical Considerations

6.1 Force Trace Considerations

- **Invalid Quiet Phase:** The athlete must remain still before the jump. **All metrics will not be valid without the correct quiet phase.**
- **Pre-Movement:** Any notable shift in force prior to jump initiation can lead to inaccuracies in the data.



Figure 3. Excessive movement during quiet standing phase.

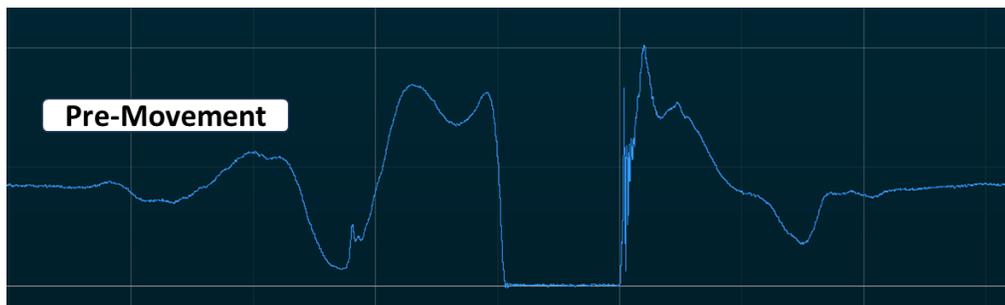


Figure 4. Upward movement prior to jump initiation.

6.2 Technical Violations (Invalid Trials)

The following violations **invalidate** the trial:

- Hands leaving the hips.
- Upward motion before the official “jump” cue.
- Landing with **excessive** knee or hip flexion at initial contact (e.g., tuck jump).
- Landing partially or fully off the plates.



Figure 5. Technical violations. Left) Hands leaving hips (**even subtly**) during the jump. Middle) Upward movement prior to initiation of jump. Right) Heels lifting off during the jump.

If any of these occur, **repeat the trial** and exclude the invalid trial from the data set.

Proceed with caution if the following occur:

- Heels lifting prematurely during the countermovement (may indicate mobility issues).
- Bending knees or hips mid-flight (tucking/piking) if flight time is used for calculations.

End of Protocol

Note: Always document any deviations from this protocol and ensure consistency in data collection to maintain reliability and validity of results.

7. Reporting Considerations

7.1 Selection of best or mean of the trials

- In most cases, it's best to use the **mean of all completed trials** to represent performance. When displaying the data visually, using **mean \pm standard deviation** helps illustrate the day-to-day variability (see Figure 6).
 - In case of unusually large variation (>10% from the mean), consider discarding the variable effort
- However, if you're conducting **entry/exit testing** or using a **cross-sectional approach**, it may be more appropriate to use the **best (peak) value**. In that case, select the highest output (e.g., jump height) along with all associated metrics from that specific trial.
 - Keep in mind, measurement and biological error become more of a problem using best effort

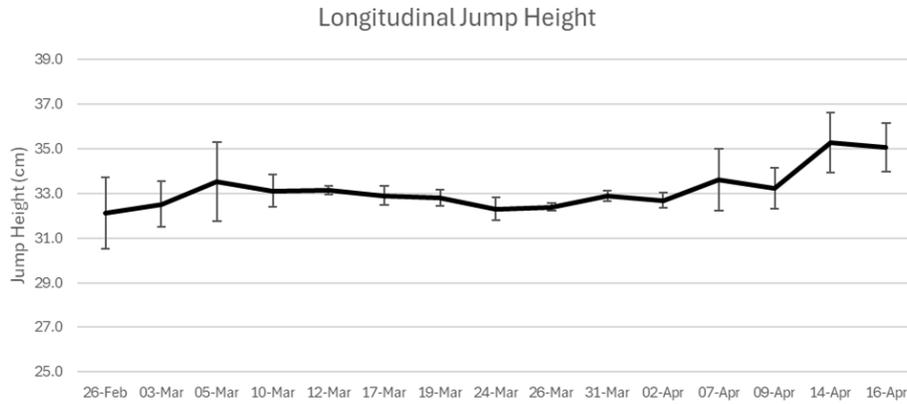
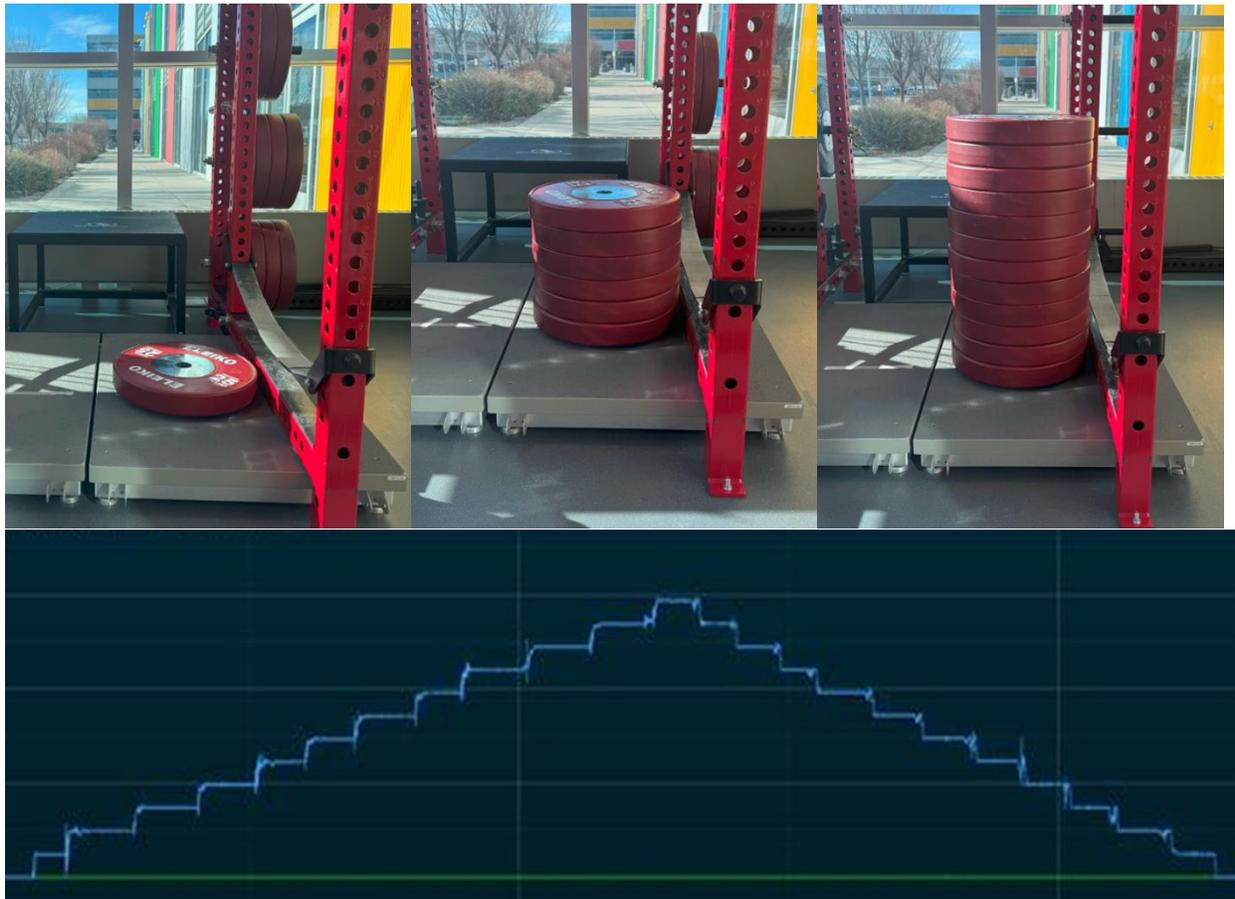


Figure 6. Daily reporting of jump height (cm), incorporating standard deviation bars.

8. Appendix A

Calibration/Verification.

- Conduct verification quarterly.
- Perform a static load assessment of up to 300 kg to ensure accuracy.



9. Appendix B

Phase Identification

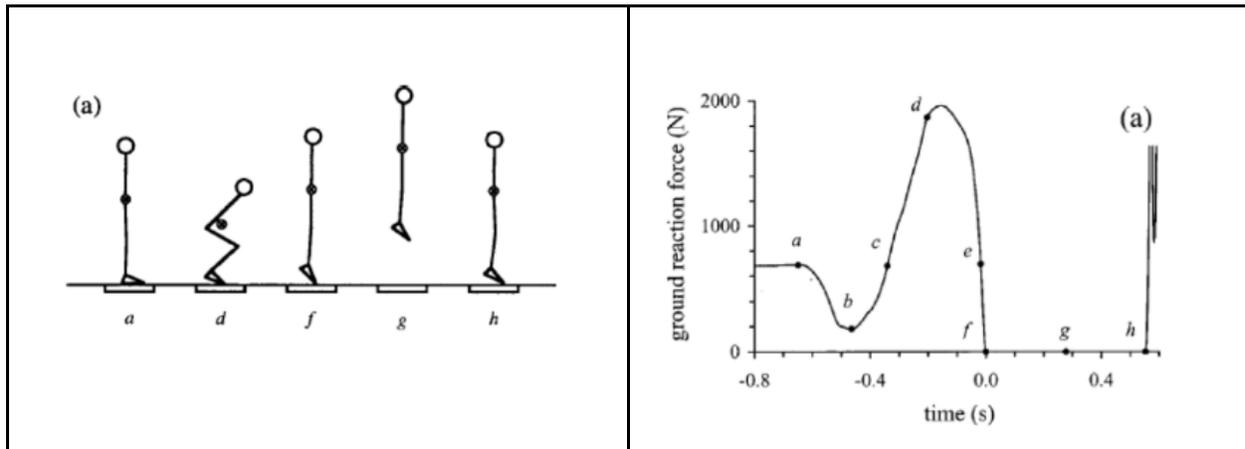


Figure 1. Force-time characteristics of a countermovement jump (CMJ). The jump sequence initiates from a stationary standing position (a), followed by an unweighting phase (a–c) where the jumper relaxes the agonist musculature to accelerate the center of mass downward. Point b represents the instant of maximum downward acceleration. As muscle activation increases, downward velocity is attenuated until it reaches its maximum at point c. During the braking phase (c–d), the ground reaction force exceeds body weight until the c.m. reaches its lowest vertical displacement at point d (zero velocity). The subsequent propulsion phase (d–f) involves a rapid increase in upward velocity; maximum upward velocity occurs at point e, where force returns to body weight. Takeoff is defined at point f, where the feet leave the force platform and the athlete becomes a projectile. The flight phase consists of an ascent (f–g) to the jump peak (apex, g) and a descent (g–h) until initial landing contact (h), characterized by a sharp impact force peak.

Adapted from: Linthorne, N. P. (2001). Analysis of standing vertical jumps using a force platform. *American Journal of Physics*, 69(11), 1198–1204.

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