8-2024

The Effects of a Period of Match Congestion on Countermovement Jump Height and Match Performance Variables in NCAA Division I Female Soccer Players

Fiona Dodge
East Tennessee State University

Recommended Citation

Dodge, Fiona, "The Effects of a Period of Match Congestion on Countermovement Jump Height and Match Performance Variables in NCAA Division I Female Soccer Players" (2024). *Electronic Theses and Dissertations.* Paper 4448. https://dc.etsu.edu/etd/4448

The Effects of a Period of Match Congestion on Countermovement Jump Height and Match Performance Variables in NCAA Division I Female Soccer Players

---

A dissertation

presented to

the faculty of the Department of Sport, Exercise, Recreation, and Kinesiology

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Doctor of Philosophy in Sport Physiology and Sport Performance

---

by

Fiona Dodge

August 2024

Dr. Michael H. Stone, Chair

Dr. Satoshi Mizuguchi

Margaret E. Stone

Dr. Joanne Spalding

Dr. Marco Duca

Keywords: match-congestion, collegiate, soccer, jump height, match performance variables

ABSTRACT

The Effects of a Period of Match Congestion on Countermovement Jump Height and Match Performance Variables in NCAA Division I Female Soccer Players

by

Fiona Dodge

Effects of a congested match period on countermovement jump height (CMJ) and match performance variables were examined over the course of a D-I female soccer season. Twenty-one female collegiate soccer players (20.3 ± 1.8 yrs, body mass (kg): 62.3 ± 7.3, height (cm): 168.9 ± 6.1, body fat (%): 23.0 ± 3.7. performed CMJ testing prior to regular season matches. Global Positioning System (GPS) was used to assess physical match performance, while pre- and post-season lab and field-based testing was also performed. Analysis of variance trend analyses (ANOVA) were conducted using a linear mixed-effects model (LMM) to examine trends in mean CMJ height and match performance variables over the course of the season. Post hoc comparisons (Cohen’s d) were conducted to clarify trend analysis and to compare and quantify the magnitude of change between consecutive matches. LMM were used to examine relationships between two match performance variables and match-to-match changes in CMJ height. ANOVA was also performed using LMM to examine changes in lab and field-based fitness measures from pre to post-season. Cohen’s d effect sizes focused on pre to post season comparisons. Pre-match CMJ height decreased over time and between consecutive matches separated by 42-92 hours season ($p < 0.05$). Distance per minute and high-speed running distance per minute fluctuated over the season but did not demonstrate a linear trend ($p > 0.5$). Match relative volume and intensity were inversely related to pre-match jump height changes in the subsequent match ($p < 0.05$). Pre and post season lab and field-based testing showed no signs of detraining, suggesting decreases in jump height over the season are unlikely related to loss of fitness components. Decreased jump height between consecutive matches, suggests players are unable to fully recover from previous physical match demands.

DEDICATION

This dissertation is dedicated to my grandparents, sister, and parents for their endless love and support. I would not be the person I am today or could not have accomplished all that I have without everything you have done for me.

ACKNOWLEDGEMENTS

I would like to thank my family, friends, co-workers and classmates for their endless love and support throughout this journey. Thank you to all my committee members. I would not have completed this without your guidance and support. A special thank you to Dr. Michael Stone and Meg Stone for their continuous support and belief, and their dedication to education and excellence. Thank you, Dr. Mizuguchi, for being a statistical genius, always finding the time to guide and educate, and providing interesting insights into professional fishing. Lastly, Jay and Matt Yelton, without your trust and belief I would not be where I am today. Thank you for always taking care of me and the team.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1. Introduction

The regular season, in which female collegiate soccer players participate, can involve congested match periods, including two matches being played per weekly micro-cycle with 42 to 44 hours between consecutive matches. Reduced recovery time between fixtures and accumulated fatigue as a result of successive matches, has been shown to affect subsequent physical performance (Andersson et al., 2008; Buchheit et al., 2010; Dupont et al., 2010). Therefore, congested collegiate soccer schedules may subsequently and substantially impact consecutive match-play.

Despite the outcome of matches, the consequences of accumulated fatigue as a result of congested match schedules should be considered in female collegiate soccer players, as periods of match congestion appear to amplify player injury susceptibility in male professional soccer players (Bengtsson et al., 2013; Carling et al., 2015; Dellal et al., 2015; Dupont et al., 2010; Howle et al., 2020; Page et al., 2023). Such findings demonstrate the importance of appropriate recovery time between consecutive matches, while highlighting the importance of fatigue monitoring and training and recovery strategies.

Global Positioning Systems (GPS) and time-motion analysis have been used to assess physical performance variables during match-play and match-play during congested periods (Arruda et al., 2015; Buchheit et al., 2010; Carling et al., 2015; Castagna et al., 2009, 2010; Djaoui et al., 2022; Harley et al., 2010; Jones et al., 2019; Mendez-Villanueva et al., 2012). Previous research suggests that physical match performance variables are unaffected during short and prolonged periods of match congestion and between congested and non-congested match periods (two consecutive matches separated by 3-4 days/72-96 hours and 6-8 successive matches in 21-26 days, respectively) (Carling et al., 2012; Dellal et al., 2015; Djaoui et al., 2013; Dupont et al., 2010; Folgado et al., 2015; Rey et al., 2012; Soroka & Lago-Peñas, 2016).

The countermovement jump (CMJ) is a well-studied and commonly used monitoring tool used to assess athletic performance and neuromuscular fatigue (NMF) status (Claudino et al., 2017; Yoshida et al., 2024). Jump performance, as a result of NMF, is reportedly impaired up to 12-72 hours following a soccer match (Andersoon et al., 2008; Goulart et al., 2022; Hoffman et al., 2003; Magalhães et al., 2010).

The current body of literature relating to match congestion primarily focuses on physical match performance amongst male professional soccer players. To the authors knowledge, there is no literature concerning physical match performance or countermovement jump height during periods of match congestion in collegiate female soccer players.

Statement of Purpose

1. To examine the effects of a period of match congestion on countermovement jump height and match performance variables in NCAA division I female soccer players.

Operational Definitions

1. Congested match schedule: Successive matches played within a short time period.
2. Countermovement jump (CMJ): A vertical jump involving a pre-jump countermovement, which takes advantage of the stretch reflex and stored elastic energy.
3. Jump height: The distance, measured in centimeters (cm), the athlete jumps off the force plate
4. Match performance variables: The metrics used to evaluate physical performance during match-play

5. Distance per minute: The average distance, measured in meters (m), a player covers in one minute of match-play
6. High-speed running distance per minute: The average high-speed running distance, measured in meters (m), a player covers in one minute of match-play.
7. Total distance: The total distance, measured in meters (m), a player covers during match-play.
8. Neuromuscular fatigue: A contribution of peripheral and central fatigue, impacting contractile function and muscle activation, respectively.

Chapter 2. Review of the Literature

Physical Demands of Soccer

Soccer is characterized as an intermittent sport that strongly depends on the physiological capabilities of the players. The sport involves periods of high intense activity (sprinting, high intensity running, changes in direction, jumping and tackling), interspersed with periods of primarily aerobic activity as well as active recovery (Alexander, 2014; Bangsbo et al., 2006; Castagna et al., 2006; Krustrup et al., 2010; Markovic et al., 2014; Reilly & Rigby, 2007; Rey et al., 2012). Due to soccer's competitive and physical nature, soccer matches produce high levels of fatigue and physiological stress in players (Gümüşdağ et al., 2013). Results from previous studies suggest that up to 72-hours can be required for players to return to pre-competition levels of performance, as match demands can lead to lingering fatigue which may result in a decline in performance (Andersson et al., 2008; Cormack et al., 2008; Ekstrand et al., 2004; Hoffman et al., 2003; Manzi et al., 2010; Rollo & Williams, 2011). Furthermore, reduced recovery time between fixtures and accumulated fatigue as a result of successive matches, has been shown to affect subsequent physical performance (Andersson et al., 2008; Buchheit et al., 2010; Dupont et al., 2010).

Match Congestion at the Professional Level

Despite the physiological implications of a single soccer match, periods of intense match congestion often occur at the professional level. Match congestion has been limitedly defined as competing in a minimum of two successive bouts of match-play, with an inter-match recovery period of < 96 hours (Julian et al., 2021). Many professional club teams are confronted with two or more matches in a weekly micro-cycle throughout phases of the season due to dual participation in league and cups (Fatouros et al., 2008; Folgado et al., 2015). This results in limited recovery opportunities of less than three to four days between consecutive matches (Folgado et al., 2015). International tournament style play (European and World Cup Qualifiers and Finals) can also involve periods of match congestion, however, due to the physical and psychological demands of international tournaments, organizers attempt to strategically coordinate events to minimize subsequent effects on club seasons and player load.

Match Congestion at the Collegiate Level

Periods of match congestion are not only observed at the professional level. Due to the structure of collegiate soccer in the U.S., female collegiate players are also subject to match congestion when they participate solely in regular-season matches while competing for a regular-season championship within their conference. The National Collegiate Athletic Association (NCAA) division I women's soccer regular-season typically begins in late August or mid-September and ends in late October, depending on the number of teams competing in each conference. In recent years, some division I conferences were required to compete twice a week, with matches taking place on Friday and Sunday. Therefore, the schedule of matches allowed for approximately 42 to 44 hours between Friday and Sunday matches, and 101 to 126 hours between Sunday and Friday matches. As a result, division I female soccer teams were expected to compete twice a week for five to eight weeks over the course of the regular season, with limited recovery opportunity between successive matches (Friday and Sunday). Though, recent amendments to scheduling within some conferences means that most division I conferences now compete on a Wednesday and Saturday or Thursday and Sunday, which provides some additional recovery between successive matches compared to the previous structure. Nevertheless, teams are still expected to compete in two successive bouts of match play per week with as little as 67-hours of rest between some successive matches over the course of a season.

Such matches consist of two 45-minute periods, separated by 15-minutes of recovery time. Unlimited substitutions are permitted for all matches, while only one re-entry is allowed for players during the second period of matches.

According to Sausaman et al. (2019) division I collegiate female soccer players who compete for the full duration of a regular-season championship game can accumulate a total distance of 9,486 ± 300 m in a single match, irrespective of playing position. Of that distance, 1,014 ± 118 m is achieved at high-speed (> 15 $km \cdot h^{-1}$). Specifically, attacking/forward players average a total distance of 9882 (9414-10349) m, with approximately 1333 (1147-1519) m of that distance achieved at high-speed. Whereas midfielders accumulate an average total distance of 9536 (8998-10034) m, with 840 (626-1054) m of that distance produced at high-speed. Lastly, defenders accumulate approximately 9039 (8527-9551) m during a 90-minute regular-season game, with 868 (665-1071) m achieved at high-speed.

Injury Risk During Match Congestion

When recovery is insufficient over extended periods, the risk of injury rises, and performance either plateaus or declines (Meeusen et al., 2013; Sands et al., 2007; Taylor et al., 2012). Match congestion over a short period of time could result in residual fatigue, increased injury risk and underperformance associated with minimal recovery time (Carling et al., 2015; Dupont et al., 2010). Match congestion in relation to injury has primarily been investigated at the male professional level, where findings have been somewhat inconsistent. Periods of match congestion appear to amplify player injury susceptibility (Bengtsson et al., 2013; Carling et al., 2015; Dellal et al., 2015; Dupont et al., 2010; Howle et al., 2020; Page et al., 2023). Specifically, male professional players that compete substantially (> 75 minutes per game) in short congested match cycles (≤3-4 days between successive matches) are at greater risk of injury compared to match-play outside of congested match cycles (Carling et al., 2015; Dupont et al., 2010; Howle et al., 2020; Page et al., 2023).

In contrast, Carling et al. (2015) observed injuries sustained across four-seasons of a male French League-1 club who competed in domestic league and cup games, along with European competitions. Injury rates were comparable between players who competed in consecutive games with ≤ 3 days between matches and players who competed in consecutive matches with longer recovery intervals (≥ 4 days). In an earlier study conducted by Carling et al. (2012) found that injury risk is generally unaffected during a prolonged period of match congestion in male professional soccer players who competed in eight matches in 26 days. Dellal et al. (2015) reported that total injury incidence (matches and training) during a congested match period was not statistically different compared to a non-congested match period (six games in 18 days, with three days between consecutive matches). However, injury rate during match-play during the congested match period was greater compared to non-congested match play, while training injury rate was lower during a congested match period.

Contradictory findings concerning injury propensity during periods of match congestion may be related to tactical player rotation, injury, illness or suspension subsequently affecting playing time, which was not always stated in the study design by the authors in the previously mentioned studies (Bengtsson et al., 2013; Carling et al., 2015; Dellal et al., 2015; Howle et al., 2020; Page et al., 2023). Access to enhanced post-match recovery resources and strategies at the professional level may also be a reasonable explanation for conflicting findings. For example, practitioners may reduce training loads and intensity during periods of match congestion, while players may subconsciously reduce training efforts to be able to repeat/compete at a high performance level (Page et al., 2023). There may also be limited opportunity to train during periods of match congestion. This may explain the lower training injury rate observed by Dellal et al. (2015) during a period of match congestion.

Measuring Changes in Performance

Physical Match Performance During Match Congestion

The assessment of physical performance during matches has been investigated during single-match weeks and during congested match schedules (2-3 games per week). Global Positioning Systems (GPS) and time-motion analysis have been used to assess physical performance variables including total distance, high and lower speed distance, and acceleration and deceleration related parameters during match-play and match-play during congested periods (Arruda et al., 2015; Buchheit et al., 2010; Carling et al., 2015; Castagna et al., 2009, 2010; Djaoui et al., 2022; Harley et al., 2010; Jones et al., 2019; Mendez-Villanueva et al., 2012).

Physical performance during periods of match congestion (2-3 matches per week) has been largely investigated at the male professional level. Dupont et al. (2010) investigated physical performance (total distance covered, high-intensity distance, sprint distance, and number of sprints) throughout two seasons for 32 professional soccer players in a top-level team participating in the UEFA (Union of European Football Associations) Champions League. The authors reported no statistical differences in the physical performance variables of players who competed in either one or two matches per week. Carling and Dupont (2011) reported similar findings in professional soccer players who competed in three successive matches within a seven-day period. (Djaoui et al., 2013) found no differences between congested and non-congested periods (two vs. one match a week, respectively) for the total distance covered at all the speed thresholds over 18 $\text{km}\cdot\text{h}^{-1}$ of elite soccer players competing in prolonged periods of fixture congestion. Limited changes in physical performance between two games that are played with 3–4 days between have also been reported (Dupont et al., 2010; Folgado et al., 2015; Rey et al., 2012; Soroka & Lago-Peñas, 2016).

Carling et al. (2012) investigated the effects of a more intense prolonged period of fixture congestion (8 successive official matches in 26 days) on physical performance. The total distance covered, and lower running intensities varied across matches, however high-intensity running were generally unaffected. Furthermore, Dellal et al. (2015) reported no differences in in the physical performance of 16 international players competing in six matches in 18 days, along with no differences in physical performance during periods of match congestion (six matches in 18 days) compared to matches outside congested periods.

Countermovement Jump Assessment

The countermovement jump (CMJ) is a well-studied and commonly used monitoring test use to assess athletic performance and neuromuscular fatigue (NMF) status (Claudino et al., 2017; Yoshida et al., 2022). Because of its high practicality and less fatiguing testing protocol, it enables athletes to perform the test frequently for longitudinal monitoring purposes. Indeed, a CMJ is one of the essential athletic movements in sport performance and is a measure of a stretch shortening cycle (SSC) performance (≥ 250 millisecond) (Hennessy and Kilty, 2001). The SSC is characterized as a cyclical muscle action whereby the muscle experiences an eccentric action (pre-stretch/countermovement), prior to a transitional period (amortization phase) followed by a concentric contraction (Walker, 2024). This cyclic muscle action is frequently utilized in soccer, and it may be important during phases of the game that involve jumping and sprinting (Oliver et al., 2008). Muscle damage and fatigue have been shown to inhibit muscle functions such as the SSC (Enoka & Duchateau, 2008; Ross et al., 2007). Therefore, diminishing function of the SSC due to fatigue-induced impairments could influence match performance and outcome (Oliver et al., 2008).

Energy depletion, disturbances to peripheral homeostasis and damage to muscle tissues contribute to fatigue post-match-play. Consequently, damage to muscle tissue, particularly the quadricep muscles, implicates the force generating capacity (Brownstein et al., 2017). Acute muscle fatigue has been referred to as a decline in maximum voluntary contraction (MVC) strength, and reductions occurring post-exercise MVC are characteristically ascribed to neuromuscular fatigue (NMF) (Gandevia, 2001). Peripheral fatigue and central fatigue contribute to neuromuscular fatigue, impacting contractile function and muscle activation, respectively (Gandevia, 2001). Inadequate force restoration or the accumulation of work, influencing accumulative fatigue, can have immediate and prolonged consequences for neuromuscular performance, subsequently influencing team sport performance during regular matches with a congested fixture calendar (Alba-Jimenez et al., 2022).

Changes in stretch shortening capabilities of the lower-limb muscles, reflecting neuromuscular function, can be monitored through the assessment of countermovement jump performance, which emphasizes pre-stretch action (Alba-Jimenez et al., 2022; Byrne & Eston, 2002; Oliver et al., 2008). The countermovement jump is one of the most popular employed tools utilized by practitioners to objectively assess neuromuscular fatigue due to its high validity and reliability (Alba-Jimenez et al., 2022; Armada-Cortés et al., 2022; Claudino et al., 2017). Furthermore, such jump tests are easy to implement, time-efficient, and non-fatiguing and can be performed using contact mats, force platforms, linear position transducers, high-speed video cameras and software, or infrared platforms (Alba-Jimenez et al., 2022; Walker, 2024). Average

CMJ height is reportedly a more sensitive representation of neuromuscular fatigue, as opposed to the highest CMJ height (Claudino et al., 2017).

The fatigue and recovery time course following soccer matches in female soccer players of varying playing ability demonstrated that CMJ height was not statistically impacted immediately post-match, however reductions in CMJ height were observed 12- and 24-hours post-match (Goulart et al., 2022). This coincides with findings reported by Krustrup et al. (2010) where authors reported no changes in countermovement jump height immediately post-match in elite female soccer players. Hoffman et al. (2003) reported similar findings showing no change in jump performance immediately after a soccer game in female division III collegiate soccer players, but performance was impaired 24 hours later. In an earlier study, Andersson et al. (2008) investigated the time course of recovery from neuromuscular fatigue between two elite female soccer matches whom completed either active or passive recovery between the consecutive matches (69 hours). Countermovement jump height was assessed prior to the first match, immediately after, 5-, 21-, 45-, 51-, and 69-hours post-match, and immediately after a second match. Reductions in jump height were observed immediately after the first match and remained below baseline at the beginning of the second match in both groups. Magalhães et al. (2010) reported similar findings when examining the impact of a soccer match on physiological, biochemical and neuromuscular parameters among sixteen male soccer players from 2nd and 3rd Portuguese divisions. Specifically, the authors reported reductions in countermovement jump height up to 72 hours post-match. In contrast, Lundberg and Weckstrom, (2017) examined 16 professional male players during a regular one-match week and during a congested three-match week. The authors reported no change in jump performance 72 hours post-match during a one-match week and three-match week.

Student Athlete Stressors Impacting Athletic Performance

Implications of Travel on Athletic Performance

The physical and psychological demands of successive matches can be further compounded by travelling to and from away competition (Abbott et al., 2018; Fowler et al., 2015; Gouttebarge et al., 2019). There is a disparity between resources at the division I collegiate level, whereby power five conferences typically have larger athletic budgets, state-of-the-art facilities, and greater access to resources for recruiting, training, and travel. Whereas mid-major conferences compete at a slightly lower level of resources. Travel is an essential factor of collegiate athletics, but presents challenges for student athletes (Heller et al., 2024). Power five conferences may travel via air to away competitions as opposed to road travel experienced by mid-major conference teams. Additionally, away fixtures may mean that players cross different time zones and are often required to stay in hotels before and after away matches or travel home from away matches immediately after competition. This may impact recovery, as well as, academic performance, as student athletes are unable to attend class, while facing distractions and non-optimal scheduling impacting assignment and exam completion (Heller et al., 2024). Furthermore, travel-impaired learning and athletic performance is compounded by irregular and shortened sleep, which is intensified when travelling across time-zones, disrupting circadian rhythms (jet lag) (Heller et al., 2024).

In a study examining the subjective wellbeing of eleven professional male soccer players, players reported lower sleep quality and mood, and higher stress after away fixtures. It has been suggested that such responses may be due to psychological or environmental factors including travel, unfamiliar surroundings, habit disruption, changes in food provision, pressure from away supporters and sleep loss (Abbott et al., 2018). In the same study, sleep quality was reportedly lower after away matches, which may have been impacted by lower mood, elevated stress, late night away fixtures and that players needed to travel further distance to return home (Abbott et al., 2018; Fullagar et al., 2016). This may affect perceived sleep quality (Abbott et al., 2018; Nédélec et al., 2015). Furthermore, qualitive interviews revealed travel and sleep are two key reasons why soccer players prefer playing at home (Abbott et al., 2018).

In a study examining sleep quality, sleep duration and daytime sleepiness of 628 collegiates student athletes, 42.4% of athletes experience poor sleep quality, 39.1% reported regularly achieving less than seven hours of sleep on weekdays, and 51.1% of athletes reported greater levels of daytime sleepiness. Likewise, lower frequency of difficulty waking up for practice and class, and less trouble staying awake during daily activities was associated with greater total sleep duration (Mah et al., 2018). It is recommended that college students achieve between seven to nine hours of sleep per night to function physically, emotionally and cognitively (Hirshkowitz et al., 2015). However, student's, particularly student athletes, may require extended sleep duration depending on prior sleep deprivation, physical activity, environment and illness for optimal performance (Heller et al., 2024; Hirshkowitz et al., 2015; N. F. Watson et al., 2015). New and noisy environments also influence undisturbed sleep, without further implication of different time zones (Heller et al., 2024). Achieving less than seven hours of sleep per night elicits endocrine and other physiological responses including; increased circulating stress hormones (e.g., cortisol); reduction in the regeneration of carbohydrate stores (i.e., glycogen); deregulation of appetite, impacting energy expenditure; increased catabolism and the reduction of anabolism, impacting the rate of muscle repair/muscle protein synthesis (Atrooz & Salim, 2020; Doherty et al., 2021; Fullager et al., 2015; Knutson et al., 2007; Meerlo et al., 2008). Such responses may impact post-exercise recovery or the reduction and reversal process of fatigue (De Pauw et al., 2013; Doherty et al., 2021). Overall, poor sleep can negatively impact athletic performance, while increased sleep duration and quality have been associated with enhanced performance and competitive success (Charest & Grandner, 2020; Cook & Charest, 2023; Craven et al., 2022; Doherty et al., 2021; A. M. Watson, 2017).

Academic and Athletic Stressors

Professional athletes typically devote their time to developing their sporting career within a professional environment, with minimal time or need dedicated to developing additional aspects of their lives (Aquilina, 2013). Whereas, collegiate soccer players, who are considered student-athletes are required to balance their academic and athletic commitment (Lopes Dos Santos et al., 2020). The current NCAA rules state that collegiate athletes are permitted to engage in required athletic activities for 4 hours per day and 20 hours per week during in-season and 8 hours per week during the off-season throughout the academic year. Furthermore, during the academic year, collegiate athletes are not permitted to engage in any countable athletically related activities on one day per week (any seven consecutive days) during the season and two days per week during the off-season. Nevertheless, an (NCAA, 2019) study investigating the experiences and well-being of student athletes reported that student athletes commit up to 34 hours per week to athletics. Athletic responsibilities include training time (physical conditioning and sport related practice), travelling to competitions which often results in missing academic related classes, dealing with injuries (physical therapy/rehabilitation) and sport related meetings concerning playing status and tactical approaches (Etzl, 2009; Fogaca, 2019; Lopes Dos Santos et al., 2020; Maloney & McCormick, 1993; Scott et al., 2008). Furthermore, student athletes devote between 38.5 and 40 hours per week to academic-related tasks (NCAA, 2019). In addition, regulations imposed by the NCAA requires collegiate athletes to uphold a certain grade point average (GPA) to maintain academic and athletic scholarships and athletic eligibility (Lopes Dos Santos et al., 2020).

Performing academically is a major source of stress among most regular college students (Aquilina, 2013; Davis et al., 2019; De Beandt et al., 2018; Lopes Dos Santos et al., 2020; Lopez de Subijana et al., 2015). Such stress may increase the chance of mental health issues, particularly anxiety and depression (Li et al., 2017; Lopes Dos Santos et al., 2020; Moreland et al., 2018). In 2019, the (American College Health Association, 2019) surveyed 67,972 college students via the National College Health Assessment, where 27.8% students reported anxiety, while 20.2% reported feeling depressed which negatively affected their academic performance. Stress and its physiological responses may be further exacerbated in collegiate soccer players as they simultaneously focus on academic and athletic success (Aquilina, 2013; Hamlin et al., 2019; Huml et al., 2016; Lopes Dos Santos et al., 2020; Lopez de Subijana et al., 2015).

Investigating levels of perceived stress in 182 collegiate athletes, Hamlin et al. (2019) reported that perceived academic stress was heightened during periods of the academic year which coincided with examination weeks within competitive seasons. Student athletes reported difficulties managing athletic and academic responsibilities associated with decreased energy levels and overall sleep quality. Furthermore, incidences of stress and anxiety may lead to physiological responses, including increased muscle tension, physical fatigue, reductions in neurocognitive and perception process that may lead to physical injuries (Ivarsson et al., 2017). Therefore, it may be appropriate to suggest that such physiological responses relating to stress not only implicates psychological well-being, but may subsequently impact negatively upon athletic performance (Hamlin et al., 2019; Lopes Dos Santos et al., 2020).

Summary

Further research is required to determine the impact of match congestion relating to match physical performance and neuromuscular fatigue. As the CMJ is a valid and reliable measurement tool, sensitive to fatigue level, field-based research using the CMJ is viable. Currently, most of the literature concerning match congestion focuses on physical match performance at the male professional level, with 3-4 days of recovery between successive matches. This differs from the match congestion experienced by female collegiate soccer players. To the authors’ knowledge, there is little to no literature concerning match congestion at the female collegiate level. Furthermore, there is limited research that incorporates the CMJ as an assessment of NMF during long periods of match congestion Monitoring fatigue at the female collegiate level would provide valuable knowledge to coaches, practitioners, and athletes as they face recovery time frames and academic and travel commitments.

References

Abbott, W., Brownlee, T. E., Harper, L. D., Naughton, R. J., & Clifford, T. (2018). The independent effects of match location, match result and the quality of opposition on subjective wellbeing in under 23 soccer players: A case study. Research in Sports Medicine, 26(3), 262–275. https://doi.org/10.1080/15438627.2018.1447476

Alba-Jimenez, C., Moreno-Doutres, D., & Pena, J. (2022). Trends Assessing Neuromuscular Fatigue in Team Sports: A Narrative Review. Journal of Sports, 10(3). https://doi.org/10.3390/sports10030033.

Alexander, R. (2014). Physical and Technical Demands of Women's Collegiate Soccer. East Tennessee State University.

American College Health Association. (2019). National College Health Assessment II. Reference Group Executive Summary.

Andersson, H., Raastad, T., Nilsson, J., Paulsen, G., Garthe, I., & Kadi, F. (2008). Neuromuscular Fatigue and Recovery in Elite Female Soccer: Effects of Active Recovery. Medicine & Science in Sports & Exercise, 40(2), 372–380. https://doi.org/10.1249/mss.0b013e31815b8497

Aquilina, D. (2013). A Study of the Relationship Between Elite Athletes' Educational Development and Sporting Performance. The International Journal of the History of Sport, 30(4), 374–392. https://doi.org/10.1080/09523367.2013.765723

Armada-Cortés, E., Benítez-Muñoz, J. A., San Juan, A. F., & Sánchez-Sánchez, J. (2022). Evaluation of Neuromuscular Fatigue in a Repeat Sprint Ability, Countermovement Jump and Hamstring Test in Elite Female Soccer Players. International Journal of

Environmental Research and Public Health, 19(22), 15069. https://doi.org/10.3390/ijerph192215069

Arruda, A. F. S., Carling, C., Zanetti, V., Aoki, M. S., Coutts, A. J., & Moreira, A. (2015). Effects of a Very Congested Match Schedule on Body-Load Impacts, Accelerations, and Running Measures in Youth Soccer Players. International Journal of Sports Physiology and Performance, 10(2), 248–252. https://doi.org/10.1123/ijspp.2014-0148

Atrooz, F., & Salim, S. (2020). Sleep deprivation, oxidative stress and inflammation. Advances in Protein Chemistry and Structural Biology, 119, 309–336. https://doi.org/10.1016/bs.apcsb.2019.03.001

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. Journal of Sports Sciences, 24(7), 665–674. https://doi.org/10.1080/02640410500482529

Bengtsson, H., Ekstrand, J., & Hägglund, M. (2013). Muscle injury rates in professional football increase with fixture congestion: An 11-year follow-up of the UEFA Champions League injury study. British Journal of Sports Medicine, 47(12), 743–747. https://doi.org/10.1136/bjsports-2013-092383

Brownstein, C. G., Dent, J. P., Parker, P., Hicks, K. M., Howatson, G., Goodall, S., & Thomas, K. (2017). Etiology and Recovery of Neuromuscular Fatigue following Competitive Soccer Match-Play. Frontiers in Physiology, 8, 831. https://doi.org/10.3389/fphys.2017.00831

Buchheit, M., Mendez-Villanueva, A., Simpson, B. M., & Bourdon, P. C. (2010). Match Running Performance and Fitness in Youth Soccer. International Journal of Sports Medicine, 31(11), 818–825. https://doi.org/10.1055/s-0030-1262838

Byrne, C., & Eston, R. (2002). Maximal-intensity isometric and dynamic exercise performance after eccentric muscle actions. Journal of Sports Sciences, 20(12), 951–959. https://doi.org/10.1080/026404102321011706

Carling, C., & Dupont, G. (2011). Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play? Journal of Sports Sciences, 29(1), 63–71. https://doi.org/10.1080/02640414.2010.521945

Carling, C., Le Gall, F., & Dupont, G. (2012). Are Physical Performance and Injury Risk in a Professional Soccer Team in Match-Play Affected Over a Prolonged Period of Fixture Congestion? International Journal of Sports Medicine, 33(1), 36–42. https://doi.org/10.1055/s-0031-1283190

Carling, C., Mccall, A., Le Gall, F., & Dupont, G. (2015). The impact of short periods of match congestion on injury risk and patterns in an elite football club. British Journal of Sports Medicine, 50(12). https://doi.org/10.1136/bjsports-2015-095501

Castagna, C., Impellizzeri, F. M., Chamari, K., carlomagno, D., & Rampinini, E. (2006). Aerobic fitness and yo-yo continuous and intermittent tests performances in soccer players: A correlation study. Journal of Strength and Conditioning Research, 20(2), 320–325.

Castagna, C., Impellizzeri, F., Cecchini, E., Rampinini, E., & Alvarez, J. C. B. (2009). Effects of Intermittent-Endurance Fitness on Match Performance in Young Male Soccer Players. Journal of Strength and Conditioning Research, 23(7), 1954–1959. https://doi.org/10.1519/JSC.0b013e3181b7f743

Castagna, C., Manzi, V., Impellizzeri, F., Weston, M., & Barbero Alvarez, J. C. (2010). Relationship Between Endurance Field Tests and Match Performance in Young Soccer

Players. Journal of Strength and Conditioning Research, 24(12), 3227–3233. https://doi.org/10.1519/JSC.0b013e3181e72709

Charest, J., & Grandner, M. A. (2020). Sleep and Athletic Performance. Sleep Medicine Clinics, 15(1), 41–57. https://doi.org/10.1016/j.jsmc.2019.11.005

Claudino, J. G., Cronin, J., Mezêncio, B., McMaster, D. T., McGuigan, M., Tricoli, V., Amadio, A. C., & Serrão, J. C. (2017). The countermovement jump to monitor neuromuscular status: A meta-analysis. Journal of Science and Medicine in Sport, 20(4), 397–402. https://doi.org/10.1016/j.jsams.2016.08.011

Cook, J. D., & Charest, J. (2023). Sleep and Performance in Professional Athletes. Current Sleep Medicine Reports, 9(1), 56–81. https://doi.org/10.1007/s40675-022-00243-4

Cormack, S. J., Newton, R. U., McGuigan, M. R., & Cormie, P. (2008). Neuromuscular and Endocrine Responses of Elite Players During an Australian Rules Football Season. International Journal of Sports Physiology and Performance, 3(4), 439–453. https://doi.org/10.1123/ijspp.3.4.439

Craven, J., McCartney, D., Desbrow, B., Sabapathy, S., Bellinger, P., Roberts, L., & Irwin, C. (2022). Effects of Acute Sleep Loss on Physical Performance: A Systematic and Meta-Analytical Review. Sports Medicine, 52(11), 2669–2690. https://doi.org/10.1007/s40279-022-01706-y

Davis, P., Halvarsson, A., Lundström, W., & Lundqvist, C. (2019). Alpine Ski Coaches’ and Athletes’ Perceptions of Factors Influencing Adaptation to Stress in the Classroom and on the Slopes. Frontiers in Psychology, 10, 1641. https://doi.org/10.3389/fpsyg.2019.01641

De Beandt, K., Wylleman, P., Torregrossa, M., & Schipper van Veldhoven, N. (2018). Exploring the factor structure of the Dual Career Competency Questionnaire for Athletes in European pupil-and student-athletes. International Journal of Sport and Exercise Physiology.

De Pauw, K., Roelands, B., Marusic, U., Fernandez Tellez, H., Knaepen, K., & Meeusen, R. (2013). Brain mapping after prolonged cycling and during recovery in the heat. Journal of Applied Physiology, 115(9), 1324–1331. https://doi.org/10.1152/japplphysiol.00633.2013

Dellal, A., Lago-Peñas, C., Rey, E., Chamari, K., & Orhant, E. (2015). The effects of a congested fixture period on physical performance, technical activity and injury rate during matches in a professional soccer team. British Journal of Sports Medicine, 49(6), 390–394. https://doi.org/10.1136/bjsports-2012-091290

Djaoui, L., Owen, A., Newton, M., Theodoros Nikolaidis, P., Dellal, A., & Chamari, K. (2022). Effects of congested match periods on acceleration and deceleration profiles in professional soccer. Biology of Sport, 39(2), 307–317. https://doi.org/10.5114/biolsport.2022.103725

Djaoui, L., Wong, D. P., Pialoux, V., Hautier, C., Da Silva, C. D., Chamari, K., & Dellal, A. (2013). Physical Activity during a Prolonged Congested Period in a Top-Class European Football Team. Asian Journal of Sports Medicine, 5(1). https://doi.org/10.5812/asjsm.34233

Doherty, R., Madigan, S. M., Nevill, A., Warrington, G., & Ellis, J. G. (2021). The Sleep and Recovery Practices of Athletes. Nutrients, 13(4), 1330. https://doi.org/10.3390/nu13041330

Dupont, G., Nedelec, M., McCall, A., McCormack, D., Berthoin, S., & Wisløff, U. (2010). Effect of 2 Soccer Matches in a Week on Physical Performance and Injury Rate. The American Journal of Sports Medicine, 38(9), 1752–1758. https://doi.org/10.1177/0363546510361236

Ekstrand, J., Walden, M., & Hagglund, M. (2004). Risk for injury when playing in a national football team. Scandinavian Journal of Medicine and Science in Sports, 14(1), 34–38. https://doi.org/10.1111/j.1600-0838.2003.00330.x

Enoka, R. M., & Duchateau, J. (2008). Muscle fatigue: What, why and how it influences muscle function. The Journal of Physiology, 586(1), 11–23. https://doi.org/10.1113/jphysiol.2007.139477

Etzl, E. F. (2009). Counseling and psychological services for college student-athletes. Fitness Information Technology.

Fatouros, I. G., Chatzinikolaou, A., Ispirlidis, I., Jamurtas, A. Z., Nikolaidis, M. G., Michailidis, I., Douroudos, I., Margonis, K., & Taxildaris, K. (2008). Time-course of Changes in Inflammatory and Performance Responses Following a Soccer Game: 2328 Board #108 May 30 3:30 PM - 5:00 PM. Medicine & Science in Sports & Exercise, 40(5), S432. https://doi.org/10.1249/01.mss.0000322840.72766.9f

Fogaca, J. (2019). Combining Mental Health and Performance Interventions: Coping and Social Support for Student-Athletes. Journal of Applied Sport Psychology, 33(3), 1–16. https://doi.org/10.1080/10413200.2019.1648326

Folgado, H., Duarte, R., Marques, P., & Sampaio, J. (2015). The effects of congested fixtures period on tactical and physical performance in elite football. Journal of Sports Sciences, 33(12), 1238–1247. https://doi.org/10.1080/02640414.2015.1022576

Fowler, P., Duffield, R., Howle, K., Waterson, A., & Vaile, J. (2015). Effects of Northbound Long-Haul International Air Travel on Sleep Quantity and Subjective Jet Lag and Wellness in Professional Australian Soccer Players. International Journal of Sports Physiology and Performance, 10(5), 648–654. https://doi.org/10.1123/ijspp.2014-0490

Fullagar, H. H. K., Skorski, S., Duffield, R., Julian, R., Bartlett, J., & Meyer, T. (2016). Impaired sleep and recovery after night matches in elite football players. Journal of Sports Sciences, 34(14), 1333–1339. https://doi.org/10.1080/02640414.2015.1135249

Fullager, H. H. K., Skorski, S., Duffield, R., hammes, D., Coutts, A. J., & Meyer, T. (2015). Sleep and athletic performance: The effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. Sports Medicine, 45(2), 161–186. https://doi.org/10.1007/s40279-014-0260-0

Gandevia, S. C. (2001). Spinal and supraspinal factors in human muscle fatigue. Physiological Reviews, 81(4), 1725–1789. https://doi.org/10.1152/physrev.2001.81.4.1725

Goulart, K. N. O., Coimbra, C. C., Campos, H. O., Drummond, L. R., Ogando, P. H. M., Brown, G., Couto, B. P., Duffield, R., & Wanner, S. P. (2022). Fatigue and Recovery Time Course After Female Soccer Matches: A Systematic Review and Meta-analysis. Sports Medicine - Open, 8(1), 72. https://doi.org/10.1186/s40798-022-00466-3

Gouttebarge, V., Brink, M. S., & Kerkhoffs, G. M. M. J. (2019). The perceptions of elite professional footballers on the International Match Calendar: A cross-sectional study. Science and Medicine in Football, 3(4), 339–342. https://doi.org/10.1080/24733938.2019.1617432

Gümüşdağ, H., Bastik, C., Yamaner, F., Kartal, A., & Ünlü, C. (2013). Burnout in Professional Soccer Players: The Role of Aggression and Anxiety. 04(10).

Hamlin, M. J., Wilkes, D., Elliot, C. A., Lizamore, C. A., & Kathiravel, Y. (2019). Monitoring Training Loads and Perceived Stress in Young Elite University Athletes. Frontiers in Physiology, 10, 34. https://doi.org/10.3389/fphys.2019.00034

Harley, J. A., Barnes, C. A., Portas, M., Lovell, R., Barrett, S., Paul, D., & Weston, M. (2010). Motion analysis of match-play in elite U12 to U16 age-group soccer players. Journal of Sports Sciences, 28(13), 1391–1397. https://doi.org/10.1080/02640414.2010.510142

Heller, H. C., Herzog, E., Brager, A., Poe, G., Allada, R., Scheer, F. A. J. L., Carskadon, M., De La Iglesia, H. O., Jang, R., Montero, A., Wright, K., Mouraine, P., Walker, M. P., Goel, N., Hogenesch, J., Van Gelder, R. N., Kriegsfeld, L., Mah, C., Colwell, C., … Paul, K. (2024). The Negative Effects of Travel on Student Athletes Through Sleep and Circadian Disruption. Journal of Biological Rhythms, 39(1), 5–19. https://doi.org/10.1177/07487304231207330

Hennessy, L. and Kilty, J. Relationship of the stretch-shortening cycle to sprint performance in trained female athletes. J Strength Cond Res 15: 326-331, 2001.

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O’Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, J. C., & Adams Hillard, P. J. (2015). National Sleep Foundation’s sleep time duration recommendations: Methodology and results summary. Sleep Health, 1(1), 40–43. https://doi.org/10.1016/j.sleh.2014.12.010

Hoffman, J. R., Nusse, V., & Kang, J. (2003). The Effect of an Intercollegiate Soccer Game on Maximal Power Performance. Canadian Journal of Applied Physiology, 28(6), 807–817. https://doi.org/10.1139/h03-060

Howle, K., Waterson, A., & Duffield, R. (2020). Injury Incidence and Workloads during congested Schedules in Football. International Journal of Sports Medicine, 41(2), 75–81. https://doi.org/10.1055/a-1028-7600

Huml, M. R., Hambrick, M. E., & Hums, M. A. (2016). Coaches' Perceptions of the Reduction of Athletic Commitment for Division II Student-Athletes: Development and Validation of a Measure of Athletic/Academic Balance. Journal of Intercollegiate Sport, 9(2), 303–325. https://doi.org/10.1123/jis.2015-0055

Ivarsson, A., Tranaeus, U., Johnson, U., & Stenling, A. (2017). Negative psychological responses of injury and rehabilitation adherence effects on return to play in competitive athletes: A systematic review and meta-analysis. Open Access Journal of Sports Medicine, Volume 8, 27–32. https://doi.org/10.2147/OAJSM.S112688

Jones, R. N., Greig, M., Mawéné, Y., Barrow, J., & Page, R. M. (2019). The influence of short-term fixture congestion on position specific match running performance and external loading patterns in English professional soccer. Journal of Sports Sciences, 37(12), 1338–1346. https://doi.org/10.1080/02640414.2018.1558563

Julian, R., Page, R. M., & Harper, L. D. (2021). The Effect of Fixture Congestion on Performance During Professional Male Soccer Match-Play: A Systematic Critical Review with Meta-Analysis. Sports Medicine, 51(2), 255–273. https://doi.org/10.1007/s40279-020-01359-9

Knutson, K. L., Spiegel, K., Penev, P., & Van Cauter, E. (2007). The metabolic consequences of sleep deprivation. Sleep Medicine Reviews, 11(3), 163–178.

Krustrup, P., Zebis, M., Jensen, J. M., & Mohr, M. (2010). Game-Induced Fatigue Patterns in Elite Female Soccer. Journal of Strength and Conditioning Research, 24(2), 437–441. https://doi.org/10.1519/JSC.0b013e3181c09b79

Li, H., Moreland, J. J., Peek-Asa, C., & Yang, J. (2017). Preseason Anxiety and Depressive Symptoms and Prospective Injury Risk in Collegiate Athletes. The American Journal of Sports Medicine, 45(2).

Lopes Dos Santos, M., Uftring, M., Stahl, C. A., Lockie, R. G., Alvar, B., Mann, J. B., & Dawes, J. J. (2020). Stress in Academic and Athletic Performance in Collegiate Athletes: A Narrative Review of Sources and Monitoring Strategies. Frontiers in Sports and Active Living, 2, 42. https://doi.org/10.3389/fspor.2020.00042

Lopez de Subijana, C., Barriopedro, M., & Conde, E. (2015). Supporting Dual Career in Spain: Elite Athletes' Barriers to Study. Psychology of Sport and Exercise, 21. https://doi.org/10.1016/j.psychsport.2015.04.012

Lundberg, T. R., & Weckstrom, K. (2017). Fixture congestion modulates post-match recovery kinetics in professional soccer players. Research in Sports Medicine, 25(4), 408–420. https://doi.org/10.1080/15438627.2017.1365296

Magalhães, J., Rebelo, A., Oliveira, E., Silva, J. R., Marques, F., & Ascensão, A. (2010). Impact of Loughborough Intermittent Shuttle Test versus soccer match on physiological, biochemical and neuromuscular parameters. European Journal of Applied Physiology, 108(1), 39–48. https://doi.org/10.1007/s00421-009-1161-z

Mah, C. D., Kezirian, E. J., Marcello, B. M., & Dement, W. C. (2018). Poor sleep quality and insufficient sleep of a collegiate student-athlete population. Sleep Health, 4(3), 251–257. https://doi.org/10.1016/j.sleh.2018.02.005

Maloney, M. T., & McCormick, R. E. (1993). An Examination of the Role That Intercollegiate Athletic Participation Plays in Academic Achievement. Jounral of Human Resources, 28(3), 555–570.

Manzi, V., D’Ottavio, S., Impellizzeri, F. M., Chaouachi, A., Chamari, K., & Castagna, C. (2010). Profile of Weekly Training Load in Elite Male Professional Basketball Players. Journal of Strength and Conditioning Research, 24(5), 1399–1406. https://doi.org/10.1519/JSC.0b013e3181d7552a

Markovic, S., Mirkov, D. M., Nedeljkovic, A., & Jaric, S. (2014). Body size and countermovement depth confound relationship between muscle power output and jumping performance. Human Movement Science, 33, 203–210. https://doi.org/10.1016/j.humov.2013.11.004

Meerlo, P., Sgoifo, A., & Suchecki, D. (2008). Restricted and disrupted sleep: Effects on autonomic function, neuroendocrine stress systems and stress responsivity. Sleep Medicine Reviews, 12(3), 197–210. https://doi.org/10.1016/j.smrv.2007.07.007

Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Nieman, D., Raglin, J., Rietjens, G., Steinacker, J., & Urhausen, A. (2013). Prevention, diagnosis and treatment of the overtraining syndrome: Joint consensus statement of the European College of Sport Science (ECSS) and the American College of Sports Medicine (ACSM). European Journal of Sport Science, 13(1), 1–24. https://doi.org/10.1080/17461391.2012.730061

Mendez-Villanueva, A., Buchheit, M., Simpson, B., & Bourdon, P. (2012). Match Play Intensity Distribution in Youth Soccer. International Journal of Sports Medicine, 34(02), 101–110. https://doi.org/10.1055/s-0032-1306323

Moreland, J. J., Coxe, K. A., & Yang, J. (2018). Collegiate athletes’ mental health services utilization: A systematic review of conceptualizations, operationalizations, facilitators, and barriers. Journal of Sport and Health Science, 7(1), 58–69. https://doi.org/10.1016/j.jshs.2017.04.009

NCAA. (2019). NCAA Goals Study.

Nédélec, M., Halson, S., Abaidia, A.-E., Ahmaidi, S., & Dupont, G. (2015). Stress, Sleep and Recovery in Elite Soccer: A Critical Review of the Literature. Sports Medicine, 45(10), 1387–1400. https://doi.org/10.1007/s40279-015-0358-z

Oliver, J., Armstron, N., & Williams, C. (2008). Changes in jump performance and muscle activity following soccer-specific exercise. Journal of Sports Sciences, 26(2), 141–148. https://doi.org/10.1080/02640410701352018

Page, R. M., Field, A., Langley, B., Harper, L. D., & Julian, R. (2023). The Effects of Fixture Congestion on Injury in Professional Male Soccer: A Systematic Review. Sports Medicine, 53(3), 667–685. https://doi.org/10.1007/s40279-022-01799-5

Reilly, T., & Rigby, M. (2007). Effect of an Active Warm-Down Following Competitive Soccer (1st ed.). Routledge.

Rey, E., Lago-Peñas, C., Casais, L., & Lago-Ballesteros, J. (2012). The Effect of Immediate Post-Training Active and Passive Recovery Interventions on Anaerobic Performance and Lower Limb Flexibility in Professional Soccer Players. Journal of Human Kinetics, 31, 121–129. https://doi.org/10.2478/v10078-012-0013-9

Rollo, I., & Williams, C. (2011). Effect of Mouth-Rinsing Carbohydrate Solutions on Endurance Performance. Sports Med.

Ross, E. Z., Middleton, N., Shave, R., George, K., & Nowicky, A. (2007). Corticomotor excitability contributes to neuromuscular fatigue following marathon running in man. Journal of Experimental Physiology, 92(2), 417–426. https://doi.org/10.1113/expphysiol.2006.035972

Sands, W., Stone, M. H., & Stone, M. E. (2007). Principles and Practice of Resistance Training. Human Kinetics.

Sausaman, R. W., Sams, M. L., Mizuguchi, S., DeWeese, B. H., & Stone, M. H. (2019). The Physical Demands of NCAA Division I Women's College Soccer. Journal of Functional Morphology and Kinesiology, 4(4), 73. https://doi.org/10.3390/jfmk4040073

Scott, B. M., Paskus, T. S., Miranda, M., Petr, T. A., & McArdle, J. J. (2008). In-Season vs. Out-of-Season Academic Performance of College Student-Athletes. Journal of Intercollegiate Sport, 1(2), 202–226. https://doi.org/10.1123/jis.1.2.202

Soroka, A., & Lago-Peñas, C. (2016). The effect of a succession of matches on the physical performance of elite football players during the World Cup Brazil 2014. International Journal of Performance Analysis in Sport, 16(2), 434–441. https://doi.org/10.1080/24748668.2016.11868899

Taylor, K.-L., Chapman, D. W., Cronin, J. B., Newton, M. J., & Gill, N. (2012). Fatigue Monitoring in High Performance Sport: A Survey of Current Trends. 20(1).

Walker, O. (2024). Countermovement Jump (CMJ) [2024]. https://www.scienceforsport.com/countermovement-jump-cmj/

Watson, A. M. (2017). Sleep and Athletic Performance. 16(6).

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S.

R., Quan, S., & Tasali, E. (2015). Recommended Amount of Sleep for a Healthy Adult: A Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society. SLEEP. https://doi.org/10.5665/sleep.4716

Yoshida, N., Hornsby, W.G., Sole, C.J., Sato, K. and Stone, M.H., 2022. Effect of Neuromuscular Fatigue on the Countermovement Jump Characteristics: Basketball-Related High-Intensity Exercises. The Journal of Strength & Conditioning Research, 2024 38(1):164-173

Chapter 3. The Effects of a Period of Match Congestion on Countermovement Jump Height and Match Performance Variables in NCAA Division I Female Soccer Players

Fiona Dodge[1], Satoshi Mizuguchi[1], Margaret E. Stone[1], Joanne Spalding[2], Marco Duca[1], Michael H. Stone[1]

[1]School of Human Performance and Spry Science, Center of Excellence for Sport Science and Coach Education East Tennessee State University, Johnson City, USA 37614

[2]School of Health and Human Performance, Georgia College, Milledgeville, GA, USA 31061

dodgef@etsu.edu

The Effects of a Period of Match Congestion on Countermovement Jump Height and Match Performance Variables in NCAA Division I Female Soccer Players

Abstract

Effects of a congested match period on countermovement jump height (CMJH) and match performance variables were examined over the course of a D-I female soccer season. Twenty-one female collegiate soccer players (20.3 ± 1.8 yrs, body mass (kg): 62.3 ± 7.3, height (cm): 168.9 ± 6.1, body fat (%): 23.0 ± 3.7) performed CMJ testing prior to regular season matches. Global Positioning System (GPS) was used to assess physical match performance, while pre- and post-season lab and field-based testing was also performed. Analysis of variance trend analyses (ANOVA) were conducted using a linear mixed-effects model (LMM) to examine trends in mean CMJH and match performance variables over the course of the season. Post hoc comparisons (Cohen's d) were conducted to clarify trend analysis and to compare and quantify the magnitude of change between consecutive matches. LMM were used to examine relationships between two match performance variables and match-to-match changes in CMJH. ANOVA was also performed using LMM to examine changes in lab and field-based fitness measures from pre to post-season. Cohen's d effect sizes focused on pre to post season comparisons. Pre-match CMJH decreased over time and between consecutive matches separated by 42-92 hours season ($p < 0.05$). Distance per minute (DPM) and high-speed running distance per minute (HSR DPM) fluctuated over the season but did not demonstrate a linear trend ($p > 0.5$). Match relative volume and intensity were inversely related to pre-match jump height (JH) changes in the subsequent match ($p < 0.05$). Pre and post season lab and field-based testing showed no signs of detraining, suggesting decreases in JH over the season are unlikely related to loss of fitness components. Decreased JH between consecutive matches, suggests players are unable to fully recover from previous physical match demands.

Keywords: match-congestion, collegiate, soccer, jump height, match performance variables

Introduction

Match congestion has been defined as competing in a minimum of two consecutive matches, with a recovery period of $\leq$ 96 hours / < 3-4 days (Julian et al., 2021). Unacknowledged by many, periods of match congestion take place at the amateur collegiate level, whereby female soccer players compete in two consecutive matches per week over the course of a regular season (five to eight weeks). Before recent changes to the scheduling of matches, matches allowed for approximately 42 to 44 hours between consecutive match-play. Though, recent amendments to scheduling means that most players now compete in two successive bouts of match-play per week with approximately 67-hours between successive matches. Nevertheless, recovery time is limited between match-play.

Soccer matches produce high levels of fatigue and physiological stress in players due to the physical demands of the sport which include high intensity activity (sprinting, high intensity running, changes in direction, jumping and tackling), interspersed with periods of primarily aerobic activity (Alexander, 2014; Bangsbo et al., 2006; Castagna et al., 2006; Gümüşdağ et al., 2013; Krustrup et al., 2010; Markovic et al., 2014; Reilly & Rigby, 2007; Rey et al., 2012). Due to such physical match demands, it has been suggested that up to 72-hours are required for players to return to pre-match levels of performance, since lingering fatigue may result in a decline in performance (Andersson et al., 2008; Cormack et al., 2008; Ekstrand et al., 2004; Hoffman et al., 2003; Manzi et al., 2010; Rollo & Williams, 2011).

Accumulated fatigue as a result of successive matches and reduced recovery time between matches (match congestion) has been shown to affect subsequent physical performance (Andersson et al., 2008; Buchheit et al., 2010; Carling et al., 2015; Dupont et al., 2010). Not only does insufficient recovery lead to a plateau or decline in performance, the chance of injury increases. (Meeusen et al., 2013; Sands et al., 2007; Taylor et al., 2012). Periods of match congestion appear to amplify player injury susceptibility (Bengtsson et al., 2013; Carling et al., 2015; Dellal et al., 2015; Dupont et al., 2010; Howle et al., 2020; Page et al., 2023).

Global Positioning Systems (GPS) and time-motion analysis have been used to assess physical performance variables during match-play and match-play during congested periods (Arruda et al., 2015; Buchheit et al., 2010; Carling et al., 2015; Castagna et al., 2009, 2010; Djaoui et al., 2022; Harley et al., 2010; Jones et al., 2019; Mendez-Villanueva et al., 2012). Previous research suggests that there may be little difference in physical match performance variables between two consecutive matches, separated by 3-4 days / 72-96 hours (Folgado et al., 2015; Rey et al., 2012; Soroka & Lago-Peñas, 2016). Similarly, in periods of prolonged match congestion that better reflect the match congestion experienced by female collegiate soccer players, physical match performance variables appear to be unaffected in male professional soccer players (6 - 8 successive matches in 21 - 26 days) (Carling et al., 2012; Dellal et al., 2015). Additionally, there appears to be little differences in physical match performance variables when comparing congested and non-congested match periods (Djaoui et al., 2013; Dupont et al., 2010).

It is beneficial for practitioners, coaches and players to have a profound awareness of accumulated fatigue associated with a congested match schedule, so that players can appropriately recover from such fatigue and prevent declines in subsequent performance

(Doeven et al., 2017; Maso et al., 2002). The countermovement jump (CMJ) is a well-studied and commonly employed monitoring tool used to assess athletic performance and neuromuscular fatigue (NMF) status (Claudino et al., 2017; Yoshida et al., 2024). It is also used to examine the stretch-shortening cycle, which is cyclic muscle action frequently utilized in soccer (jumping and sprinting) (Hennessy and Kilty, 2001; Oliver et al., 2008). Peripheral fatigue and central fatigue contribute to NMF, impacting contractile function and muscle activation, respectively (Gandevia, 2001). Inadequate force restoration or the accumulation of work, influencing accumulative fatigue, can have immediate and prolonged consequences for neuromuscular performance, subsequently influencing team sport performance during regular matches with a congested fixture calendar (Alba-Jimenez et al., 2022). It has been demonstrated that jump performance, as a result of NMF, is impaired up to 12-72 hours following a soccer match (Andersoon et al., 2008; Goulart et al., 2022; Hoffman et al., 2003; Magalhães et al., 2010).

Despite the increasing popularity of female soccer, research focusing on female soccer players is lacking and limited (Castagna & Castellini, 2013). Currently, most of the literature concerning match congestion focuses on physical match performance at the male professional level, with 3-4 days of recovery between successive matches. This differs from the match congestion experienced by female collegiate soccer players, in which players compete twice a week with 42-44 hours / <2 days between consecutive match play over the course of five-week season. There is also limited research that incorporates the CMJ as an assessment of NMF during long periods of match congestion. To the authors' knowledge, no studies have examined fatigue/recovery associated with match congestion at the female collegiate level. Therefore, the aim of this study was to examine the effects of a period of match congestion on countermovement jump height (CMJH) and match performance variables in NCAA division I female soccer players.

Methods

Experimental Approach to the Problem

This study focused on examining the effects of a congested match schedule on CMJ height and match performance variables in NCAA division I female soccer players. Routine countermovement jumps and match performance variables were assessed over a division I collegiate women's soccer season in accordance with an ongoing athlete monitoring program observing physical performance and neuromuscular fatigue. A Global Positioning System (GPS) (Optimeye S5 devices, Catapult Sports, Melbourne, Australia) sampling at 10 Hz was used to monitor player movements during competition, specifically total distance (meters), high-speed running (15 $km \cdot h^{-1}$ – 18 $km \cdot h^{-1}$) (HSR) and distance per minute (DPM), having previously been recognized as physical variables relating to match performance (Alexander, 2014; Andersson et al., 2010; Krustrup et al., 2005; Sausaman et al., 2019). Portable ForceDecks dual force plate system (FD Lite, VALD Performance, Queensland, Australia), sampling at 1000 Hz was used to assess CMJ height, which has previously been associated with critical underlying physical attributes for soccer performance, including strength, linear speed, and change of direction (Bishop et al., 2023). Furthermore, the CMJ is a commonly used monitoring tool used to assess NMF status (Claudino et al., 2017). Institutional Review Board (IRB) approval was obtained for a retrospective analysis of athlete monitoring data.

Subjects (Athletes)

Twenty-one female outfield players with a mean age (years): 20.3 ± 1.8 (pre-season, n = 20) and 20.7 ± 1.8 (post-season, n = 16), body mass (kg): 62.3 ± 7.3 (pre-season, n = 20) and

63.6 ± 7.0 (post-season, n = 16), height (cm): 168.9 ± 6.1, body fat (%): 23.0 ± 3.7 (pre-season, n = 20) and 23.8 ± 3.4 (post-season, n = 16), and collegiate playing experience (years): one through four, were observed over the course of an NCAA division I collegiate soccer season. One player was absent from pre-season testing due to international call up. Differences in the number of subjects with regards to pre- and post-season subject characteristics and pre- and post-season lab and field-based testing was associated with injury, illness, international call up and that senior players are not required to test post-season at the end of their collegiate soccer career.

Competition Design/Schedule

Athlete monitoring data was obtained over the course of a division I collegiate soccer season (five weeks). The season consisted of nine regular season matches, which primarily took place on Friday (6:00 p.m. ET) and Sundays (2:00 p.m. ET). Due to inclement weather, two matches scheduled for Friday and Sunday were rescheduled for Thursday (7:00 p.m. ET) and Monday (2:00 p.m. ET). This allowed 92-hours between competition. The final game of the regular season allowed for 168 hours (7-days) between competitions. The structure of the conference allowed for 42 to 44 hours between Friday and Sunday competition, and 101 to 126 hours between Sunday and Friday competition. Travel for away fixtures occurred the day before competition, which involved two to six hours of travelling depending on the location of the opposition. The matches took place in the United States, adhering to the standard field dimensions set by the NCAA for soccer matches. The matches consisted of two 45-minute periods, separated by 15-minutes of recovery time. Unlimited substitutions were permitted for all matches, while one re-entry was allowed for players during the second period of matches.

Match Performance Variables

Global Positioning System (GPS) Optimeye S5 devices (Catapult Sports, Melbourne, Australia) sampling at 10 Hz were used to monitor player movements during competition. Having previously been recognized as physical variables relating to match performance, total distance (meters), HSR (15 $km \cdot h^{-1}$ - 18 $km \cdot h^{-1}$) and DPM were selected for analysis (Alexander, 2014; Andersson et al., 2010; Krustrup et al., 2005; Sausaman et al., 2019). HSR distance was converted to HSR distance per minute (HSR DPM) to standardize the measure of activity, allowing comparisons across players and matches regardless of their match-play time. DPM provides an indicator of the intensity of match-play, while again accounting for variation in match-play time.

Countermovement Jump Assessment

Countermovement jump assessment was performed four to six hours prior to each match. Countermovement JH was collected via portable ForceDecks dual force plate system (FD Lite, VALD Performance, Queensland, Australia), sampling at 1000 Hz. The force plates were positioned in a custom frame to prevent disruptive movement upon take-off and landing. JH was collected and analyzed using manufacturers proprietary ForceDecks software (Vald Performance, Queensland, Australia).

The players were in a rested state prior to testing and completed a standardized warm-up protocol preceding jump testing (Table 3.1). To prohibit arm-use during CMJ and to isolate lower-body performance, a polyvinyl chloride (PVC) pipe was placed on the players shoulders, representing the bar placement during a back squat throughout the 50%, 75% and 100% perceived maximum CMJ efforts.

Table 3. 1

Warm-up Protocol

Exercise
Jumping Jacks (x25)
Body Weight Squats (x5)
50% Effort CMJ (x1)
75% Effort CMJ (x1)

Proceeding the standardized warm-up, players completed two 100% perceived maximum effort trials on the ForceDecks with 1.5 minutes of rest between each trial. The players were requested to stand still on the force plates and perform a CMJ upon the command “3, 2, 1 jump”. Players were instructed to perform a fluid CMJ with no pause occurring between eccentric and concentric phases. A trial considered to be poor was repeated (e.g., submaximal effort and flicking legs outward or flexing knee during flight phase). Player jump depth was self-selected. The JH average of the two trials was obtained for statistical analysis.

Pre- and Post-Season Lab and Field-Based Testing

As part of an ongoing athlete monitoring program, a battery of lab and field-based test were conducted 7-weeks prior to the start of the regular season and 19-days after the regular season ended. Prior to the beginning of the regular season, the players participated in exhibition and pre-season competition and training. After the regular season, the players competed in a tournament championship game one week following the last regular season match. Four days separated the last regular season match and the tournament game. The tournament game and pre-season games were not included in the analysis of this study, as they took place outside of the congested regular season period. The players rested for 14-days after the tournament game before completing post-season lab and field-based testing. There were no required or scheduled training sessions during the 14-day rest period.

Due to the physical demands of soccer, players require a complex physical capacity that includes anaerobic, aerobic, strength and power components in order to sprint, repeat high-speed running and jumping during competition (Ishida et al., 2021). Therefore, the following tests were administered pre- and post-season to assess such soccer specific characteristics: linear speed, Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1), unloaded and loaded static and countermovement jumps (SJ & CMJ, respectively), and isometric midthigh pull (IMTP). Lab and field-based testing took place on the same day, with lab-based testing conducted in the A.M. (jumps & IMTP), and field-based testing conducted in the P.M. (linear speed & Yo-Yo IRT1). Field-based testing was conducted on a grass soccer field.

Static and Countermovement Jump

JH was assessed in a lab setting with loaded (11 & 20 kg) and unloaded (0 kg) SJ and CMJ. Prior to jump testing, the players completed a standardized warm-up consisting of 25 jumping jacks, followed by 5 repetitions of the mid-thigh pull (MTP) with 20 kg, before performing 3x5 mid-thigh pulls with 40 kg. Proceeding the warm-up, the players performed two trials at 50% and 75% of their perceived maximum effort for the respected loads for SJ before each perceived maximum effort trial. A polyvinyl chloride (PVC) pipe was placed on the players shoulder during unloaded jumps to eliminate arm-use and emphasize lower body explosiveness, similar to a bar placement used during a back squat. Similarly, an 11 kg and 20 kg barbell were positioned on the players shoulders for the loaded jumps. During the SJ, the players were instructed to stand still on dual force plates (91.0 cm × 91.0 cm; Rice Lake Weighing Systems, Rice Lake, WI, USA) and uphold a squat position with a 90° knee angle which was measured with a goniometer (Ishida et al., 2021). On the command of “3, 2, 1, Jump”, the players vertically jumped from the squat position.

Unloaded and loaded CMJ were performed immediately after SJ. The players completed a warm-up trial at 75% of their perceived maximum effort for each load. Players stood still on the dual force plates and were instructed to vertically jump following the command of “3, 2, 1, Jump” by flexing the hip, knee and ankle joints. SJ trials were discarded and repeated if a countermovement from the force-time curve was observed (>200 N). Furthermore, if two SJ or CMJ trials differed by more than 2.0 cm in JH, additional trials were performed. The mean JH (centimeters), determined via flight time, of the best two trials was used for data analysis for each jump type and load.

Isometric Mid-thigh Pull

The IMTP was performed after CMJ using dual force plates (Rice Lake Systems, Rice Lake, WI, USA; 1000 Hz sampling rate). The players knees were positioned at 125 ± 5° using a goniometer and instructed to retain an upright torso with extended elbows (Ishida et al., 2021). The players performed two trials at 50% and 75% of their perceived maximum effort prior to trials at 100% of perceived maximum effort. On the command of “3, 2, 1, Pull”, the players pulled upwards as fast and hard as possible. If those administering the test observed a countermovement (>200N), the trial was disregarded and repeated. The average of the best two trials (isometric peak force measured in Newtons) was obtained and used for analysis.

Linear Speed

A standardized dynamic warm-up was performed prior to field-based testing. Prior to the Yo-Yo IRT1, the players completed two maximal perceived effort linear sprints over 40-meters with ~2 minutes of rest between each trial. Preceding maximal effort trials, the players completed one 40-meter trial at 75% of perceived maximal effort. Timing gates (Brower; Draper, Utah, USA & Microgate; Mahopac, NY, USA) were placed at 0, 10, 20, 30 and 40-meters. A staggered stance was adopted by the players as they positioned themselves 30-centimeters behind the first timing gate (0-meters) before the start of each trial. The best time of the two trials for each distance (10, 20, 30 & 40-meters) was recorded and used for analysis.

Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IRT1)

The Yo-Yo IRT1 test consists of 2 x 20-meter shuttle runs, with a 10-second period of active recovery between each running bout (Bangsbo et al., 2008). The test was implemented using a compact disk (CD) which produces continuous audio bleeps corresponding to the speed level of the test. The test begins with four running bouts between 10-13 km·h-1 (0–160 m), before seven running bouts between 13.5–14 km·h-1 (160– 440 m). The speed of the test then increases in 0.5 km·h-1 increments after every eight running bouts (Krustrup et al., 2003). The test concluded when players failed twice to complete a shuttle run or abandoned the test due to perceived exhaustion. The speed level and the number of shuttles completed at that given speed level (Yo-Yo IRT1 score) in which the players discontinued the test was recorded and used in analysis.

Statistical Analysis

Training Load

Descriptive statistics of the training load for individual training sessions prior to each match was conducted using Microsoft Excel (Microsoft LTSC Professional Plus 2021, Version 2108). Descriptive statistics including means and standard deviations were calculated from individual global positioning data to represent the mean team training load for a given training session. Training load variables included minutes played, total distance (m), distance per minute (DPM) and high-speed running distance (m).

Countermovement Jump Assessment and Match Performance Variables

The statistical software R (Version 4.3.3) was used to conduct the remaining statistical analyses with a level of significance set at $p \leq 0.05$. One-way repeated measures analysis of variance trend analyses were performed using a linear mixed-effects model to examine trends in mean CMJ height, distance per min (DPM), and high-speed running distance per minute (HSR DPM) over the course of a season. Athlete was used as the random effect variable for the intercept. The use of a linear mixed-effects model was favored over a general linear model to account for injury, illness and/or team selection, which meant certain athletes were absent from some pre-match testing sessions and matches. Post hoc comparisons with Sidak correction were conducted to compare two consecutive match means if a statistically significant trend was found. Cohen's d effect sizes were also calculated to quantify the magnitude of differences between consecutive matches and provide a measure of practical significance.

Furthermore, linear mixed-effects models with fixed effects were used to examine the relationships between two match metrics (dependent variable) and match-to-match changes in CMJ height (independent variable). The two-match metrics were relative match volume (distance in meters) and relative match intensity (distance per minute). Athlete was used as the random effect variable for the intercept. Including athlete as a random effect for the slopes did not improve any of the models and thus only the fixed effect was considered for the slopes.

Pre- and Post-Season Lab and Field-Based Testing

Another round of analyses of variance was also performed using linear mixed-effects models to examine changes in lab and field-based fitness measures from pre to post-season. Athlete was used as the random effect variable for the intercept. For the Yo-Yo IRT1 test and IMTP, two-way mixed ANOVAs were used to examine the main effects of position and season as well as the interaction of such variables. A three-way mixed ANOVA was used to examine the main effects of distance, position, and season as well the interaction effects of such variables for the linear speed test. Lastly, a four-way mixed ANOVA was used to examine the main effects of jump type, loading, season, and position as well as the interaction effects of such variables for JH.

It must be noted that although positional differences were not of our interest, position was included in these analyses as its presence markedly improved the model diagnostic outcomes of these models (i.e. the assumptions appeared satisfactorily met with the inclusion of position). Post hoc analyses were conducted, while Cohen's d effect sizes were also calculated to quantify the degree of differences between pre and post season test results and provide a measure of practical significance.

It should be acknowledged that linear speed times used in post hoc analyses included an average sum of the mean sprint time across each measured distance (10, 20, 30 and 40-meters) in order to provide a simplified measure of sprint performance across multiple distances for pre- and post-season comparison. Furthermore, JH used in post hoc analyses included an average sum of the mean JH which was comprised of both jump types (SJ and CMJ) across each load condition (0 kg, 11 kg and 20 kg) to provide a comprehensive measure of overall jump performance from pre to post-season.

Results

Training Load

The training load outlining the minutes played, total distance, DPM and HSR accumulated in training sessions prior to each game are highlighted in Table 3.2.

Table 3.2

Mean Training Load for Individual Training Sessions Prior to Each Match with Standard Deviations

	Training Day Code	Minutes Played	Total Distance (meters)	Distance Per Minute	High Speed Running (meters)
Pre-M1	MD-5	63.99 ± 8.49	3847.83 ± 697.60	60.16 ± 7.47	184.37 ± 47.72
	MD -4	67.57 ± 7.74	3721.73 ± 470.05	55.39 ± 5.87	275.37 ± 167.77
	MD – 3	Day Off			
	MD -2	62.97 ± 3.43	3357.21 ± 407.74	53.39 ± 6.34	143.47 ± 56.06
	MD -1	37.07 ± 0.93	2179.69 ± 271.65	58.78 ± 7.17	150.75 ± 43.28
M1-M2	MD +1-1	Day Off			
M2-M3	MD +1-3	Day Off			
	MD +2-2	46.25 ± 3.61	2398.19 ± 346.03	52.06 ± 7.76	123.17 ± 40.93
	MD +3-1	49.01 ± 0.13	2793.24 ± 302.49	56.98 ± 6.11	153.56 ± 53.23
M3-M4	MD +1-3	Travel Day			
	MD +2-2	Day Off			
	MD +3-1	28.88 ± 0.01	1393.57 ± 88.19	48.25 ± 3.05	24.25 ± 5.17
M4-M5	MD +1-3	Day Off			
	MD +2-2	46.70 ± 5.91	2834.06 ± 334.43	61.12 ± 6.22	80.59 ± 29.97
	MD +3-1	42.15 ± 0.00	1510.35 ± 106.00	35.84 ± 2.51	79.60 ± 24.28
M5-M6	MD +1-1	Day Off			
M6- M7	MD +1-4	Day Off			
	MD +2-3	52.41 ± 0.41	2162.52 ± 357.20	41.30 ± 7.11	36.95 ± 28.73
	MD +3-2	42.71 ± 3.55	2571.41 ± 369.80	60.09 ± 5.48	134.90 ± 53.35
	MD +4-1	Travel Day			
M7-M8	MD +1-1	Travel Day			
M8-M9	MD +1-6	Day Off			
	MD +2-5	32.24 ± 3.05	1687.19 ± 189.50	52.38 ± 3.45	75.07 ± 24.06
	MD +3-4	65.37 ± 3.06	2770.04 ± 339.47	42.49 ± 5.67	116.90 ± 38.08
	MD +4-3	63.94 ± 6.15	3836.72 ± 368.60	60.30 ± 5.20	367.06 ± 72.93
	MD +5-2	49.04 ± 6.06	2536.69 ± 435.29	51.55 ± 5.33	101.33 ± 41.44
	MD +6-1	40.28 ± 1.45	2079.66 ± 272.52	51.82 ± 7.84	124.71 ± 42.59

Note. MD = Match Day. The first numerical code following MD indicates the number of days since the previous match. The second numerical code indicates the number of days before the next match.

Countermovement Jump Assessment

The ANOVA trend analysis showed a significant negative linear trend in JH over the course of the season (Table 3.3). Comparisons of two neighboring matches showed a statistically lower JH for the latter match in the post hoc comparisons with Sidak correction when two neighboring matches were separated by 42-92 hours (Table 3.4). Specifically, results indicated a significant decrease in JH between matches 1 and 2 (44 h), matches 3 and 4 (92 h), matches 5 and 6 (44 h) and matches 7 to 8 (42 h). Whereas a significant increase in JH was demonstrated between matches 4 and 5 (124 h) (Figure 3.1)

Table 3.3

ANOVA Trend Analysis of Jump Height Over the Course of the Season

contrast	estimate	SE	t-value	df	p-value
linear	-20.9	3.78	-5.540	152	<.0001*
quadratic	-35.3	17.41	-2.029	152	0.2374
cubic	-43.2	8.52	-5.067	152	<.0001*
quartic	37.1	15.30	2.427	152	0.0945
degree 5	10.3	7.12	1.453	152	0.6186
degree 6	10.5	12.02	0.876	152	0.9445

Note. *****$p < 0.05$ indicates statistical significance

Table 3.4

Match to Match Post Hoc Comparisons of Jump Height with Effect Sizes and 95% Confidence Intervals

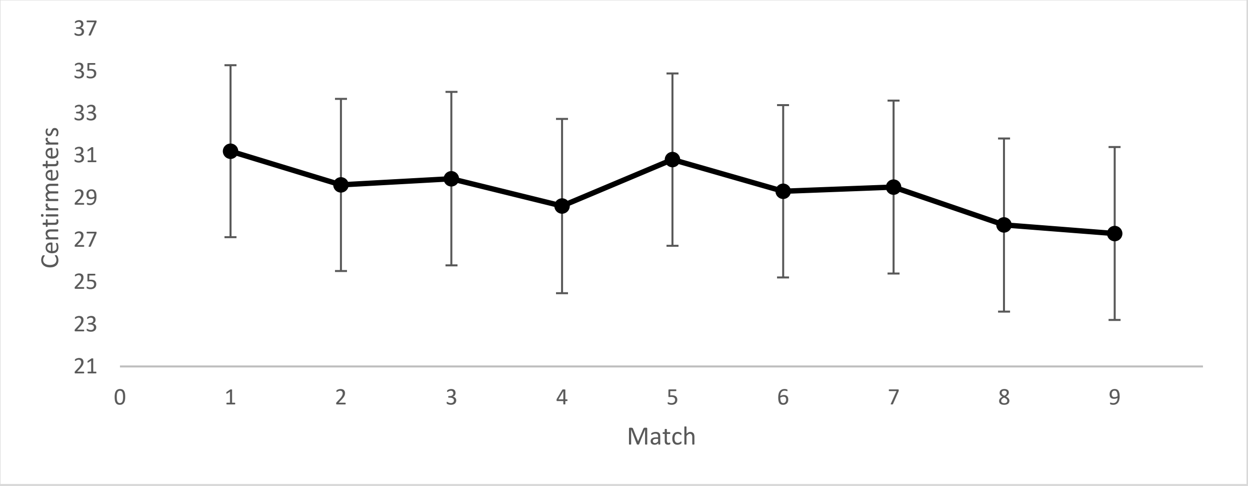
Match Comparisons	Estimate	Std.Error	t-value	df	p-value	d	95% CI
M2 - M1	-1.611	0.388	-4.150	152	0.0004*	-0.337	[-0.500, -0.173]
M3 - M2	0.312	0.405	0.771	152	0.9906	0.063	[-0.097, 0.222]

M4 - M3	-1.310	0.417	-3.138	152	0.0162*	-0.255	[-0.416, -0.093]
M5 - M4	2.191	0.416	5.271	152	< .0001*	0.428	[0.261, 0.593]
M6 - M5	-1.460	0.395	-3.701	152	0.0024*	-0.300	[-0.462, -0.137]
M7 - M6	0.251	0.402	0.626	152	0.9977	0.051	[-0.108, 0.210]
M8 - M7	-1.846	0.401	-4.608	152	0.0001*	-0.374	[-0.583, -0.209]
M9 - M8	-0.378	0.399	-0.946	152	0.9664	-0.077	[-0.236, 0.083]

Note. *****$p < 0.05$ indicates statistical significance

Figure 3.1

Mean Pre-match Jump Heights Across the Season with Standard Deviations



Match Performance Variables

Results concerning match performance variables including DPM and HSR DPM did not exhibit a negative linear trend (Table 3.5). Specifically, post hoc analysis with Sidak corrections and effect sizes showed a significant decrease in distance per minute between game 1 and 2 and game 7 and 8, with a significant increase between game 2 and 3 and game 6 and 7 (Table 3.6). Furthermore, results from post hoc analysis indicated that there was a significant decrease in HSR DPM between game 1 and 2 and game 7 and 8 (Table 3.7). The means for DPM and HSR DPM for each game across the season are displayed in Figure 3.2 and Figure 3.3, respectively.

Table 3.5

ANOVA Trend Analysis of Distance per Minute and High-speed Running Distance per Minute Over the Course of the Season

Match Performance Variable	contrast	Estimate	SE	t-value	df	p-value
DPM	linear	-13.5	6.77	-1.993	111	0.2589
	quadratic	-15.2	57.77	-0.263	111	0.9999
	cubic	-58.4	27.35	-2.136	111	0.1917
	quartic	148.6	43.68	3.401	111	0.0056
	degree 5	-67.2	16.17	-4.156	111	0.0004*
	degree 6	231.9	43.32	5.354	111	<.0001*
HSR DPM	linear	-2.74	1.49	-1.845	111	0.3435
	quadratic	-13.50	11.37	-1.188	111	0.8034
	cubic	-18.51	5.95	-3.108	111	0.0143
	quartic	25.98	8.56	3.036	111	0.0178
	degree 5	3.86	3.60	1.072	111	0.8674
	degree 6	23.98	8.71	2.752	111	0.0408

Note. *****$p < 0.05$ indicates statistical significance
DPM = Distance Per Minute. HSR = High Speed Running

Table 3.6

Match to Match Post Hoc Comparisons of Distance per Minute with Effect Sizes and 95% Confidence Intervals

Match Comparisons	Estimate	Std. Error	t-value	df	p-value	d	95% CI
M2 – M1	-8.112	0.92	-8.819	111	<.0001*	-0.837	[-1.052, -0.620]
M3 – M2	5.843	1.16	5.03	111	<.0001*	0.477	[0.280, 0.673]
M4 – M3	0.879	1.36	0.648	111	0.9971	0.0615	[-0.125, 0.248]
M5 – M4	-2.057	1.34	-1.533	111	0.6657	-0.146	[-0.332, 0.042]
M6 – M5	-2.235	1.29	-1.738	111	0.5086	-0.165	[-0.352, 0.023]
M7 – M6	5.22	1.19	4.382	111	0.0002*	0.416	[0.221, 0.609]
M8 – M7	-6.009	1.05	-5.709	111	<.0001*	-0.542	[-0.740, -0.342]
M9 – M8	2.038	1.3	1.569	111	0.6387	0.149	[-0.038, 0.336]

Note. *****p < 0.05 indicates statistical significance

Figure 3.2

Mean Distance per Minute with Standard Deviations

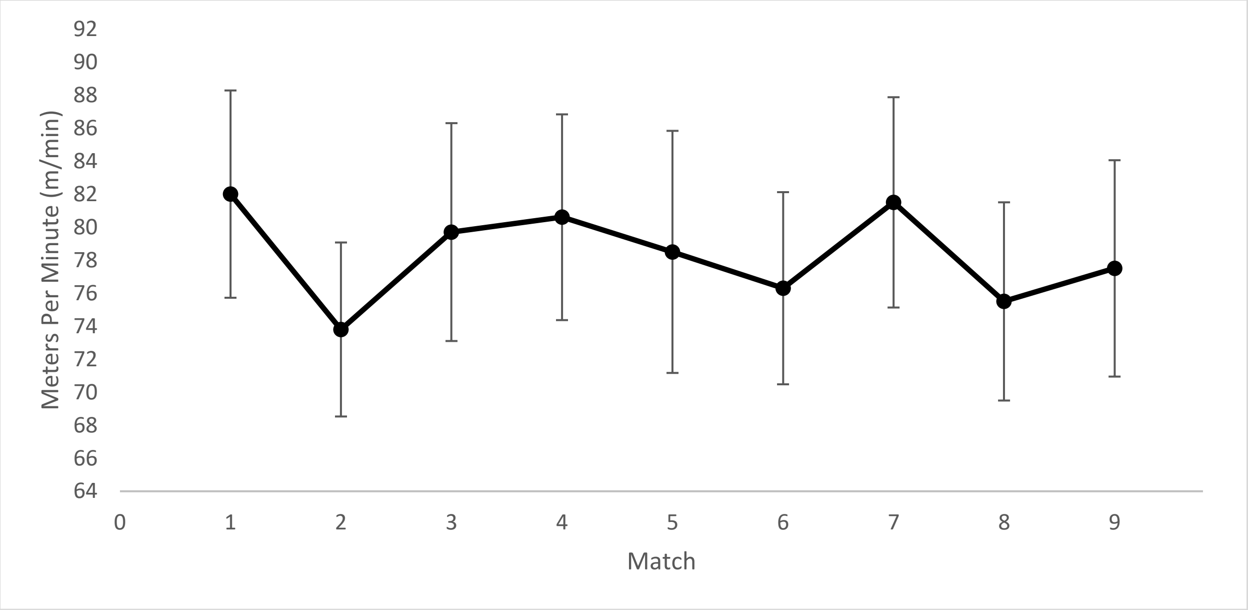


Table 3.7

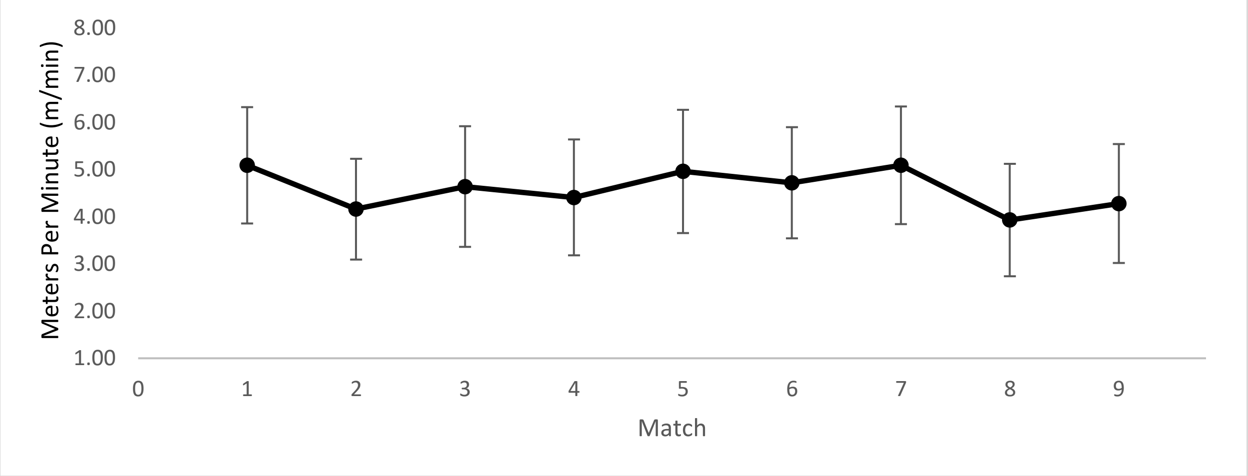
Match to Match Post Hoc Comparisons of High-speed Running Distance per Minute with Effect Sizes and 95% Confidence Intervals

Match Comparisons	Estimate	Std. Error	t-value	df	p-value	d	95% CI
M2 – M1	-0.937	0.196	-4.774	111	<.0001*	-0.453	[-0.648, -0.257]
M3 – M2	0.483	0.25	1.936	111	0.3665	0.184	[-0.004, 0.371]
M4 – M3	-0.226	0.28	-0.808	111	0.9874	-0.077	[-0.263, 0.110]
M5 – M4	0.551	0.243	2.262	111	0.1878	0.215	[0.0260, 0.402]
M6 – M5	-0.24	0.234	-1.023	111	0.9478	-0.097	[-0.283, 0.090]
M7 – M6	0.366	0.262	1.401	111	0.7617	0.133	[-0.054, 0.319]
M8 – M7	-1.163	0.219	-5.308	111	<.0001*	-0.504	[-0.700, -0.305]
M9 – M8	0.349	0.269	1.296	111	0.8283	0.123	[-0.064, 0.309]

Note. *****p < 0.05 indicates statistical significance

Figure 3.3

Mean High-speed Running Distance per Minute with Standard Deviations



Relative total distance and relative match intensity from the former match showed significant inverse relationships with subsequent pre-match JH (Table 3.8 and Figures 3.4 – 3.5).

Table 3.8

Linear Mixed-effect Model Analyses of the Former Relative Match Volume and Intensity on Subsequent Pre-match Jump Height

	Value	Std.Error	DF	t-value	p-value
(Intercept)	-0.08762	0.13192	159	-0.6642	0.508
RMV (Distance)	-0.0001	3.82E-05	159	-2.74327	0.007*
(Intercept)	0.189739	0.116518	159	1.628413	0.105
RMI (DPM)	-0.01657	0.003041	159	-5.44949	0.000*

Note. *****$p < 0.05$ indicates statistical significance
RMV = Relative Match Volume (Distance in meters)
RMI (DPM) = Relative Match Intensity (Distance Per Minute)

Figure 3.4

Former Relative Match Volume on Subsequent Pre-match Jump Height

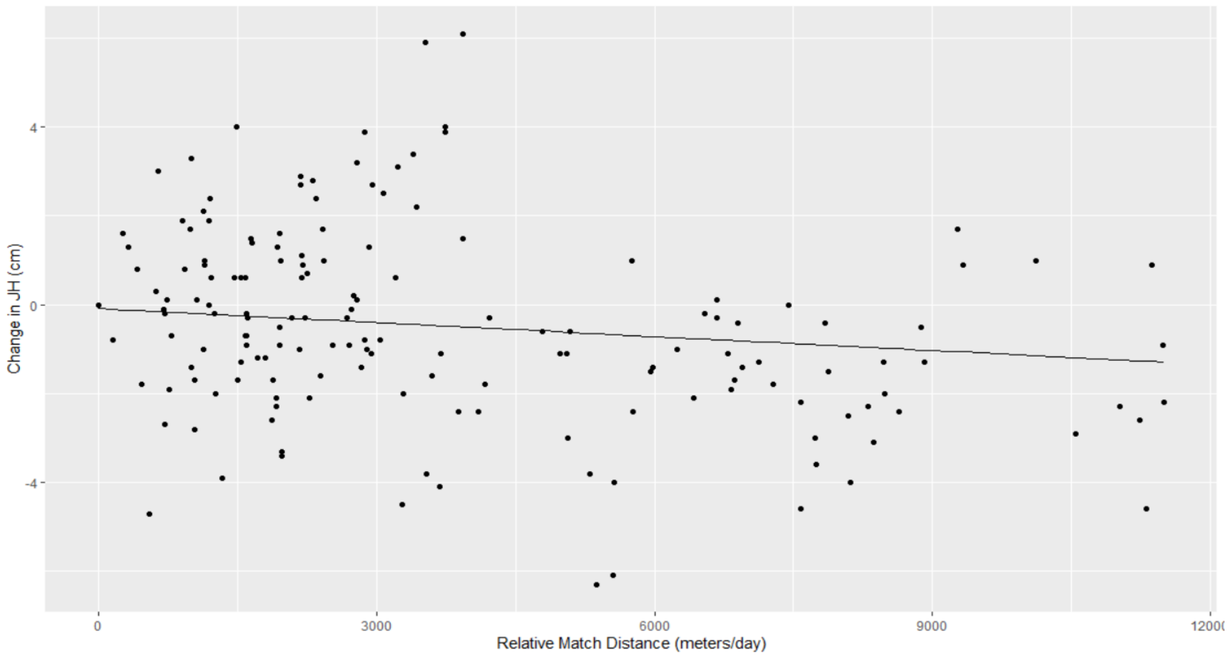
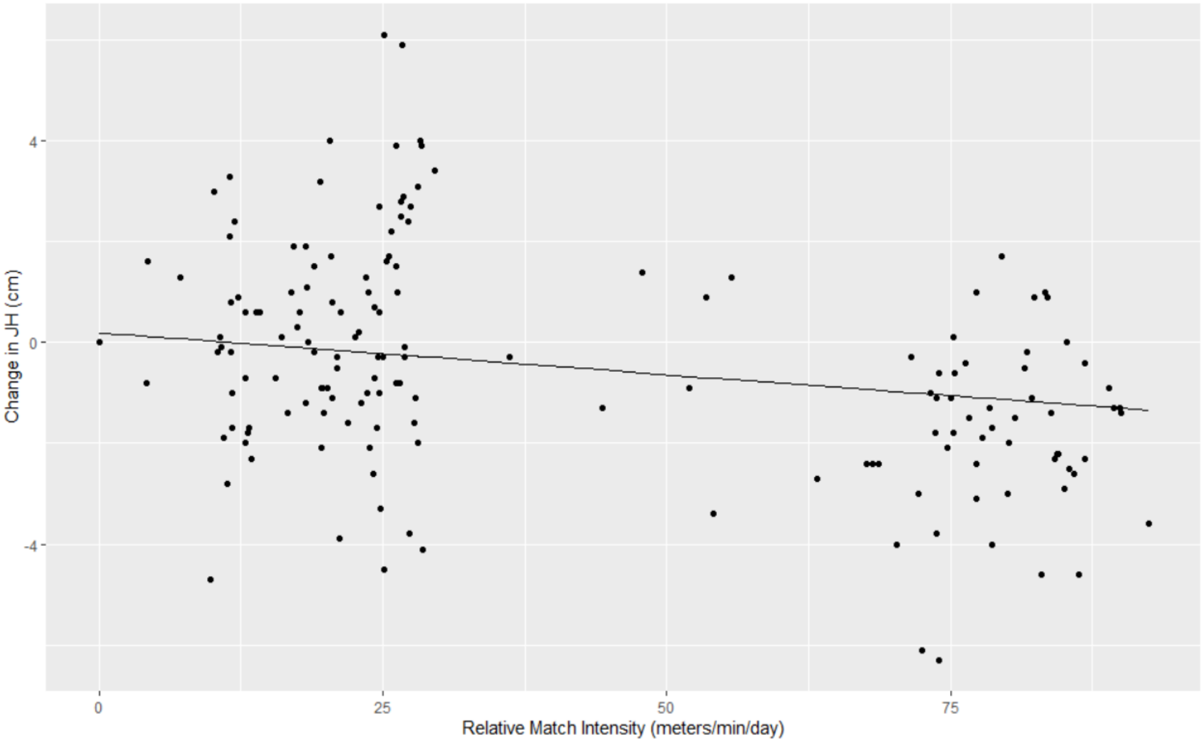


Figure 3.5

Former Relative Match Intensity on Subsequent Pre-match Jump Height



Pre- and Post-Season Lab and Field-Based Testing

Comparisons of the Yo-Yo IRT1 and linear speed demonstrated statistically significant difference from pre to post-season (Table 3.9) with large positive and small negative effect sizes, respectively (Table 3.11). There were insignificant statistical differences between pre and post season for jumps and isometric mid-thigh pull (Table 3.9). However, the effect size for jump performance showed a small difference between pre- and post-season (Table 3.11). Similarly, the effect size for IMTP demonstrated a medium to large difference for season comparisons (Table 3.11). Pre- and post-season means, with standard deviations and 95% confidence intervals (CI) for field and lab-based testing are illustrated in Table 3.10.

Table 3.9

ANOVA Analyses of the Effect of Season on Yo-Yo IRT, Linear Speed, Jumps and IMTP

Testing Variable		numDF	denDF	F-value	p-value
Yo-Yo IRT1	(Intercept)	1	12	55112	<.0001
	season	1	9	9	0.015*
	position	3	12	6.88	0.006*
	season:position	3	9	3.30	0.071
Linear Speed	(Intercept)	1	72	1139.87	<.0001
	season	1	72	6.44	0.0134*
	distance	3	72	481.34	<.0001*
	position	3	12	0.77	0.5328
	distance:season	3	72	0.07	0.9751
	distance:position	9	72	1.28	0.2654
	season:position	3	72	2.04	0.1159
	distance:season:position	9	72	0.27	0.98
Jumps	(Intercept)	1	516	72.10	<.0001
	season	1	516	0.77	0.3819
	position	3	17	0.08	0.9714
	bar	2	516	12.58	<.0001*
	jump type	1	516	0.51	0.4757
	season:position	3	516	0.04	0.9907
	season:bar	2	516	1.50	0.2243
	position:bar	6	516	1.40	0.2121
	season:jumptype	1	516	0.11	0.7444

	position:jumptype	3	516	0.47	0.7034
	bar:jumptype	2	516	0.12	0.8856
	season:position:bar	6	516	0.67	0.6761
	season:position:jumptype	3	516	0.32	0.8127
	season:bar:jumptype	2	516	0.84	0.4323
	position:bar:jumptype	6	516	0.46	0.8385
	season:position:bar:jumptype	6	516	0.39	0.8853
IMTP	(Intercept)	1	18	86.65	<.0001
	season	1	8	4.85	0.0588
	position	3	18	2.37	0.1041
	position:season	3	8	1.45	0.3001

Note. *$p < 0.05$ indicates statistical significance
IMTP = Isometric Mid-Thigh Pull

Table 3.10

Means and Standard Deviations with 95% CI for Pre- and Post-season Field and Lab-based Tests

				95% CI	
Testing Variable	Season	Mean ± SD	df	lower CI	upper CI
Yo-Yo IRT1 (level)	Pre-season	16.3 ± 0.319	9	16.1	16.6
	Post-season	16.5 ± 0.368	12	16.3	16.7
Linear Speed	Pre-season	3.96 ± 0.145	12	3.87	4.05
	Post-season	3.90 ± 0.145	12	3.81	3.99
Jumps (cm)	Pre-season	20.9 ± 0.95	17	18.9	22.9
	Post-season	22.2 ± 0.96	17	20.2	24.2
IMTP (N)	Pre-season	2475 ± 116	8	2207	2742
	Post-season	2616 ± 118	18	2368	2864

Note. CI = Confidence Interval

Table 3.11

Post Hoc Comparisons with Effects Sizes for Pre- and Post-season Lab and Field-based Tests

Test	contrast	estimate	SE	df	t-value	d	95% CI
Yo-Yo IRT1	Post -pre-season	0.152	0.135	9	1.125	0.375	[-0.310, 1.041]
Linear Speed	Post -pre-season	-0.058	0.032	72	-1.710	-0.212	[-0.445, 0.022]
Jumps	Post -pre-season	1.340	0.379	516	3.537	0.156	[0.069, 0.242]
IMTP	Post -pre-season	140.938	72.842	8	1.935	0.684	[-0.100, 1.434]

Discussion

The purpose of this study was to determine the effects of match congestion on countermovement jump performance and physical match performance variables in division I female soccer players. The main findings from the study are as followed (a) Pre-match countermovement JH can decrease over the course season and between consecutive matches separated by 42-92 hours without a similar downward trend in DPM and HSR DPM (b) The downward trend in CMJH (and the fluctuations in the match metrics) can occur without observable decreases in soccer-related fitness qualities, implying the negative impact of accumulated fatigue during a season (c) Match relative volume and intensity appear to be inversely related to pre-match jump height changes in the subsequent match.

The statistically significant linear trend concerning pre-match CMJH over the course of the season may indicate accumulated neuromuscular fatigue. To the authors' knowledge, there is no other related research that incorporates the CMJ to longitudinally assess neuromuscular fatigue during prolonged periods of match congestion. Match to match comparisons of JH demonstrated statistically significant decreases in JH between consecutive matches separated by

42 to 92 hours. In this study specifically, there were significant decreases in JH between matches 1 and 2 (44 h), matches 3 and 4 (92 h), matches 5 and 6 (44 h) and matches 7 to 8 (42 h). However, there were statistically significant increases in pre-match JH between consecutive matches separated by 124 hours (match 4 and 5). This explains the fluctuation in JH over the course of the season. These results are similar to findings reported by Andersson et al. (2008), who reported reductions in JH up to 69-hours post-match 1/pre-match 2 in elite female soccer players who competed in two consecutive matches separated by 69 hours. In the same study, JH following the second match did not return to baseline measures (JH prior to match 1). Furthermore, results from other studies have shown reductions in JH 12-72 hours post-match in female soccer players of varying playing ability, division III female collegiate soccer players and male soccer players (Goulart et al., 2022; Hoffman et al., 2003; Magalhães et al., 2010). Such findings differ from those reported by Lundberg and Weckstrom, (2017), who found no change in jump performance 72-hours post-match during a one-match week and a congested 3-match week.

Previous studies have suggested that up to 72-hours can be required for players to return to pre-competition levels of performance, as match demands can lead to lingering fatigue which may result in a decline in performance (Andersson et al., 2008; Cormack et al., 2008; Ekstrand et al., 2004; Hoffman et al., 2003; Manzi et al., 2010; Rollo & Williams, 2011). Considering findings from the current study and previous studies, the recovery time course following a soccer match support the suggestion that 72-hours is necessary to diminish lingering fatigue and maintain or improve subsequent match performance. Furthermore, reduced recovery time between fixtures and accumulated fatigue as a result of successive matches, has been shown to affect subsequent physical performance (Andersson et al., 2008; Buchheit et al., 2010; Dupont et al., 2010). This may explain the overall linear trend in JH over the course of the congested match period.

There were no statistically significant linear trends for DPM and HSR DPM over the course of the season, however, physical match performance variables fluctuated across the season. These results differ with the findings reported by Dupont et al. (2010), who reported no statistically significant differences in physical match performance variables (total distance, high-intensity distance, sprint distance, number of sprints) of male professional players who competed in congested and non-congested match periods (two vs. one match per week, respectively). Although, it must be noted that the reported congested match periods did not take place over a prolonged period, which differs in comparison with a division I female collegiate soccer season (five weeks). Numerous authors have also reported that two consecutive matches, separated by 3-4 days / 72-96 hours, have failed to demonstrate statistical significant differences in physical match performance variables (Folgado et al., 2015; Rey et al., 2012; Soroka & Lago-Peñas, 2016).

In previous studies that better reflect periods of match congestion experienced by female collegiate soccer players, Carling et al. (2012) reported fluctuations in total distance and lower running intensities, while high-intensity running was generally unaffected during intense periods of match congestion (8 successive matches in 26 days) in male professional soccer players. These findings partially agree with the findings of the current study. Whereas, Djaoui et al. (2013) reported no significant differences between congested and non-congested periods in distances covered at running intensities over 18 $\mathrm{km \cdot h^{-1}}$ in male professional soccer players. Additionally, total distance covered and high intensity running distances did not reportedly vary during a prolonged period of match congestion. Periods of match congestion consisted of six matches in 21 days, seven matches in 21 days, seven matches in 22 days, 6 matches in 24 days (2 matches per week). Similarly, Dellal et al (2015) reported no statistically significant differences in match physical performance (overall distance, light-intensity, low-intensity, moderate-intensity and high-intensity running) of 16 international players competing in six matches in 18 days, along with no differences in physical match performance during periods of match congestion (six matches in 18 days) compared to matches outside of congested periods.

Although the previously mentioned authors investigated different physical match performance variables in their respective studies, the consensus suggests that physical match performance variables are unaffected during short and prolonged periods of match congestion. Essentially, it appears that players can maintain their level of physical performance despite limited recovery time between consecutive matches and during a period of prolonged match congestion. Such findings may be due to, but not limited to; the implementation of light training loads and supplemental fitness sessions between games, recovery strategies, tactical and/or injury/suspension player rotation, or that physical match performance variables are not sensitive enough to identify accumulated fatigue. Playing formation, match situations, the tactical and technical level of the players and quality of opponent may be reasonable explanations for the fluctuation in physical match performance variables demonstrated in this study and in the study conducted by Carling et al. 2012 (Carling et al., 2012; Dellal et al., 2015; Dupont et al., 2010); Djaoui et al., 2013).

Match relative volume and intensity were inversely related to changes in pre-match JH in the subsequent match, while considering the numbers of days elapsed between matches. Such results suggest that the greater the relative match volume and intensity of the former match, the greater the decrease in pre-match JH of the subsequent match. This at least partially explains why JH fluctuated over the course of the season and that such fluctuations are likely due to fatigue originating from physical match demands. To the authors knowledge, there is no supporting literature that examines the effects of physical match performance on subsequent changes in pre-match JH in consecutive match play or during periods of match congestion.

Comparisons of pre- and post-season lab and field-based testing showed no decrements in fitness performance. These results combined with earlier findings in this study suggest that an overall decrease in JH and fluctuations in JH over the course of the season may be related to accumulated neuromuscular fatigue as a consequence of physical match demands and limited recovery time as opposed to detraining.

Although not a focus of this study, academic and travel related stress may also impact physical match performance and have implications for recovery at the female collegiate soccer level. Unlike professional soccer players, collegiate soccer players, who are considered student-athletes are required to balance their academic and athletic commitments (Lopes Dos Santos et al., 2020). Performing academically is a major source of stress among most regular college students (Aquilina, 2013; Davis et al., 2019; De Beandt et al., 2018; Lopes Dos Santos et al., 2020; Lopez de Subijana et al., 2015). Academic mid-term exams and regular assignments and course work coincide with the competitive season at the collegiate soccer level. In a study investigating levels of perceived stress in 182 collegiate athletes, Hamlin et al (2019) reported that perceived academic stress was heightened during periods of the academic year which coincided with examination weeks within competitive seasons. Student athletes reported difficulties managing athletic and academic responsibilities associated with decreased energy levels and overall sleep quality. Such stress may increase the chance of mental health issues, particularly anxiety and depression (Li et al., 2017; Lopes Dos Santos et al., 2020; Moreland et al., 2018). Incidences of stress and anxiety may lead to physiological responses, including increased muscle tension, physical fatigue, reductions in neurocognitive and perception process that may lead to physical injuries (Ivarsson et al., 2017). Therefore, it may be appropriate to suggest that such physiological responses relating to stress not only implicates psychological well-being, but may subsequently impact negatively upon athletic performance (Hamlin et al., 2019; Lopes Dos Santos et al., 2020).

The physical and psychological demands of successive matches can be further compounded by travelling to and from away competition (Abbott et al., 2018; Fowler et al., 2015; Gouttebarge et al., 2019). Away fixtures may mean that players cross different time zones and are often required to stay in hotels before and after away matches or travel home from away matches immediately after competition. Such travel complications were observed and noted during this study, whereby players returned home in the early hours of the morning following an away match, while having to attend early morning classes at 8:00 A.M. (< 7 hours of sleep). It is recommended that college students achieve between seven to nine hours of sleep per night to function physically, emotionally and cognitively (Hirshkowitz et al., 2015). However, student athletes may require extended sleep duration depending on prior sleep deprivation, physical activity, environment and illness for optimal performance (Heller et al., 2024; Hirshkowitz et al., 2015; Watson et al., 2015). Reportedly, 39.1% of collegiate student athletes regularly achieve less than seven hours of sleep on weekdays, while new and noisy environments influence undisturbed sleep, without further implication of different time zones (Heller et al., 2024; Mah et al., 2018). Achieving less than seven hours of sleep per night elicits endocrine and other physiological responses including; increased circulating stress hormones (e.g., cortisol); reduction in the regeneration of carbohydrate stores (i.e., glycogen); deregulation of appetite, impacting energy expenditure; increased catabolism and the reduction of anabolism, impacting the rate of muscle repair/muscle protein synthesis (Atrooz & Salim, 2020; Doherty et al., 2021; Fullager et al., 2015; Knutson et al., 2007; Meerlo et al., 2008). Such responses may impact post-exercise recovery or the reduction and reversal process of fatigue (De Pauw et al., 2013; Doherty et al., 2021).

In summary, pre- and post-season lab and field-based testing showed no statistically significant signs of detraining, suggesting that decreases in JH over the course of the season are unlikely related to loss of fitness components. As performance decrements are only likely due to detraining, lack of effort or fatigue, and lack of effort, the process of elimination supports fatigue and/or lack of effort as the likely reason for the decreasing trend in JH over the course of the season. Careful observation and questioning suggested that lack of effort may not be the cause. Statistically significant decreases in JH between consecutive matches separated by 42-92 hours, suggests that players are unable to physically recover from previous match demands within such a short time frame. This supports the suggestion of at least 72- hours of recovery between successive match play to is necessary to diminish lingering fatigue and maintain or improve subsequent match performance (Andersson et al., 2008; Cormack et al., 2008; Ekstrand et al., 2004; Hoffman et al., 2003; Manzi et al., 2010; Rollo & Williams, 2011). Based on the findings from the current study concerning decrements in JH over the course of the season and between consecutive matches, the countermovement jump appears to be a practical and sensitive tool to measure neuromuscular fatigue.

Physical match performance variables fluctuated over the course of the season and did not exhibit a statistically significant linear trend. Fluctuation may be related to playing formation, match situations, the tactical and technical level of the players and quality of opponent (Carling et al., 2015; Dellal et al., 2015; Djaoui et al., 2013; Dupont et al., 2010). Therefore, it may be reasonable to suggest that exclusively monitoring physical match performance variables in an attempt to identify neuromuscular fatigue may be impractical due to the tactical components of the game. Furthermore, there were greater changes in subsequent match JH when the former match exhibited greater relative volume and intensity. This partially explains the fluctuation in JH over the course of the season, while emphasizing the importance of squad rotation and recovery strategies between consecutive matches that pose limited recovery time.

Insufficient recovery over extended periods may not only have consequences for performance, but the risk of injury also rises (Carling et al., 2015; Dupont et al., 2010; Meeusen et al., 2013; Sands et al., 2007; Taylor et al., 2012). Periods of match congestion appear to amplify player injury susceptibility in soccer players (Bengtsson et al., 2013; Carling et al., 2015; Dellal et al., 2015; Dupont et al., 2010; Howle et al., 2020; Page et al., 2023).

Future research should focus on assessing the effects on match congestion on position, technical match performance, match outcome, injury rates and the subjective wellness of collegiate soccer players. It may also be beneficial for future researchers to compare congested and non-congested match periods, study multiple teams at various playing levels and investigate the effects of travel and academics on match performance and neuromuscular fatigue.

Practical Applications

CMJ JH may be an appropriate and sensitive monitoring tool for sports practitioners to identify neuromuscular fatigue between two consecutive matches separated by limited recovery time and across a congested match season. For fatigue and injury management during periods of match congestion, coaches and players should consider player rotation and recovery strategies.

Whereas governing bodies such as the National Collegiate Athletic Association (NCAA) should consider the implications of match congestion on physical performance, injury risk, recovery and the wellbeing of student athletes when scheduling competitive seasons. The findings from this study may also help practitioners prescribe appropriate training loads between consecutive matches and during periods of match congestion. Such training loads should promote optimal performance during competition, and prevent the accumulation of fatigue, injury and overtraining. Although, it must be noted that fatigue monitoring capabilities, and evidence-based recovery and training strategies are not universally accessible at the collegiate level.

References

Abbott, W., Brownlee, T. E., Harper, L. D., Naughton, R. J., & Clifford, T. (2018). The independent effects of match location, match result and the quality of opposition on subjective wellbeing in under 23 soccer players: A case study. Research in Sports Medicine, 26(3), 262–275. https://doi.org/10.1080/15438627.2018.1447476

Alba-Jimenez, C., Moreno-Doutres, D., & Pena, J. (2022). Trends Assessing Neuromuscular Fatigue in Team Sports: A Narrative Review. Journal of Sports, 10(3). https://doi.org/10.3390/sports10030033.

Alexander, R. (2014). Physical and Technical Demands of Women's Collegiate Soccer. East Tennessee State University.

Andersson, H. Å., Randers, M. B., Heiner-Møller, A., Krustrup, P., & Mohr, M. (2010). Elite Female Soccer Players Perform More High-Intensity Running When Playing in International Games Compared with Domestic League Games. Journal of Strength and Conditioning Research, 24(4), 912–919. https://doi.org/10.1519/JSC.0b013e3181d09f21

Andersson, H., Raastad, T., Nilsson, J., Paulsen, G., Garthe, I., & Kadi, F. (2008). Neuromuscular Fatigue and Recovery in Elite Female Soccer: Effects of Active Recovery. Medicine & Science in Sports & Exercise, 40(2), 372–380. https://doi.org/10.1249/mss.0b013e31815b8497

Aquilina, D. (2013). A Study of the Relationship Between Elite Athletes' Educational Development and Sporting Performance. The International Journal of the History of Sport, 30(4), 374–392. https://doi.org/10.1080/09523367.2013.765723

Arruda, A. F. S., Carling, C., Zanetti, V., Aoki, M. S., Coutts, A. J., & Moreira, A. (2015). Effects of a Very Congested Match Schedule on Body-Load Impacts, Accelerations, and

Running Measures in Youth Soccer Players. International Journal of Sports Physiology and Performance, 10(2), 248–252. https://doi.org/10.1123/ijspp.2014-0148

Atrooz, F., & Salim, S. (2020). Sleep deprivation, oxidative stress and inflammation. Advances in Protein Chemistry and Structural Biology, 119, 309–336. https://doi.org/10.1016/bs.apcsb.2019.03.001

Bangsbo, J., Iaia, F. M., & Krustrup, P. (2008). The Yo-Yo Intermittent Recovery Test: A Useful Tool for Evaluation of Physical Performance in Intermittent Sports. Sports Medicine, 38(1), 37–51. https://doi.org/10.2165/00007256-200838010-00004

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. Journal of Sports Sciences, 24(7), 665–674. https://doi.org/10.1080/02640410500482529

Bengtsson, H., Ekstrand, J., & Hägglund, M. (2013). Muscle injury rates in professional football increase with fixture congestion: An 11-year follow-up of the UEFA Champions League injury study. British Journal of Sports Medicine, 47(12), 743–747. https://doi.org/10.1136/bjsports-2013-092383

Bishop, C., Jordan, M., Torres-Ronda, L., Loturco, I., Harry, J., Virgile, A., Mundy, P., Turner, A., & Comfort, P. (2023). Selecting Metrics That Matter: Comparing the Use of the Countermovement Jump for Performance Profiling, Neuromuscular Fatigue Monitoring, and Injury Rehabilitation Testing.

Buchheit, M., Mendez-Villanueva, A., Simpson, B. M., & Bourdon, P. C. (2010). Match Running Performance and Fitness in Youth Soccer. International Journal of Sports Medicine, 31(11), 818–825. https://doi.org/10.1055/s-0030-1262838

Carling, C., Le Gall, F., & Dupont, G. (2012). Are Physical Performance and Injury Risk in a Professional Soccer Team in Match-Play Affected Over a Prolonged Period of Fixture Congestion? International Journal of Sports Medicine, 33(1), 36–42. https://doi.org/10.1055/s-0031-1283190

Carling, C., Mccall, A., Le Gall, F., & Dupont, G. (2015). The impact of short periods of match congestion on injury risk and patterns in an elite football club. British Journal of Sports Medicine, 50(12). https://doi.org/10.1136/bjsports-2015-095501

Castagna, C., & Castellini, E. (2013). Vertical jump performance in Italian male and female national team soccer players. Journal of Strength & Conditioning Research, 27(4), 1156-1161.

Castagna, C., Impellizzeri, F. M., Chamari, K., carlomagno, D., & Rampinini, E. (2006). Aerobic fitness and yo-yo continuous and intermittent tests performances in soccer players: A correlation study. Journal of Strength and Conditioning Research, 20(2), 320–325.

Castagna, C., Impellizzeri, F., Cecchini, E., Rampinini, E., & Alvarez, J. C. B. (2009). Effects of Intermittent-Endurance Fitness on Match Performance in Young Male Soccer Players. Journal of Strength and Conditioning Research, 23(7), 1954–1959. https://doi.org/10.1519/JSC.0b013e3181b7f743

Castagna, C., Manzi, V., Impellizzeri, F., Weston, M., & Barbero Alvarez, J. C. (2010). Relationship Between Endurance Field Tests and Match Performance in Young Soccer Players. Journal of Strength and Conditioning Research, 24(12), 3227–3233. https://doi.org/10.1519/JSC.0b013e3181e72709

Claudino, J. G., Cronin, J., Mezêncio, B., McMaster, D. T., McGuigan, M., Tricoli, V., Amadio, A. C., & Serrão, J. C. (2017). The countermovement jump to monitor neuromuscular status: A meta-analysis. Journal of Science and Medicine in Sport, 20(4), 397–402. https://doi.org/10.1016/j.jsams.2016.08.011

Cohen J. (1988). Statistical Power Analysis for the Behavioral Sciences. New York, NY: Routledge Academic

Cormack, S. J., Newton, R. U., McGuigan, M. R., & Cormie, P. (2008). Neuromuscular and Endocrine Responses of Elite Players During an Australian Rules Football Season. International Journal of Sports Physiology and Performance, 3(4), 439–453. https://doi.org/10.1123/ijspp.3.4.439

Craven, J., McCartney, D., Desbrow, B., Sabapathy, S., Bellinger, P., Roberts, L., & Irwin, C. (2022). Effects of Acute Sleep Loss on Physical Performance: A Systematic and Meta-Analytical Review. Sports Medicine, 52(11), 2669–2690. https://doi.org/10.1007/s40279-022-01706-y

Davis, P., Halvarsson, A., Lundström, W., & Lundqvist, C. (2019). Alpine Ski Coaches' and Athletes' Perceptions of Factors Influencing Adaptation to Stress in the Classroom and on the Slopes. Frontiers in Psychology, 10, 1641. https://doi.org/10.3389/fpsyg.2019.01641

De Beandt, K., Wylleman, P., Torregrossa, M., & Schipper van Veldhoven, N. (2018). Exploring the factor structure of the Dual Career Competency Questionnaire for Athletes in European pupil-and student-athletes. International Journal of Sport and Exercise Physiology.

De Pauw, K., Roelands, B., Marusic, U., Fernandez Tellez, H., Knaepen, K., & Meeusen, R. (2013). Brain mapping after prolonged cycling and during recovery in the heat. Journal of

Applied Physiology, 115(9), 1324–1331. https://doi.org/10.1152/japplphysiol.00633.2013

Dellal, A., Lago-Peñas, C., Rey, E., Chamari, K., & Orhant, E. (2015). The effects of a congested fixture period on physical performance, technical activity and injury rate during matches in a professional soccer team. British Journal of Sports Medicine, 49(6), 390–394. https://doi.org/10.1136/bjsports-2012-091290

Djaoui, L., Owen, A., Newton, M., Theodoros Nikolaidis, P., Dellal, A., & Chamari, K. (2022). Effects of congested match periods on acceleration and deceleration profiles in professional soccer. Biology of Sport, 39(2), 307–317. https://doi.org/10.5114/biolsport.2022.103725

Djaoui, L., Wong, D. P., Pialoux, V., Hautier, C., Da Silva, C. D., Chamari, K., & Dellal, A. (2013). Physical Activity during a Prolonged Congested Period in a Top-Class European Football Team. Asian Journal of Sports Medicine, 5(1). https://doi.org/10.5812/asjsm.34233

Doeven, S., Brink, M. S., Kosse, S. J., & Lemmink, K. A. P. M. (2017). Post match recovery of physical performance and biochemical markers in team ball sports: A systematic review. BMJ Sport & Exercise Medicine, 14(1).

Doherty, R., Madigan, S. M., Nevill, A., Warrington, G., & Ellis, J. G. (2021). The Sleep and Recovery Practices of Athletes. Nutrients, 13(4), 1330. https://doi.org/10.3390/nu13041330

Dupont, G., Nedelec, M., McCall, A., McCormack, D., Berthoin, S., & Wisløff, U. (2010). Effect of 2 Soccer Matches in a Week on Physical Performance and Injury Rate. The

American Journal of Sports Medicine, 38(9), 1752–1758. https://doi.org/10.1177/0363546510361236

Ekstrand, J., Walden, M., & Hagglund, M. (2004). Risk for injury when playing in a national football team. Scandinavian Journal of Medicine and Science in Sports, 14(1), 34–38. https://doi.org/10.1111/j.1600-0838.2003.00330.x

Folgado, H., Duarte, R., Marques, P., & Sampaio, J. (2015). The effects of congested fixtures period on tactical and physical performance in elite football. Journal of Sports Sciences, 33(12), 1238–1247. https://doi.org/10.1080/02640414.2015.1022576

Fowler, P., Duffield, R., Howle, K., Waterson, A., & Vaile, J. (2015). Effects of Northbound Long-Haul International Air Travel on Sleep Quantity and Subjective Jet Lag and Wellness in Professional Australian Soccer Players. International Journal of Sports Physiology and Performance, 10(5), 648–654. https://doi.org/10.1123/ijspp.2014-0490

Fullagar, H. H. K., Skorski, S., Duffield, R., Julian, R., Bartlett, J., & Meyer, T. (2016). Impaired sleep and recovery after night matches in elite football players. Journal of Sports Sciences, 34(14), 1333–1339. https://doi.org/10.1080/02640414.2015.1135249

Fullager, H. H. K., Skorski, S., Duffield, R., hammes, D., Coutts, A. J., & Meyer, T. (2015). Sleep and athletic performance: The effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. Sports Medicine, 45(2), 161–186. https://doi.org/10.1007/s40279-014-0260-0

Gandevia, S. C. (2001). Spinal and supraspinal factors in human muscle fatigue. Physiological Reviews, 81(4), 1725–1789. https://doi.org/10.1152/physrev.2001.81.4.1725

Goulart, K. N. O., Coimbra, C. C., Campos, H. O., Drummond, L. R., Ogando, P. H. M., Brown, G., Couto, B. P., Duffield, R., & Wanner, S. P. (2022). Fatigue and Recovery Time

Course After Female Soccer Matches: A Systematic Review and Meta-analysis. Sports Medicine - Open, 8(1), 72. https://doi.org/10.1186/s40798-022-00466-3

Gouttebarge, V., Brink, M. S., & Kerkhoffs, G. M. M. J. (2019). The perceptions of elite professional footballers on the International Match Calendar: A cross-sectional study. Science and Medicine in Football, 3(4), 339–342. https://doi.org/10.1080/24733938.2019.1617432

Gümüşdağ, H., Bastik, C., Yamaner, F., Kartal, A., & Ünlü, C. (2013). Burnout in Professional Soccer Players: The Role of Aggression and Anxiety. 04(10).

Hamlin, M. J., Wilkes, D., Elliot, C. A., Lizamore, C. A., & Kathiravel, Y. (2019). Monitoring Training Loads and Perceived Stress in Young Elite University Athletes. Frontiers in Physiology, 10, 34. https://doi.org/10.3389/fphys.2019.00034

Harley, J. A., Barnes, C. A., Portas, M., Lovell, R., Barrett, S., Paul, D., & Weston, M. (2010). Motion analysis of match-play in elite U12 to U16 age-group soccer players. Journal of Sports Sciences, 28(13), 1391–1397. https://doi.org/10.1080/02640414.2010.510142

Heller, H. C., Herzog, E., Brager, A., Poe, G., Allada, R., Scheer, F. A. J. L., Carskadon, M., De La Iglesia, H. O., Jang, R., Montero, A., Wright, K., Mouraine, P., Walker, M. P., Goel, N., Hogenesch, J., Van Gelder, R. N., Kriegsfeld, L., Mah, C., Colwell, C., … Paul, K. (2024). The Negative Effects of Travel on Student Athletes Through Sleep and Circadian Disruption. Journal of Biological Rhythms, 39(1), 5–19. https://doi.org/10.1177/07487304231207330

Hennessy, L. and Kilty, J. Relationship of the stretch-shortening cycle to sprint performance in trained female athletes. J Strength Cond Res 15: 326-331, 2001.

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O'Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, J. C., & Adams Hillard, P. J. (2015). National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. Sleep Health, 1(1), 40–43. https://doi.org/10.1016/j.sleh.2014.12.010

Hoffman, J. R., Nusse, V., & Kang, J. (2003). The Effect of an Intercollegiate Soccer Game on Maximal Power Performance. Canadian Journal of Applied Physiology, 28(6), 807–817. https://doi.org/10.1139/h03-060

Howle, K., Waterson, A., & Duffield, R. (2020). Injury Incidence and Workloads during congested Schedules in Football. International Journal of Sports Medicine, 41(2), 75–81. https://doi.org/10.1055/a-1028-7600

Ishida, A., Travis, S., & Stone, M. (2021). Associations of Body Composition, Maximum Strength, Power Characteristics with Sprinting, Jumping, and Intermittent Endurance Performance in Male Intercollegiate Soccer Players. Journal of Functional Morphology and Kinesiology, 6(1), 7. https://doi.org/10.3390/jfmk6010007

Ivarsson, A., Tranaeus, U., Johnson, U., & Stenling, A. (2017). Negative psychological responses of injury and rehabilitation adherence effects on return to play in competitive athletes: A systematic review and meta-analysis. Open Access Journal of Sports Medicine, Volume 8, 27–32. https://doi.org/10.2147/OAJSM.S112688

Jones, R. N., Greig, M., Mawéné, Y., Barrow, J., & Page, R. M. (2019). The influence of short-term fixture congestion on position specific match running performance and external loading patterns in English professional soccer. Journal of Sports Sciences, 37(12), 1338–1346. https://doi.org/10.1080/02640414.2018.1558563

Julian, R., Page, R. M., & Harper, L. D. (2021). The Effect of Fixture Congestion on Performance During Professional Male Soccer Match-Play: A Systematic Critical Review with Meta-Analysis. Sports Medicine, 51(2), 255–273. https://doi.org/10.1007/s40279-020-01359-9

Knutson, K. L., Spiegel, K., Penev, P., & Van Cauter, E. (2007). The metabolic consequences of sleep deprivation. Sleep Medicine Reviews, 11(3), 163–178.

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, P. K., & Bangsbo, J. (2003). The Yo-Yo Intermittent Recovery Test: Physiological Response, Reliability, and Validity: Medicine & Science in Sports & Exercise, 35(4), 697–705. https://doi.org/10.1249/01.MSS.0000058441.94520.32

Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J. (2005). Physical Demands during an Elite Female Soccer Game: Importance of Training Status. Medicine & Science in Sports & Exercise, 37(7), 1242–1248. https://doi.org/10.1249/01.mss.0000170062.73981.94

Krustrup, P., Zebis, M., Jensen, J. M., & Mohr, M. (2010). Game-Induced Fatigue Patterns in Elite Female Soccer. Journal of Strength and Conditioning Research, 24(2), 437–441. https://doi.org/10.1519/JSC.0b013e3181c09b79

Li, H., Moreland, J. J., Peek-Asa, C., & Yang, J. (2017). Preseason Anxiety and Depressive Symptoms and Prospective Injury Risk in Collegiate Athletes. The American Journal of Sports Medicine, 45(2).

Lopes Dos Santos, M., Uftring, M., Stahl, C. A., Lockie, R. G., Alvar, B., Mann, J. B., & Dawes, J. J. (2020). Stress in Academic and Athletic Performance in Collegiate Athletes: A

Narrative Review of Sources and Monitoring Strategies. Frontiers in Sports and Active Living, 2, 42. https://doi.org/10.3389/fspor.2020.00042

López de Subijana, C., Barriopedro, M., & Conde, E. (2015). Supporting Dual Career in Spain: Elite Athletes' Barriers to Study. Psychology of Sport and Exercise, 21. https://doi.org/10.1016/j.psychsport.2015.04.012

Lundberg, T. R., & Weckstrom, K. (2017). Fixture congestion modulates post-match recovery kinetics in professional soccer players. Research in Sports Medicine, 25(4), 408–420. https://doi.org/10.1080/15438627.2017.1365296

Magalhães, J., Rebelo, A., Oliveira, E., Silva, J. R., Marques, F., & Ascensão, A. (2010). Impact of Loughborough Intermittent Shuttle Test versus soccer match on physiological, biochemical and neuromuscular parameters. European Journal of Applied Physiology, 108(1), 39–48. https://doi.org/10.1007/s00421-009-1161-z

Mah, C. D., Kezirian, E. J., Marcello, B. M., & Dement, W. C. (2018). Poor sleep quality and insufficient sleep of a collegiate student-athlete population. Sleep Health, 4(3), 251–257. https://doi.org/10.1016/j.sleh.2018.02.005

Manzi, V., D'Ottavio, S., Impellizzeri, F. M., Chaouachi, A., Chamari, K., & Castagna, C. (2010). Profile of Weekly Training Load in Elite Male Professional Basketball Players. Journal of Strength and Conditioning Research, 24(5), 1399–1406. https://doi.org/10.1519/JSC.0b013e3181d7552a

Markovic, S., Mirkov, D. M., Nedeljkovic, A., & Jaric, S. (2014). Body size and countermovement depth confound relationship between muscle power output and jumping performance. Human Movement Science, 33, 203–210. https://doi.org/10.1016/j.humov.2013.11.004

Maso, F., Cazorla, G., & Godemet, M., et al. (2002). Physiological features of rugby players of French team. Journal of Science of Sports, 17, 297–301.

Meerlo, P., Sgoifo, A., & Suchecki, D. (2008). Restricted and disrupted sleep: Effects on autonomic function, neuroendocrine stress systems and stress responsivity. Sleep Medicine Reviews, 12(3), 197–210. https://doi.org/10.1016/j.smrv.2007.07.007

Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Nieman, D., Raglin, J., Rietjens, G., Steinacker, J., & Urhausen, A. (2013). Prevention, diagnosis and treatment of the overtraining syndrome: Joint consensus statement of the European College of Sport Science (ECSS) and the American College of Sports Medicine (ACSM). European Journal of Sport Science, 13(1), 1–24. https://doi.org/10.1080/17461391.2012.730061

Mendez-Villanueva, A., Buchheit, M., Simpson, B., & Bourdon, P. (2012). Match Play Intensity Distribution in Youth Soccer. International Journal of Sports Medicine, 34(02), 101–110. https://doi.org/10.1055/s-0032-1306323

Moreland, J. J., Coxe, K. A., & Yang, J. (2018). Collegiate athletes' mental health services utilization: A systematic review of conceptualizations, operationalizations, facilitators, and barriers. Journal of Sport and Health Science, 7(1), 58–69. https://doi.org/10.1016/j.jshs.2017.04.009

Oliver, J., Armstron, N., & Williams, C. (2008). Changes in jump performance and muscle activity following soccer-specific exercise. Journal of Sports Sciences, 26(2), 141–148. https://doi.org/10.1080/02640410701352018

Page, R. M., Field, A., Langley, B., Harper, L. D., & Julian, R. (2023). The Effects of Fixture Congestion on Injury in Professional Male Soccer: A Systematic Review. Sports Medicine, 53(3), 667–685. https://doi.org/10.1007/s40279-022-01799-5

Reilly, T., & Rigby, M. (2007). Effect of an Active Warm-Down Following Competitive Soccer (1st ed.). Routledge.

Rey, E., Lago-Peñas, C., Casais, L., & Lago-Ballesteros, J. (2012). The Effect of Immediate Post-Training Active and Passive Recovery Interventions on Anaerobic Performance and Lower Limb Flexibility in Professional Soccer Players. Journal of Human Kinetics, 31, 121–129. https://doi.org/10.2478/v10078-012-0013-9

Rollo, I., & Williams, C. (2011). Effect of Mouth-Rinsing Carbohydrate Solutions on Endurance Performance. Sports Med.

Sands, W., Stone, M. H., & Stone, M. E. (2007). Principles and Practice of Resistance Training. Human Kinetics.

Sausaman, R. W., Sams, M. L., Mizuguchi, S., DeWeese, B. H., & Stone, M. H. (2019). The Physical Demands of NCAA Division I Women's College Soccer. Journal of Functional Morphology and Kinesiology, 4(4), 73. https://doi.org/10.3390/jfmk4040073

Soroka, A., & Lago-Peñas, C. (2016). The effect of a succession of matches on the physical performance of elite football players during the World Cup Brazil 2014. International Journal of Performance Analysis in Sport, 16(2), 434–441. https://doi.org/10.1080/24748668.2016.11868899

Taylor, K.-L., Chapman, D. W., Cronin, J. B., Newton, M. J., & Gill, N. (2012). FATIGUE MONITORING IN HIGH PERFORMANCE SPORT: A SURVEY OF CURRENT TRENDS. 20(1).

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S., & Tasali, E. (2015). Recommended Amount of Sleep for a Healthy Adult:

A Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society. SLEEP. https://doi.org/10.5665/sleep.4716

Yoshida, N., Hornsby, W.G., Sole, C.J., Sato, K. and Stone, M.H., 2022. Effect of Neuromuscular Fatigue on the Countermovement Jump Characteristics: Basketball-Related High-Intensity Exercises. The Journal of Strength & Conditioning Research, 2024 38(1):164-173

Chapter 4. Summary and Future Investigations

The purpose of this dissertation was to examine the effects of a period of match congestion on match performance variables and countermovement jump height in division I female soccer players. The results of this study indicated that a congested match period negatively affected jump height over the season. It also indicated that there might not be sufficient recovery time between consecutive matches (separated by 42- 92 hours), since jump height significantly decreased between such matches. This may be an indication of accumulative and neuromuscular fatigue since pre- and post-season lab and field-based testing showed no signs of detraining. Therefore, coaches and practitioners should employ strategies to mitigate fatigue, reduce injury risk and optimize match performance. Since jump height was affected by a congested match schedule, the CMJ may be a useful tool for coaches to monitor fatigue throughout a congested match period.

Furthermore, although match performance variables fluctuated over the course of the season, the greater the relative match volume and intensity of the former match, the greater the decrease in pre-match jump height of the subsequent match. Such findings may help practitioners and coaches to better understand how physical match demands influence fatigue in collegiate soccer players, while highlighting the importance of player rotation. The use of GPS and accelerometry may help establish player load during match-play within a congested match period.

While this study successfully illustrated the effects of a period of match congestion on match performance variables and CMJ height in female collegiate soccer players, future research should include the examination of technical match performance, match outcome and the subjective wellness of collegiate soccer players during periods of match congested. Also, positional analysis could help coaches understand fatigue relating to positional physical match demands during periods of match congestion. Injury rates should also be monitored to help better understand the relationship between physical performance, fatigue and injury risk during congested match schedules. Lastly, future researchers should compare congested and non-congested match periods, study multiple teams at various playing levels and investigate the effects of travel and academics on match performance and neuromuscular fatigue.

References

Abbott, W., Brownlee, T. E., Harper, L. D., Naughton, R. J., & Clifford, T. (2018). The independent effects of match location, match result and the quality of opposition on subjective wellbeing in under 23 soccer players: A case study. Research in Sports Medicine, 26(3), 262–275. https://doi.org/10.1080/15438627.2018.1447476

Alba-Jimenez, C., Moreno-Doutres, D., & Pena, J. (2022). Trends Assessing Neuromuscular Fatigue in Team Sports: A Narrative Review. Journal of Sports, 10(3). https://doi.org/10.3390/sports10030033.

Alexander, R. (2014). Physical and Technical Demands of Women's Collegiate Soccer. East Tennessee State University.

American College Health Association. (2019). National College Health Assessment II. Reference Group Executive Summary.

Andersson, H. Å., Randers, M. B., Heiner-Møller, A., Krustrup, P., & Mohr, M. (2010). Elite Female Soccer Players Perform More High-Intensity Running When Playing in International Games Compared with Domestic League Games. Journal of Strength and Conditioning Research, 24(4), 912–919. https://doi.org/10.1519/JSC.0b013e3181d09f21

Andersson, H., Raastad, T., Nilsson, J., Paulsen, G., Garthe, I., & Kadi, F. (2008). Neuromuscular Fatigue and Recovery in Elite Female Soccer: Effects of Active Recovery. Medicine & Science in Sports & Exercise, 40(2), 372–380. https://doi.org/10.1249/mss.0b013e31815b8497

Aquilina, D. (2013). A Study of the Relationship Between Elite Athletes' Educational Development and Sporting Performance. The International Journal of the History of Sport, 30(4), 374–392. https://doi.org/10.1080/09523367.2013.765723

Armada-Cortés, E., Benítez-Muñoz, J. A., San Juan, A. F., & Sánchez-Sánchez, J. (2022). Evaluation of Neuromuscular Fatigue in a Repeat Sprint Ability, Countermovement Jump and Hamstring Test in Elite Female Soccer Players. International Journal of Environmental Research and Public Health, 19(22), 15069. https://doi.org/10.3390/ijerph192215069

Arruda, A. F. S., Carling, C., Zanetti, V., Aoki, M. S., Coutts, A. J., & Moreira, A. (2015). Effects of a Very Congested Match Schedule on Body-Load Impacts, Accelerations, and Running Measures in Youth Soccer Players. International Journal of Sports Physiology and Performance, 10(2), 248–252. https://doi.org/10.1123/ijspp.2014-0148

Atrooz, F., & Salim, S. (2020). Sleep deprivation, oxidative stress and inflammation. Advances in Protein Chemistry and Structural Biology, 119, 309–336. https://doi.org/10.1016/bs.apcsb.2019.03.001

Bangsbo, J., Iaia, F. M., & Krustrup, P. (2008). The Yo-Yo Intermittent Recovery Test: A Useful Tool for Evaluation of Physical Performance in Intermittent Sports. Sports Medicine, 38(1), 37–51. https://doi.org/10.2165/00007256-200838010-00004

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. Journal of Sports Sciences, 24(7), 665–674. https://doi.org/10.1080/02640410500482529

Bengtsson, H., Ekstrand, J., & Hägglund, M. (2013). Muscle injury rates in professional football increase with fixture congestion: An 11-year follow-up of the UEFA Champions League injury study. British Journal of Sports Medicine, 47(12), 743–747. https://doi.org/10.1136/bjsports-2013-092383

Bishop, C., Jordan, M., Torres-Ronda, L., Loturco, I., Harry, J., Virgile, A., Mundy, P., Turner, A., & Comfort, P. (2023). Selecting Metrics That Matter: Comparing the Use of the Countermovement Jump for Performance Profiling, Neuromuscular Fatigue Monitoring, and Injury Rehabilitation Testing.

Brownstein, C. G., Dent, J. P., Parker, P., Hicks, K. M., Howatson, G., Goodall, S., & Thomas, K. (2017). Etiology and Recovery of Neuromuscular Fatigue following Competitive Soccer Match-Play. Frontiers in Physiology, 8, 831. https://doi.org/10.3389/fphys.2017.00831

Buchheit, M., Mendez-Villanueva, A., Simpson, B. M., & Bourdon, P. C. (2010). Match Running Performance and Fitness in Youth Soccer. International Journal of Sports Medicine, 31(11), 818–825. https://doi.org/10.1055/s-0030-1262838

Byrne, C., & Eston, R. (2002). Maximal-intensity isometric and dynamic exercise performance after eccentric muscle actions. Journal of Sports Sciences, 20(12), 951–959. https://doi.org/10.1080/026404102321011706

Carling, C., & Dupont, G. (2011). Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play? Journal of Sports Sciences, 29(1), 63–71. https://doi.org/10.1080/02640414.2010.521945

Carling, C., Le Gall, F., & Dupont, G. (2012). Are Physical Performance and Injury Risk in a Professional Soccer Team in Match-Play Affected Over a Prolonged Period of Fixture Congestion? International Journal of Sports Medicine, 33(1), 36–42. https://doi.org/10.1055/s-0031-1283190

Carling, C., Mccall, A., Le Gall, F., & Dupont, G. (2015). The impact of short periods of match congestion on injury risk and patterns in an elite football club. British Journal of Sports Medicine, 50(12). https://doi.org/10.1136/bjsports-2015-095501

Castagna, C., & Castellini, E. (2013). Vertical jump performance in Italian male and female national team soccer players. Journal of Strength & Conditioning Research, 27(4), 1156-1161.

Castagna, C., Impellizzeri, F. M., Chamari, K., carlomagno, D., & Rampinini, E. (2006). Aerobic fitness and yo-yo continuous and intermittent tests performances in soccer players: A correlation study. Journal of Strength and Conditioning Research, 20(2), 320–325.

Castagna, C., Impellizzeri, F., Cecchini, E., Rampinini, E., & Alvarez, J. C. B. (2009). Effects of Intermittent-Endurance Fitness on Match Performance in Young Male Soccer Players. Journal of Strength and Conditioning Research, 23(7), 1954–1959. https://doi.org/10.1519/JSC.0b013e3181b7f743

Castagna, C., Manzi, V., Impellizzeri, F., Weston, M., & Barbero Alvarez, J. C. (2010). Relationship Between Endurance Field Tests and Match Performance in Young Soccer Players. Journal of Strength and Conditioning Research, 24(12), 3227–3233. https://doi.org/10.1519/JSC.0b013e3181e72709

Charest, J., & Grandner, M. A. (2020). Sleep and Athletic Performance. Sleep Medicine Clinics, 15(1), 41–57. https://doi.org/10.1016/j.jsmc.2019.11.005

Claudino, J. G., Cronin, J., Mezêncio, B., McMaster, D. T., McGuigan, M., Tricoli, V., Amadio, A. C., & Serrão, J. C. (2017). The countermovement jump to monitor neuromuscular status: A meta-analysis. Journal of Science and Medicine in Sport, 20(4), 397–402. https://doi.org/10.1016/j.jsams.2016.08.011

Cohen J. (1988). Statistical Power Analysis for the Behavioral Sciences. New York, NY: Routledge Academic

Cook, J. D., & Charest, J. (2023). Sleep and Performance in Professional Athletes. Current Sleep Medicine Reports, 9(1), 56–81. https://doi.org/10.1007/s40675-022-00243-4

Cormack, S. J., Newton, R. U., McGuigan, M. R., & Cormie, P. (2008). Neuromuscular and Endocrine Responses of Elite Players During an Australian Rules Football Season. International Journal of Sports Physiology and Performance, 3(4), 439–453. https://doi.org/10.1123/ijspp.3.4.439

Craven, J., McCartney, D., Desbrow, B., Sabapathy, S., Bellinger, P., Roberts, L., & Irwin, C. (2022). Effects of Acute Sleep Loss on Physical Performance: A Systematic and Meta-Analytical Review. Sports Medicine, 52(11), 2669–2690. https://doi.org/10.1007/s40279-022-01706-y

Davis, P., Halvarsson, A., Lundström, W., & Lundqvist, C. (2019). Alpine Ski Coaches' and Athletes' Perceptions of Factors Influencing Adaptation to Stress in the Classroom and on the Slopes. Frontiers in Psychology, 10, 1641. https://doi.org/10.3389/fpsyg.2019.01641

De Beandt, K., Wylleman, P., Torregrossa, M., & Schipper van Veldhoven, N. (2018). Exploring the factor structure of the Dual Career Competency Questionnaire for Athletes in European pupil-and student-athletes. International Journal of Sport and Exercise Physiology.

De Pauw, K., Roelands, B., Marusic, U., Fernandez Tellez, H., Knaepen, K., & Meeusen, R. (2013). Brain mapping after prolonged cycling and during recovery in the heat. Journal of

Applied Physiology, 115(9), 1324–1331. https://doi.org/10.1152/japplphysiol.00633.2013

Dellal, A., Lago-Peñas, C., Rey, E., Chamari, K., & Orhant, E. (2015). The effects of a congested fixture period on physical performance, technical activity and injury rate during matches in a professional soccer team. British Journal of Sports Medicine, 49(6), 390–394. https://doi.org/10.1136/bjsports-2012-091290

Djaoui, L., Owen, A., Newton, M., Theodoros Nikolaidis, P., Dellal, A., & Chamari, K. (2022). Effects of congested match periods on acceleration and deceleration profiles in professional soccer. Biology of Sport, 39(2), 307–317. https://doi.org/10.5114/biolsport.2022.103725

Djaoui, L., Wong, D. P., Pialoux, V., Hautier, C., Da Silva, C. D., Chamari, K., & Dellal, A. (2013). Physical Activity during a Prolonged Congested Period in a Top-Class European Football Team. Asian Journal of Sports Medicine, 5(1). https://doi.org/10.5812/asjsm.34233

Doeven, S., Brink, M. S., Kosse, S. J., & Lemmink, K. A. P. M. (2017). Post match recovery of physical performance and biochemical markers in team ball sports: A systematic review. BMJ Sport & Exercise Medicine, 14(1).

Doherty, R., Madigan, S. M., Nevill, A., Warrington, G., & Ellis, J. G. (2021). The Sleep and Recovery Practices of Athletes. Nutrients, 13(4), 1330. https://doi.org/10.3390/nu13041330

Dupont, G., Nedelec, M., McCall, A., McCormack, D., Berthoin, S., & Wisløff, U. (2010). Effect of 2 Soccer Matches in a Week on Physical Performance and Injury Rate. The

American Journal of Sports Medicine, 38(9), 1752–1758. https://doi.org/10.1177/0363546510361236

Ekstrand, J., Walden, M., & Hagglund, M. (2004). Risk for injury when playing in a national football team. Scandinavian Journal of Medicine and Science in Sports, 14(1), 34–38. https://doi.org/10.1111/j.1600-0838.2003.00330.x

Enoka, R. M., & Duchateau, J. (2008). Muscle fatigue: What, why and how it influences muscle function. The Journal of Physiology, 586(1), 11–23. https://doi.org/10.1113/jphysiol.2007.139477

Etzl, E. F. (2009). Counseling and psychological services for college student-athletes. Fitness Information Technology.

Fatouros, I. G., Chatzinikolaou, A., Ispirlidis, I., Jamurtas, A. Z., Nikolaidis, M. G., Michailidis, I., Douroudos, I., Margonis, K., & Taxildaris, K. (2008). Time-course of Changes in Inflammatory and Performance Responses Following a Soccer Game: 2328 Board #108 May 30 3:30 PM - 5:00 PM. Medicine & Science in Sports & Exercise, 40(5), S432. https://doi.org/10.1249/01.mss.0000322840.72766.9f

Fogaca, J. (2019). Combining Mental Health and Performance Interventions: Coping and Social Support for Student-Athletes. Journal of Applied Sport Psychology, 33(3), 1–16. https://doi.org/10.1080/10413200.2019.1648326

Folgado, H., Duarte, R., Marques, P., & Sampaio, J. (2015). The effects of congested fixtures period on tactical and physical performance in elite football. Journal of Sports Sciences, 33(12), 1238–1247. https://doi.org/10.1080/02640414.2015.1022576

Fowler, P., Duffield, R., Howle, K., Waterson, A., & Vaile, J. (2015). Effects of Northbound Long-Haul International Air Travel on Sleep Quantity and Subjective Jet Lag and

Wellness in Professional Australian Soccer Players. International Journal of Sports Physiology and Performance, 10(5), 648–654. https://doi.org/10.1123/ijspp.2014-0490

Fullagar, H. H. K., Skorski, S., Duffield, R., Julian, R., Bartlett, J., & Meyer, T. (2016). Impaired sleep and recovery after night matches in elite football players. Journal of Sports Sciences, 34(14), 1333–1339. https://doi.org/10.1080/02640414.2015.1135249

Fullager, H. H. K., Skorski, S., Duffield, R., hammes, D., Coutts, A. J., & Meyer, T. (2015). Sleep and athletic performance: The effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. Sports Medicine, 45(2), 161–186. https://doi.org/10.1007/s40279-014-0260-0

Gandevia, S. C. (2001). Spinal and supraspinal factors in human muscle fatigue. Physiological Reviews, 81(4), 1725–1789. https://doi.org/10.1152/physrev.2001.81.4.1725

Goulart, K. N. O., Coimbra, C. C., Campos, H. O., Drummond, L. R., Ogando, P. H. M., Brown, G., Couto, B. P., Duffield, R., & Wanner, S. P. (2022). Fatigue and Recovery Time Course After Female Soccer Matches: A Systematic Review and Meta-analysis. Sports Medicine - Open, 8(1), 72. https://doi.org/10.1186/s40798-022-00466-3

Gouttebarge, V., Brink, M. S., & Kerkhoffs, G. M. M. J. (2019). The perceptions of elite professional footballers on the International Match Calendar: A cross-sectional study. Science and Medicine in Football, 3(4), 339–342. https://doi.org/10.1080/24733938.2019.1617432

Gümüşdağ, H., Bastik, C., Yamaner, F., Kartal, A., & Ünlü, C. (2013). Burnout in Professional Soccer Players: The Role of Aggression and Anxiety. 04(10).

Hamlin, M. J., Wilkes, D., Elliot, C. A., Lizamore, C. A., & Kathiravel, Y. (2019). Monitoring Training Loads and Perceived Stress in Young Elite University Athletes. Frontiers in Physiology, 10, 34. https://doi.org/10.3389/fphys.2019.00034

Harley, J. A., Barnes, C. A., Portas, M., Lovell, R., Barrett, S., Paul, D., & Weston, M. (2010). Motion analysis of match-play in elite U12 to U16 age-group soccer players. Journal of Sports Sciences, 28(13), 1391–1397. https://doi.org/10.1080/02640414.2010.510142

Heller, H. C., Herzog, E., Brager, A., Poe, G., Allada, R., Scheer, F. A. J. L., Carskadon, M., De La Iglesia, H. O., Jang, R., Montero, A., Wright, K., Mouraine, P., Walker, M. P., Goel, N., Hogenesch, J., Van Gelder, R. N., Kriegsfeld, L., Mah, C., Colwell, C., … Paul, K. (2024). The Negative Effects of Travel on Student Athletes Through Sleep and Circadian Disruption. Journal of Biological Rhythms, 39(1), 5–19. https://doi.org/10.1177/07487304231207330

Hennessy, L. and Kilty, J. Relationship of the stretch-shortening cycle to sprint performance in trained female athletes. J Strength Cond Res 15: 326-331, 2001.

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O’Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, J. C., & Adams Hillard, P. J. (2015). National Sleep Foundation’s sleep time duration recommendations: Methodology and results summary. Sleep Health, 1(1), 40–43. https://doi.org/10.1016/j.sleh.2014.12.010

Hoffman, J. R., Nusse, V., & Kang, J. (2003). The Effect of an Intercollegiate Soccer Game on Maximal Power Performance. Canadian Journal of Applied Physiology, 28(6), 807–817. https://doi.org/10.1139/h03-060

Howle, K., Waterson, A., & Duffield, R. (2020). Injury Incidence and Workloads during congested Schedules in Football. International Journal of Sports Medicine, 41(2), 75–81. https://doi.org/10.1055/a-1028-7600

Huml, M. R., Hambrick, M. E., & Hums, M. A. (2016). Coaches' Perceptions of the Reduction of Athletic Commitment for Division II Student-Athletes: Development and Validation of a Measure of Athletic/Academic Balance. Journal of Intercollegiate Sport, 9(2), 303–325. https://doi.org/10.1123/jis.2015-0055

Ishida, A., Travis, S., & Stone, M. (2021). Associations of Body Composition, Maximum Strength, Power Characteristics with Sprinting, Jumping, and Intermittent Endurance Performance in Male Intercollegiate Soccer Players. Journal of Functional Morphology and Kinesiology, 6(1), 7. https://doi.org/10.3390/jfmk6010007

Ivarsson, A., Tranaeus, U., Johnson, U., & Stenling, A. (2017). Negative psychological responses of injury and rehabilitation adherence effects on return to play in competitive athletes: A systematic review and meta-analysis. Open Access Journal of Sports Medicine, Volume 8, 27–32. https://doi.org/10.2147/OAJSM.S112688

Jones, R. N., Greig, M., Mawéné, Y., Barrow, J., & Page, R. M. (2019). The influence of short-term fixture congestion on position specific match running performance and external loading patterns in English professional soccer. Journal of Sports Sciences, 37(12), 1338–1346. https://doi.org/10.1080/02640414.2018.1558563

Julian, R., Page, R. M., & Harper, L. D. (2021). The Effect of Fixture Congestion on Performance During Professional Male Soccer Match-Play: A Systematic Critical Review with Meta-Analysis. Sports Medicine, 51(2), 255–273. https://doi.org/10.1007/s40279-020-01359-9

Knutson, K. L., Spiegel, K., Penev, P., & Van Cauter, E. (2007). The metabolic consequences of sleep deprivation. Sleep Medicine Reviews, 11(3), 163–178.

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, P. K., & Bangsbo, J. (2003). The Yo-Yo Intermittent Recovery Test: Physiological Response, Reliability, and Validity: Medicine & Science in Sports & Exercise, 35(4), 697–705. https://doi.org/10.1249/01.MSS.0000058441.94520.32

Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J. (2005). Physical Demands during an Elite Female Soccer Game: Importance of Training Status. Medicine & Science in Sports & Exercise, 37(7), 1242–1248. https://doi.org/10.1249/01.mss.0000170062.73981.94

Krustrup, P., Zebis, M., Jensen, J. M., & Mohr, M. (2010). Game-Induced Fatigue Patterns in Elite Female Soccer. Journal of Strength and Conditioning Research, 24(2), 437–441. https://doi.org/10.1519/JSC.0b013e3181c09b79

Li, H., Moreland, J. J., Peek-Asa, C., & Yang, J. (2017). Preseason Anxiety and Depressive Symptoms and Prospective Injury Risk in Collegiate Athletes. The American Journal of Sports Medicine, 45(2).

Lopes Dos Santos, M., Uftring, M., Stahl, C. A., Lockie, R. G., Alvar, B., Mann, J. B., & Dawes, J. J. (2020). Stress in Academic and Athletic Performance in Collegiate Athletes: A Narrative Review of Sources and Monitoring Strategies. Frontiers in Sports and Active Living, 2, 42. https://doi.org/10.3389/fspor.2020.00042

López de Subijana, C., Barriopedro, M., & Conde, E. (2015). Supporting Dual Career in Spain: Elite Athletes' Barriers to Study. Psychology of Sport and Exercise, 21. https://doi.org/10.1016/j.psychsport.2015.04.012

Lundberg, T. R., & Weckstrom, K. (2017). Fixture congestion modulates post-match recovery kinetics in professional soccer players. Research in Sports Medicine, 25(4), 408–420. https://doi.org/10.1080/15438627.2017.1365296

Magalhães, J., Rebelo, A., Oliveira, E., Silva, J. R., Marques, F., & Ascensão, A. (2010). Impact of Loughborough Intermittent Shuttle Test versus soccer match on physiological, biochemical and neuromuscular parameters. European Journal of Applied Physiology, 108(1), 39–48. https://doi.org/10.1007/s00421-009-1161-z

Mah, C. D., Kezirian, E. J., Marcello, B. M., & Dement, W. C. (2018). Poor sleep quality and insufficient sleep of a collegiate student-athlete population. Sleep Health, 4(3), 251–257. https://doi.org/10.1016/j.sleh.2018.02.005

Maloney, M. T., & McCormick, R. E. (1993). An Examination of the Role That Intercollegiate Athletic Participation Plays in Academic Achievement. Jounral of Human Resources, 28(3), 555–570.

Manzi, V., D’Ottavio, S., Impellizzeri, F. M., Chaouachi, A., Chamari, K., & Castagna, C. (2010). Profile of Weekly Training Load in Elite Male Professional Basketball Players. Journal of Strength and Conditioning Research, 24(5), 1399–1406. https://doi.org/10.1519/JSC.0b013e3181d7552a

Markovic, S., Mirkov, D. M., Nedeljkovic, A., & Jaric, S. (2014). Body size and countermovement depth confound relationship between muscle power output and jumping performance. Human Movement Science, 33, 203–210. https://doi.org/10.1016/j.humov.2013.11.004

Maso, F., Cazorla, G., & Godemet, M., et al. (2002). Physiological features of rugby players of French team. Journal of Science of Sports, 17, 297–301.

Meerlo, P., Sgoifo, A., & Suchecki, D. (2008). Restricted and disrupted sleep: Effects on autonomic function, neuroendocrine stress systems and stress responsivity. Sleep Medicine Reviews, 12(3), 197–210. https://doi.org/10.1016/j.smrv.2007.07.007

Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Nieman, D., Raglin, J., Rietjens, G., Steinacker, J., & Urhausen, A. (2013). Prevention, diagnosis and treatment of the overtraining syndrome: Joint consensus statement of the European College of Sport Science (ECSS) and the American College of Sports Medicine (ACSM). European Journal of Sport Science, 13(1), 1–24. https://doi.org/10.1080/17461391.2012.730061

Mendez-Villanueva, A., Buchheit, M., Simpson, B., & Bourdon, P. (2012). Match Play Intensity Distribution in Youth Soccer. International Journal of Sports Medicine, 34(02), 101–110. https://doi.org/10.1055/s-0032-1306323

Moreland, J. J., Coxe, K. A., & Yang, J. (2018). Collegiate athletes’ mental health services utilization: A systematic review of conceptualizations, operationalizations, facilitators, and barriers. Journal of Sport and Health Science, 7(1), 58–69. https://doi.org/10.1016/j.jshs.2017.04.009

NCAA. (2019). NCAA Goals Study.

Nédélec, M., Halson, S., Abaidia, A.-E., Ahmaidi, S., & Dupont, G. (2015). Stress, Sleep and Recovery in Elite Soccer: A Critical Review of the Literature. Sports Medicine, 45(10), 1387–1400. https://doi.org/10.1007/s40279-015-0358-z

Oliver, J., Armstron, N., & Williams, C. (2008). Changes in jump performance and muscle activity following soccer-specific exercise. Journal of Sports Sciences, 26(2), 141–148. https://doi.org/10.1080/02640410701352018

Page, R. M., Field, A., Langley, B., Harper, L. D., & Julian, R. (2023). The Effects of Fixture Congestion on Injury in Professional Male Soccer: A Systematic Review. Sports Medicine, 53(3), 667–685. https://doi.org/10.1007/s40279-022-01799-5

Reilly, T., & Rigby, M. (2007). Effect of an Active Warm-Down Following Competitive Soccer (1st ed.). Routledge.

Rey, E., Lago-Peñas, C., Casais, L., & Lago-Ballesteros, J. (2012). The Effect of Immediate Post-Training Active and Passive Recovery Interventions on Anaerobic Performance and Lower Limb Flexibility in Professional Soccer Players. Journal of Human Kinetics, 31, 121–129. https://doi.org/10.2478/v10078-012-0013-9

Rollo, I., & Williams, C. (2011). Effect of Mouth-Rinsing Carbohydrate Solutions on Endurance Performance. Sports Med.

Ross, E. Z., Middleton, N., Shave, R., George, K., & Nowicky, A. (2007). Corticomotor excitability contributes to neuromuscular fatigue following marathon running in man. Journal of Experimental Physiology, 92(2), 417–426. https://doi.org/10.1113/expphysiol.2006.035972

Sands, W., Stone, M. H., & Stone, M. E. (2007). Principles and Practice of Resistance Training. Human Kinetics.

Sausaman, R. W., Sams, M. L., Mizuguchi, S., DeWeese, B. H., & Stone, M. H. (2019). The Physical Demands of NCAA Division I Women’s College Soccer. Journal of Functional Morphology and Kinesiology, 4(4), 73. https://doi.org/10.3390/jfmk4040073

Scott, B. M., Paskus, T. S., Miranda, M., Petr, T. A., & McArdle, J. J. (2008). In-Season vs. Out-of-Season Academic Performance of College Student-Athletes. Journal of Intercollegiate Sport, 1(2), 202–226. https://doi.org/10.1123/jis.1.2.202

Soroka, A., & Lago-Peñas, C. (2016). The effect of a succession of matches on the physical performance of elite football players during the World Cup Brazil 2014. International Journal of Performance Analysis in Sport, 16(2), 434–441. https://doi.org/10.1080/24748668.2016.11868899

Taylor, K.-L., Chapman, D. W., Cronin, J. B., Newton, M. J., & Gill, N. (2012). Fatigue Monitoring In High Performance Sport: A Survey Of Current Trends. 20(1).

Walker, O. (2024). Countermovement Jump (CMJ) [2024]. https://www.scienceforsport.com/countermovement-jump-cmj/

Watson, A. M. (2017). Sleep and Athletic Performance. 16(6).

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S., & Tasali, E. (2015). Recommended Amount of Sleep for a Healthy Adult: A Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society. SLEEP. https://doi.org/10.5665/sleep.4716

Yoshida, N., Hornsby, W.G., Sole, C.J., Sato, K. and Stone, M.H., 2022. Effect of Neuromuscular Fatigue on the Countermovement Jump Characteristics: Basketball-Related High-Intensity Exercises. The Journal of Strength & Conditioning Research, 2024 38(1):164-173

VITA

FIONA DODGE

Education:	Ph.D. Sport Physiology and Performance, East Tennessee State University, Johnson City, Tennessee, 2024
	M.S. Sport Science and Coach Education, East Tennessee State University, Johnson City, Tennessee, 2021
	B.S. Physical Education, Exercise and Sport Science, East Tennessee State University, Johnson City, Tennessee, 2019
Professional Experience:	Graduate Assistance Coach, East Tennessee State University, 2019-2021
	Strength and Conditioning Coach, East Tennessee State University, 2021-2024
	Sport Scientist, East Tennessee State University, 2021-2024