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The acute effects of a 10-minute mobility training intervention on countermovement jump and hop test performance

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Abstract
This study investigated the acute effects of a 10-minute mobility training intervention on countermovement jump (CMJ) and hop test (HT) performance, alongside body composition analysis. Twelve healthy, recreationally active females completed pre- and post-intervention tests. Body composition and anthropometric measurements were obtained using a Fit3D ProScanner, while CMJ and HT data were collected via VALD Force Decks. Results indicated statistically significant improvements in CMJ jump height (p=0.008), peak landing force (p=0.040), peak power normalized to body mass (p=0.001), and modified Reactive Strength Index (RSI) (p<0.001) following mobility training. In contrast, the hop test showed a significant increase only in mean peak force (p=0.025), with no significant improvements in mean jump height (p=0.106) or mean RSI (p=0.125). These findings suggest that mobility training acutely enhances performance in long stretch-shortening cycle (SSC) activities like the CMJ by optimizing joint range of motion and muscle preloading. However, its benefits may not extend to short SSC tasks such as the HT, which rely more on tendon stiffness and rapid reactivity. The study highlights the importance of tailoring mobility interventions to the specific demands of performance tasks.

Keywords: Mobility training, countermovement jump (CMJ), hop test (HT), stretch-shortening cycle (SSC), body composition

Introduction

The Countermovement Jump (CMJ) is one of the most widely utilized assessments in both clinical and athletic settings for evaluating lower-body mechanical properties, neuromuscular function, and explosive strength. It is particularly valued for its ability to offer insights into athletic performance capacities such as power, speed, and agility (Anicic *et al*., 2023) [1]. The CMJ involves an initial eccentric countermovement followed by a rapid concentric action, effectively utilizing the stretch-shortening cycle (SSC) to enhance force production. This reactive strength property is central to the CMJ's diagnostic utility, as it reflects how efficiently the neuromuscular system converts stored elastic energy into mechanical power (Petrigna *et al*., 2019) [10].

Jump height is the primary outcome measure of the CMJ and serves as a direct indicator of lower-limb explosive strength. It correlates with a wide range of athletic attributes, including sprint speed, change of direction, and vertical power output, making it a critical marker of both fitness and health status (Petrigna *et al*., 2019) [10]. However, contemporary approaches to CMJ analysis also emphasize the interpretation of kinetic and kinematic variables derived from the force-time curve. These include mean force, peak force, impulse, jump duration, and time to peak force, which together provide a more nuanced understanding of neuromuscular coordination and SSC efficiency (McMahon, 2018) [7].

The CMJ is favored in sports performance testing due to its non-fatiguing nature, minimal learning curve, and applicability across various populations. The test is typically broken into five phases: starting position, push-off, toe-off, apex, and landing. During standardized administration, participants maintain an upright posture with hands on hips to minimize arm swing and isolate lower-body performance (Petrigna *et al*., 2019) [10]. Each phase contributes distinctively to the analysis of the force profile, offering insight into both movement strategy and muscular effectiveness.

In contrast to the CMJ, the Hop Test (HT) evaluates an individual's reactive strength and lower limb stiffness through repeated explosive jumps. The test is performed either bilaterally or unilaterally, requiring the participant to minimize ground contact time (GCT) and maximize jump height through rapid transitions between eccentric and concentric phases (VALD, 2025) [15]. The HT assesses short SSC function, tendon stiffness, and plyometric ability, which are critical in movements like sprinting and cutting (VALD, 2025) [15]. Central to the interpretation of the HT is the Reactive Strength Index (RSI)—calculated as the ratio of jump height to GCT—which serves as a reliable marker of plyometric efficiency and neuromuscular reactivity.

A key consideration in improving CMJ and HT performance is mobility, which refers to the capacity to move through a joint's full range of motion in a stable and coordinated manner (Skopal *et al*., 2024) [12]. Unlike flexibility, which emphasizes passive lengthening of soft tissues, mobility encompasses dynamic muscular control, which is critical for performance in explosive movements. Through methods such as dynamic stretching, yoga, and mobility drills, athletes can enhance muscular elasticity and neuromechanical coordination, thereby improving SSC utilization. Importantly, mobility training prior to performance tasks has been shown to reduce connective tissue slack and improve the transition time between eccentric and concentric muscle actions, which are fundamental to both the CMJ and HT (Skopal *et al*., 2024) [12].

Given the reliance of both the CMJ and HT on joint range of motion, neuromuscular efficiency, and SSC function, mobility may serve as a key priming intervention. Improved mobility can optimize joint kinematics, reduce ground contact times, and enhance explosive power-factors that may directly translate to improved RSI and jump height. Therefore, understanding the role of mobility in shaping performance outcomes on CMJ and HT assessments could offer valuable insight into training design and injury prevention in both clinical and athletic populations.

Methods

This study was conducted in the Exercise and Sports Science Laboratory at the University of South Carolina at Aiken. All participants provided informed consent prior to participation.

Participants

A total of 12 healthy, recreationally active females participated in the study.

Instrumentation

Body composition and anthropometric measurements were obtained using a Fit3D ProScanner (Fit3D Inc., Redwood City, CA, USA). All jump and hop test data were collected using VALD Force Decks (VALD Performance, Brisbane, Australia), which have been shown to have excellent reliability in biomechanical assessment

Procedures

The experimental protocol involved two primary phases: a pretest and a posttest, separated by a 10-minute mobility training intervention.

Body Composition and Anthropometric Measurements: Upon arrival, participants underwent a Fit3D scan. This process required participants to follow on-screen instructions while standing on the Fit3D platform. The scan generated a detailed 3D body model, comprehensive insights into body composition (e.g., body fat percentage, lean mass), and precise body measurements (e.g., waist and hip circumferences).

Countermovement Jump (CMJ) Protocol: Following the Fit3D scan, participants performed a pretest of the countermovement jump (CMJ) on the VALD Force Decks. Participants were instructed to stand erect with their trunk straight, knees extended to approximately 180∘, and feet positioned shoulder-width apart. Hands were kept on the hips throughout the entire test. The CMJ comprised five distinct stages as previously described (2):

1. **Starting Position:** Erect posture, knees at 180∘, feet shoulder-width apart.
2. **Push-off Phase:** Initiated with a downward movement, flexing the knees to approximately 90∘.
3. **Toe-off Phase:** Maximal effort for an explosive vertical jump.
4. **Apex of the Jump:** Legs maintained extension.
5. **Landing Phase:** Participants landed feet together, with knees approximately extended at 180∘. Participants completed three maximal effort repetitions of the CMJ, with a 5-second pause between each repetition.

Hop Test Protocol: Immediately following the CMJ pretest, participants completed the Hop Test on the VALD Force Decks. This test required individuals to perform five consecutive rebounding hops. Participants began by bending down, jumping upwards, and landing with minimal knee flexion on the balls of their feet. From this landing, they quickly initiated the subsequent four rebounding hops (1). The primary objective was to maximize jump height while minimizing the ground contact time between jumps. During the test, participants maintained an upright posture and kept their hands on their hips (1). The Hop Test consisted of three separate sets of five hops, with a 5-second rest period between each set.

Mobility Training Intervention: A 10-minute mobility training session was administered between the pretest and posttest. This session was structured as follows:

1. **Dynamic Warm-up (30 seconds each):** Light jog, high knees, butt kicks, and skips with arm swings (horizontal abduction and adduction).
2. **Targeted Mobility Movements (5 repetitions each leg/side, repeated for a second set):** Ankle rocks, world's greatest stretch, 90/90 hip rotations, inchworms, and thread the needle.
3. **Plyometric Drills (repeated for a second set):** 10 air squats, 6 skips for height (3 per leg), and 10 pogo hops.

Posttest: Following the completion of the mobility training, participants performed the posttest for both the countermovement jump and the hop test, replicating the exact protocols used during the pretest phase.

Data Collection and Statistical Analysis

Data were collected directly from the Fit3D program and the VALD Force Decks software. All statistical analyses were conducted using SPSS (Statistical Package for the Social Sciences, IBM Corp., Armonk, NY, USA). Descriptive statistics (means, standard deviations, and ranges) were calculated for all biomechanical and anthropometric variables. Data were screened for normality using the Shapiro-Wilk test before applying paired t-tests. Paired sample t-tests were utilized to determine significant differences between the A and B trials for the countermovement jump and hop test parameters.

Results

This section presents the findings from the analysis of biomechanical parameters and anthropometric measures. Descriptive statistics for all variables, including ranges, means, and standard deviations, are detailed. Furthermore, results from paired comparisons between specific conditions (CMJA vs. CMJB and HTA vs. HTB) are presented, highlighting statistically significant differences in jump height, landing force, power, and reactivity across various tests. These results collectively describe the performance characteristics and physical attributes of the study participants under the examined conditions.

Table 1: Paired Comparisons of Biomechanical Parameters

Pair	N	Mean	Std. Deviation	t	Sig.
1) CMJA - CMJB Jump Height (cm)	12	-2.183	2.34	-3.232	0.008
2) CMJA - CMJB Peak Landing Force (N)	12	-303.75	452.738	-2.324	0.04
3) CMJA - CMJB Peak Power / BM (W/kg)	12	-2.833	2.308	-4.252	0.001
4) CMJA - CMJB RSI modified (m/s)	12	-0.045	0.032	-4.907	<0.001
5) HTA - HTB Mean Jump Height (cm)	12	-1.167	2.298	-1.758	0.106
6) HTA - HTB Mean RSI (Jump Height/Contact Time) (m/s)	12	-0.052	0.108	-1.66	0.125
7) HTA - HTB Mean Peak Force (N)	12	-170.75	230.88	-2.562	0.025

Table 1 presents the results of paired comparisons for various biomechanical parameters between two conditions, CMJA versus CMJB and HTA versus HTB. For each comparison, the sample size (N=12) is provided, along with the mean difference, standard deviation of the difference, the calculated t-statistic, and the corresponding significance (p) value. Statistically significant differences were observed for several parameters when comparing CMJA and CMJB: jump height (p=0.008), peak landing force (p=0.040), peak power normalized to body mass (p=0.001), and modified RSI ($p<0.001$). These findings suggest a significant difference in performance between the CMJA and CMJB conditions across these metrics. Conversely, for the HTA versus HTB comparison, mean jump height (p=0.106) and mean RSI (p=0.125) did not show statistically significant differences, while mean peak force (p=0.025) did demonstrate a significant difference.

Table 2: Descriptive Statistics of Biomechanical and Anthropometric Measures

Descriptive Statistics	Range	Mean (± SD)
CMJA Jump Height (Imp-Mom) (cm)	18.8	25.6 ± 6.133
CMJB Jump Height (Imp-Mom) (cm)	17.7	27.783 ± 5.479
CMJA Peak Landing Force (N)	1841	2388.750 ± 622.339
CMJA Peak Power / BM (W/kg)	19.9	41.533 ± 6.274
CMJA RSI modified (m/s)	0.22	0.288 ± 0.062
HTA Mean Jump Height (Flight Time) (cm)	9.9	13.692 ± 3.397
HTA Mean RSI (Jump Height/Contact Time) (m/s)	0.61	0.542 ± 0.175
HTA Mean Peak Force (N)	1046	2580.083 ± 335.796
CMJB Peak Landing Force (N)	2584	2692.500 ± 950.249
CMJB Peak Power/BM (W/kg)	19.5	44.367 ± 5.765
CMJB RSI modified (m/s)	0.28	0.333 ± 0.077
HJB Mean Jump Height (Flight Time) (cm)	13.6	14.858 ± 3.761
HJB Mean RSI (Jump Height/Contact Time) (ms)	0.59	0.593 ± 0.181
HJB Mean Peak Force (N)	1053	2750.833 ± 358.783
Height	12	67.250 ± 2.896
Weight	89.7	142.167 ± 23.478
Body Fat Percent	21.4	23.833 ± 6.290
Lean Mass	48.9	107.450 ± 13.429
Fat Mass	43.6	34.717 ± 14.168
Waist Width	2.4	11.692 ± 0.845
Hips Width	3.9	14.483 ± 1.062

Table 2 provides a comprehensive overview of the descriptive statistics for various biomechanical and anthropometric measures. For each variable, the table lists the range and the mean ± standard deviation (SD). Biomechanical parameters include jump height (Imp-Mom, Flight Time), peak landing force, peak power normalized to body mass, and RSI for CMJA, CMJB, HTA, and HJB conditions. For instance, CMJA jump height (Imp-Mom) had a mean of 25.6±6.133 cm with a range of 18.800. Similarly, CMJB peak landing force averaged 2692.500±950.249, N with a range of 2584.000. Anthropometric data, including height (67.250±2.896 cm), weight (142.167±23.478), body fat percent (23.833±6.290), lean mass (107.450±13.429), fat mass (34.717±14.168), waist width (11.692±0.845), and hips width (14.483±1.062), are also detailed, providing context to the participant characteristics.

Discussion

The countermovement jump (CMJ) is a widely used assessment for evaluating lower-body explosive power, heavily reliant on the stretch-shortening cycle (SSC) and the efficiency of neuromuscular coordination (Cormie *et al.*, 2011; Suchomel *et al*., 2016) [4, 13]. The findings from this study support previous research that demonstrates improved CMJ performance following mobility exercises, which enhance joint range of motion (ROM) and allow for a deeper and more controlled countermovement. A more extensive eccentric phase facilitates optimal muscle-tendon preloading, improving force production during the concentric phase through greater utilization of stored elastic energy (Kubo *et al*., 2017; Nakamura *et al*., 2020) [6, 8]. As the pre-stretch of muscles enhances the efficiency of the SSC, jump height significantly increases due to improved neuromechanical advantage and energy transfer (Seitz *et al*., 2014) [11].

The SSC's enhanced contribution post-mobility was evident through the increased jump height and peak power. This outcome aligns with the force-velocity relationship, whereby peak power is maximized when muscle force is produced at high velocities (Zaras *et al*., 2016) [16]. The deeper countermovement allowed by mobility work may have led to improved sarcomere overlap and an extended eccentric phase, permitting a more forceful concentric contraction. The RSI-modified (jump height/time to takeoff), a sensitive indicator of neuromuscular efficiency, also increased. This metric suggests that the participants not only jumped higher but also transitioned more rapidly from eccentric to concentric motion, indicating an enhanced reactive strength response likely due to improved joint kinematics and motor coordination (Beattie *et al*., 2017) [2].

Interestingly, the increase in peak landing force corresponds with the improved jump height. This result is expected, as higher jumps increase gravitational potential energy, which must be dissipated upon landing. While this may raise concerns about increased landing stress, improved mobility may concurrently contribute to safer landings by allowing for better shock absorption mechanics through enhanced joint flexion (Padua *et al*., 2015) [9]. Thus, the training application of mobility prior to CMJ testing could be considered a double-edged sword, necessitating complementary landing technique instruction to prevent injury while capitalizing on performance gains.

In contrast to the CMJ, the horizontal triple hop test (HT) yielded different outcomes. The HT is more reliant on tendon stiffness, reflexive reactivity, and short SSC performance, which were not markedly improved by mobility interventions. Unlike the CMJ, the HT involves a series of rapid contacts requiring minimal ROM and maximal tendon recoil efficiency. The increased ROM induced by mobility work may have actually hindered the tendinous properties needed for fast reloading, as stiffer tendons respond better in short SSC tasks (Bohm *et al*., 2021) [3]. This may explain why the mean RSI (jump height/contact time) and mean jump height did not improve significantly in the HT despite increased muscle activation.

The discrepancy between increased mean peak force and unchanged mean jump height in the HT warrants further consideration. It is plausible that the initial jump in the HT series benefited from improved muscle recruitment following mobility but that subsequent reactive hops did not. Given the SSC demands of HT-specifically rapid eccentric-concentric coupling-the increased ROM may have delayed the transition phase, reducing efficiency in the repetitive hops. Increased impulse and peak force can occur without improved jump height if force is applied for a longer time but with reduced velocity (Tillin & Folland, 2014) [14]. Therefore, mobility-enhanced muscle recruitment may have led to greater peak force production, but the longer amortization phase negated gains in jump height.

Another possible explanation is that increased ROM from mobility may have desensitized proprioceptive timing or compromised the "stiff spring" mechanism necessary for efficient reactive hopping. Because coordination and timing are critical for HT success and are not directly targeted by mobility interventions, the improved muscle activation was insufficient to enhance overall HT performance. This supports the notion that mobility is more beneficial for long SSC activities like the CMJ than for short SSC tasks such as HT, which rely on tendon recoil and minimal compliance.

Conclusion

This study highlights the nuanced effects of mobility training on jump performance metrics. Mobility exercises prior to CMJ testing improved jump height, peak power, and RSI-modified due to enhanced joint ROM, improved muscle preloading, and more efficient force transfer through the SSC. However, the same interventions did not yield similar benefits for the HT, a test more dependent on tendon stiffness, reactivity, and coordination.

These findings suggest that mobility training should be selectively applied based on the SSC characteristics of the targeted performance task. Long SSC activities benefit from enhanced ROM and muscle priming, while short SSC tasks may require maintenance of tendon stiffness and reactive efficiency. Furthermore, while mobility can increase muscle recruitment and force output, it does not necessarily improve reactivity or coordination. Therefore, a balanced training program should combine mobility, plyometrics, and coordination drills tailored to the mechanical demands of specific performance assessments.

Future research should explore the time course and specificity of mobility-induced changes on muscle-tendon behavior in both short and long SSC tasks. Practitioners should also consider the timing and type of mobility work used in warm-up routines, particularly when performance assessments are being conducted, to avoid potential interference effects on reactive activities.

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