

The Acute Impacts on Countermovement Jumping Metrics Following an Exhibition Soccer Match

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ABSTRACT

Countermovement jump (CMJ) force-time assessments via force plates, are a quick and accurate way to measure a multitude of variables. However, the reporting of variables without specific groupings (strategy, driver, other) could hinder accurate interpretation of said metrics. The present study aimed to assess CMJs before and after a competitive off-season soccer scrimmage, aiming to see if any specific groupings were impacted, helping to expand on potential variables relating to neuromuscular fatigue (NMF). **Methods:** Fourteen division II female soccer players (mean $\pm$ SD: age = 19.20 ± 1.01 years) performed three hands-on-hips countermovement jumps on a dual-force plate system before and after a competitive off-season soccer exhibition. **Results:** For strategy metrics, significant differences were seen for the braking phase and propulsive phase (shorter time spent post-game) ($p = 0.010 - 0.039$). Shallower countermovement depth occurred post vs. pre-game ($p = 0.004$). For the driver metrics, no differences were seen for any RFD, force, velocity or power variables ($p = 0.060 - 0.551$). Lastly, jump momentum was the only outcome metric that reported significant differences ($p = 0.004$) (lower post- vs. pre-game). **Conclusions:** The present study observed greater deficits in strategy (braking, propulsive phase, countermovement depth) and outcome metrics (jump momentum), rather than drivers (power, force, velocity). While deficits in athletic performance within and post-game can be multi-faceted, the present findings highlight the importance for assessing different groupings and not just driver metrics, when assessing CMJ force-time metrics and potential fatigue.

Keywords: Soccer, Female, Jumping.

INTRODUCTION

Previous literature suggests that soccer athletes (minus goalkeepers), may cover 10.3 km during a game (Davis & Brewer, 1993; Krstrup et al., 2005). While total distance covered during a game is important, sprinting, jumping, tackling, sliding, etc., are other required movements (Ishida et al., 2021). Due to the multifaceted functional requirements of competitive soccer players, repetitive tasks (sprinting, jumping, etc.) could induce deficits in performance (fatigue). For example, for females, previous literature has attributed deficits in countermovement jump height (CMJH) performance to muscle damage (Andersson et al., 2008; Nedelec et al., 2014), specifically muscle damage following competitive soccer games. Furthermore, it has been suggested that the repetition of the stretch shortening cycle (SSC), throughout a game can negatively impact Countermovement Jump (CMJ) performance (power, force, vertical jump height). Knowing the SSC is a specific movement within CMJs, a multitude of sports (soccer, rugby, basketball) have used CMJ and CMJH to assess neuromuscular fatigue (Cabarkapa, Cabarkapa, et al., 2023; Dimitrije Cabarkapa et al., 2024; Ishida et al., 2021; Kennedy & Drake, 2017; Spencer et al., 2023). While assessing neuromuscular fatigue (NMF) can aid coaches and training staffs, dissimilar methods of assessment times for female soccer players (5-12 hours post-game for females) (Andersson et al., 2008; Ishida et al., 2021) call for future research to follow a unified post-testing timepoint (immediately post-game). Furthermore,

assessing the CMJ, specifically CMJ force-time characteristics, using reliable and validated force plates (Badby et al., 2022; Lake et al., 2018), can allow coaches and health care professionals the opportunity to assess all phases of the jump (unweighing, braking, deceleration, concentric, flight and landing phases) (McMahon et al., 2018; Philipp, Cabarkapa, Nijem, & Fry, 2023). While CMJ assessments before and after a soccer game are lacking for females (Andersson et al., 2008; Ishida et al., 2021), greater elaboration within CMJ force-time characteristics (braking phase, propulsive phase) variables (force, power, velocity, time), and recovery (post recovery assessment points) are also limited (Ishida et al., 2021). Although a recent study by Spencer et al., (2023) reported outcome metrics (vertical jump height, modified reactive strength index) time variables (braking phase, propulsive phase) an explosive movement (jump momentum) and strategy metrics (countermovement depth) for elite male soccer players pre – vs. post soccer game, the lack of defined variables within the phases of the CMJ are lacking, thus future studies are needed at assessing said phases, variables within each phase, and how individual variables within a phase could impact (positively or negatively) other variables. Recently, Anicic et al., (2023) and Philipp et al., (Philipp, Cabarkapa, Nijem, & Fry, 2023) published studies talking about appropriate variables to report when assessing CMJ force-time characteristics. Specifically, Anicic et al., (2023) compartmentalized the CMJ into four primary components (performance, eccentric, concentric, jump strategy). Philip et al., (2023) simplified the metrics into three metric types (strategy, driver, outcome). Regardless of the aforementioned authors, both suggest the CMJ is tied to specific SSC actions (eccentric, amortization, concentric) and variables (power, force, rate of force, time, height, etc.). Compartmentalizing said variables, and looking at them individually, as well as a group, could aid researchers, coaches, health care professionals, the ability to decipher what phase/s and variables are being impacted. For example, previous literature has reported significant deficits in countermovement depth post-match with competitive soccer players (Spencer et al., 2023; Thorlund et al., 2009). According to Phillip et al. (Philipp, Cabarkapa, Nijem, & Fry, 2023), countermovement depth would fall under a “strategy metric”, thus, the decrease in depth could negatively impact driver metrics (force, velocity) or outcome metrics (jump height). While a majority of coaches and researchers focus on outcome metrics (VJ height, mRSI), CMJ force-time characteristics

can aid with comprehension of variables and phases that are potentially impacted with fatigue. The limited studies within immediate jump performance with soccer athletes, as well as the lack of differentiation within specific phases of the CMJ, could mask potential NMF deficits. Therefore, the purpose of this study was to assess CMJ force-time characteristics before and after a competitive female soccer exhibition, and to see what phase/s are impacted.

METHODS

Participants

A convenience sample of fourteen division II collegiate female soccer players from a midwestern university volunteered to participate in the study (age = 19.20 ± 1.01 years, height $166.77 \text{ cm} \pm 5.62 \text{ cm}$, mass $63.60 \text{ kg} \pm 6.90 \text{ kg}$). The present study included all positions but goalkeeper (defender, midfielder, forward). Exclusion criteria for the study included any individuals that were currently injured or had not received a physician release for a previous injury, or did not successfully pass the PAR-Q+. This study was approved by the University Institutional Review Board, each participant completed an informed consent document and health history questionnaire.

Procedures

All participants were assessed before and after a soccer match (scrimmage 70 minutes in duration). Pre-soccer testing took place approximately 90 minutes before kickoff (testing at 14:30 and kickoff was at 16:00). Post-match testing occurred after the game (~15 – 20 minutes after the game had been completed). All participants participated in both halves of the exhibition, totaling ~ 60 minutes of competitive play. Participants participated in a previous study (unpublished data) assessing countermovement jumps, thus participants understood how the CMJs (with hands on hips) should be performed. Additionally, the researchers would instruct the participants how to appropriately move (was not needed) throughout the CMJs if necessary.

Protocol

After completing the health questionnaire and informed consent, participants had their height and weight measured on a stadiometer. Following the

anthropometric measurement, countermovement jumps were assessed using Hawk Dynamics unidimensional dual force platforms (5th generation, Westbrook, ME, USA) sampling at 1000 Hz. Force plates were zeroed/calibrated prior to the data collection. The athletes were instructed to step onto the force plates, stand still with their hands on their hips for a total of two to three seconds, and then jump as fast and as high as possible while keeping their hands on their hips throughout the entire movement. If any participant did not keep their hands on their hips throughout the CMJ, an additional attempt was performed allowing for three acceptable trials (present study did not have any additional attempts for any participant). Each jump attempt began with a command of the researcher by saying “jump”, to off-set potential for fatigue, fifteen to thirty seconds of rest were given between CMJ attempts, and a total of three jumps were attempted (Cabarkapa, Philipp, et al., 2023; Philipp, Cabarkapa, Nijem, Blackburn, et al., 2023). Strong verbal encouragement was provided for each jump through all testing procedures to ensure that maximal effort was given during each jump attempt.

Variables

When assessing CMJs, it is important to assess all

phases within the CMJ profile (weighted – landing) (McMahon et al., 2018), thus, the present study assessed metrics within each phase. Specifically, the present study followed the same assessment protocol as Philipp et al., (2023), where the braking phase was assessed when the participants' center of mass returned to baseline force, which is known as the time when there is a momentary pause at the bottom of the countermovement. The propulsive phase immediately begins as the body begins a concentric action from the bottom of the countermovement and lasts until the participant leaves the platform. For fitness activity metrics, Beyond Pulse (Portland, Oregon, USA) heart rate monitors were worn by the athletes.

Statistical Analysis

All statistical tests were carried out by IBM SPSS Statistics Version 28 statistical analysis program with the level of significance measurement set at ($p < 0.05$). All descriptive statistics were used according to the study objectives. Hedges' g was used to calculate the measure of the effect size [i.e., $g = 0.2$ is a small effect, $g = 0.5$ is a moderate effect, and $g > 0.8$ is a large effect] (Hedges, 1981). A Wilcoxon Non-Parametrics test was used for all CMJ variables to assess pre- vs. post-game

Table 1. Countermovement jump metrics before and after competitive exhibition game.

Strategy Metrics	Pre	Post	Results	g
Braking Phase Duration (s)	0.19 ± 0.05	0.18 ± 0.05	$p = 0.039^*$	0.590
Propulsive Phase (s)	0.27 ± 0.04	0.26 ± 0.04	$p = 0.010^*$	0.896
Countermovement Depth (cm)	(-) 27.33 ± 5.37	(-) 25.27 ± 4.54	$p = 0.004^*$	-0.990
Driver Metrics				
Braking RFD (N)	4098.57 ± 1782.48	4157.29 ± 1860.71	$p = 0.397$	-0.077
Avg braking force (N)	982.28 ± 151.77	971.67 ± 144.53	$p = 0.177$	0.289
Peak braking force (N)	1318.05 ± 206.93	1298.21 ± 216.07	$p = 0.470$	0.247
Average propulsion force (N)	1179.87 ± 150.09	1186.31 ± 144.96	$p = 0.470$	-0.142
Peak propulsion force (N)	1420.57 ± 182.58	1449.91 ± 179.35	$p = 0.060$	-0.422
Avg braking velocity (m·s ⁻¹)	0.66 ± 0.10	0.64 ± 0.08	$p = 0.101$	-0.403
Peak braking velocity (m·s ⁻¹)	(-) 0.99 ± 0.17	(-) 0.97 ± 0.13	$p = 0.186$	-0.317
Average propulsion velocity (m·s ⁻¹)	1.38 ± 0.11	1.36 ± 0.11	$p = 0.195$	0.363
Peak propulsion velocity (m·s ⁻¹)	2.44 ± 0.17	2.40 ± 0.17	$p = 0.076$	0.491
Average propulsion power (W)	1506.74 ± 213.19	1487.82 ± 197.73	$p = 0.551$	0.218
Peak propulsion power (W)	2784.19 ± 304.39	2762.87 ± 279.19	$p = 0.551$	0.182
Other				
VJH (cm)	27.40 ± 4.26	26.46 ± 3.90	$p = 0.056$	0.500
Takeoff Velocity (m·s ⁻¹)	2.31 ± 0.18	2.27 ± 0.17	$p = 0.062$	0.514
Jump Momentum (kg·m·s ⁻¹)	146.65 ± 15.18	142.16 ± 13.86	$p = 0.004^*$	0.977
mRSI (ratio)	0.35 ± 0.07	0.36 ± 0.06	$p = 0.548$	-0.135

* Significantly different from pre-game ($p < 0.05$), $g = 0.2$ is a small effect, $g = 0.5$ is a moderate effect, and $g > 0.8$ is a large

Table 2. Scrimmage report for Division II female soccer team.

Fitness Activity Tracker Variables	Average	SD
Total Distance (meters)	6660.93	1286.85

measurements. An average of the three jumps per participant for baseline and post measurements were used for analysis. Based upon the current research question, power statistics were run (G*Power 3.1.9.7), which suggests that a total of 35 participants would be needed.

RESULTS

For strategy metrics, significant differences were seen for braking phase duration ($p = 0.039$), specifically, shorter time was spent post-game compared to pre. Similar outcomes occurred for the concentric phase ($p = 0.010$), while a shallower countermovement depth occurred post vs. pre-game ($p = 0.004$). For the driver metrics, no differences were seen for any RFD, force, velocity or power variables ($p = 0.060 - 0.551$). Finally, outcome metrics reported no differences for VJH ($p = 0.056$), mRSI ($p = 0.548$) nor takeoff velocity ($p = 0.062$), however, there was a significant difference for jump momentum, which was significantly lower post-game ($p = 0.004$). Table 1 reports pre-game vs. post-game information for all CMJ metrics.

DISCUSSION

The purpose of the present study was to assess CMJ jumping metrics (force time characteristics) before and after a competitive soccer scrimmage with division II female soccer players. Outcomes within driver metrics observed no significant deficits post-game, while significant differences were seen within strategic and other metrics.

Other Metrics

For the present study, no differences were seen for VJH, takeoff velocity, or mRSI, however, a significant difference was observed for jump momentum pre- vs. post-game. The present findings of no difference for VJH are dissimilar to previous female soccer literature which saw significant deficits in VJH post-game (Andersson et al., 2008; Ishida et al., 2021), potential reasons for dissimilar outcomes could be related to duration of games (70 minutes vs. 90 minutes), level of play (DII, vs. DI and national

team). Additionally, no differences were seen for mRSI, these findings are dissimilar to Ishida et al., (2021), potential differences could be related to duration of game (70 vs. 90 minutes), season (off-season vs. in-season), timing of testing (immediately post vs. 12 hours post), and competition level (DII vs. DI). Additionally, the present study saw no differences for takeoff velocity, although almost statistically significant ($p = 0.062$) explosive movements did not seem to be impacted when comparing potential NMF from a competitive soccer exhibition. These findings are not comparable to previous female literature, as this exact variable has not been reported. Lastly, the present study saw significant differences in jump momentum, specifically, momentum was decreased post-game compared to pre. While direct comparisons can't be made for said variables with previous female studies, decreased jump momentum post-game is similar to Spencer et al., (2023). They also reported decreased jump momentum after competing in a competitive soccer match (English National League). Although similarities and dissimilarities are seen for the present study compared to previous literature, future research may want to follow CMJ guidelines from McMahon et al. (2018) and Anicic et al., (2023), by doing so, future research can assess similar data points, allowing for greater comparison and potential contrast based upon researcher's findings.

Driver Metrics

The present study reported no differences for Force (N), velocity ($\text{m}\cdot\text{s}^{-1}$) or power (W) within the braking or propulsion phases of the CMJ before and after a competitive soccer exhibition. These findings are dissimilar to Ishida et al., (2021) who saw significant deficits in peak propulsive force, as well as peak and average power for collegiate female soccer players. These differences could be attributed to competition level (DII vs. DI), season type (off-season vs. in-season), game duration (70 minutes vs 90 minutes), timing of post-assessment (~20 minutes post vs. 12 hours post). While non-significant, the present study observed a trend to where peak propulsive force ($p = 0.060$) and peak propulsive velocity ($p = 0.076$) was negatively impacted post-game. These potential outcomes could be attributed to the repetitive use of the stretch shortening cycle (SSC) throughout the game. Previous literature suggests that competitive soccer players can have acute and prolonged decreases in CMJ metrics after competition (Nicol et al., 2006; Russell et al., 2015). Specifically, metabolic accumulation (acute

responses), and muscle damage (prolonged responses), could attribute to decreased CMJ performance for up to 72 hours post-game. Future research may want to assess immediate (within a 30-minute window post-game), and prolonged (12-48 hours post-game), to look at CMJ recovery responses and potential factors attributing to NMF post-game. This information, coupled with GPS, fitness activity trackers, and or minutes played, can allow coaching staff (soccer and strength), to modify programming or lineups to potentially aid in positive outcomes (game wins).

Strategy Metrics

The present study observed significant differences for the braking and propulsive phases, where less time was spent (s) post-game vs. pre, and CMJ depth was significantly less post-game vs. pre. For braking and propulsive phases, direct comparison with female soccer athletes are not available, however, the significant difference in phase duration during the braking and propulsion are dissimilar to Spencer et al., (2023) who observed no differences in either phase post-match. These findings could be related to gender (females vs. males), athletic status (collegiate vs. professional), season (pre vs. in). Although a different sport (basketball), the deficits for braking and propulsive phases are dissimilar to Cabarkapa et al., (2024) who reported no differences in each phase across each quarter of a competitive professional basketball game. These differences could be related to athletic status (DII vs. professional), gender (female vs. male), duration (~55-60 minutes vs. 48 minutes). Additionally, when assessing a full-practice (~ 2 hours) for professional basketball players, significant differences were seen pre vs. post practice for the propulsive phase, while no differences were seen for the braking phase (Cabarkapa, Cabarkapa, et al., 2023). Lastly, the present study reported a decreased CMJ depth post-game. Again, direct comparison with other female soccer athletes is not available, however, these findings are similar to Spencer et al., (2023). Interestingly though, previous literature has shown that decreased CMJ depth, can negatively impact VJH (Mandic et al., 2016; Pérez-Castilla et al., 2021; Sánchez-Sixto et al., 2018). While the present study did not have a significant difference in CMJH post-game ($p = 0.056$), longer duration of a game, relating to greater volume of sprinting, jumping, and running, could negatively impact the SSC (Nicol et al., 2006; Russell et al., 2015), potentially creating greater deficits in CMJ depth, and CMJH. Knowing that duration within a movement type can impact

driver and outcome performance, future research is warranted, specifically assessing force-time metrics within a CMJ within and post practice/games.

LIMITATIONS OF THE STUDY

The present study has a handful of limitations. First, the present study only assessed 14 players from a division II midwestern university. Future research may want to assess a larger sample size (as denoted from the G*Power analysis), and other populations (division I, national team). Another limitation is the team was assessed during the off-season and not a competitive regular season game. Because of this, the scrimmage was only 70-minutes in duration compared to a traditional 90-minute game. Nevertheless, coaches, healthcare professionals and conditioning specialists may want to regularly assess their athletes before and after a competitive game, or series, to see if the volume and intensity of games, are causing deficits in jumping performance.

CONCLUSIONS

The present findings highlight specific variables within strategy (braking and propulsive phase, CMJ depth) and other (jump momentum) CMJ force-time phases that were negatively impacted pre- vs. post-game. No differences were seen within the driver phase, which is dissimilar to a majority of previous soccer literature with female athletes. Knowing that soccer requires a multitude of movement mechanics and effort throughout the duration of the game, utilizing reliable and validated force plates for assessments could allow for greater comprehension of the SSC during the movement (braking, propulsion), but can also allow for force, velocity, power, and other key performance metrics to be assessed. Collectively, performing CMJs, and the collection and assessment of said phases/metrics can aid appropriate personnel with a better understanding of the impacts of competitive soccer and potential NMF.

CONFLICTS OF INTEREST

No conflicts of interest are reported by the author(s).

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ETHICAL APPROVAL

The research was approved by the Institutional Review Board at the University of Central Oklahoma (IRB # 2024-072, approval 07/2024).

DATA AVAILABILITY STATEMENT

The data presented in this study is available on request from the corresponding author.

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