Abstract

Objectives: To investigate player responses 48 h post single (SM) and multi-match (MM) weeks on two subjective and three objective outcome measures to infer recovery status.

Methods: From 42 professional players over 2 seasons, outcome measures relevant to recovery status were collected 48h following matches, as well as during pre-season training weeks as a comparative baseline. These included 1) 5-item subjective wellness questionnaire, 2) total quality recovery (TQR) scale, 3) hip adduction squeeze test, ankle knee to wall (KTW) test, and active knee extension (AKE) flexibility test. These outcome measures 48h post-match were compared for SM (n=79) and MM (n=86) weeks where players completed >75 min of match time in only one (SM) or if both matches were played and had <96h recovery (MM). Internal match load was collected from each match based on session rating of perceived exertion (sRPE) multiplied by match duration. **Results:** Subjective wellness (specifically fatigue, sleep and soreness), TQR and hip adduction squeeze test were all significantly reduced following match 1 at 48 h post for both SM and MM ($p<0.05$), and further reduced following match 2 in MM ($p<0.05$). No other outcome measures to infer recovery showed significant differences ($p>0.05$) within or between-conditions.

Conclusions: Subjective wellness, TQR and hip adduction strength showed reduction 48h post match for players competing in multiple matches with <96h recovery. Therefore, these outcome measures may be of use to practitioners to assess readiness to compete during congested competition schedules.

Keywords: Congested schedules, recovery, groin squeeze, wellness, champions league.

Introduction

Congested scheduling has been defined as matches played with <3 days of recovery, or multi-match weeks with <4 days of recovery between matches (Carling et al., 2012). Professional football within Europe often requires players to compete in multiple concurrent competitions, including both domestic and champions leagues (Lago, Rey, Lago, Casais & Dominguez, 2011). The scheduling consequences of dual competitions can result in multiple matches within a week, whereby players experience short recovery periods (Arruda, Carling, Zanetti, Aoki, Coutts, & Moreira, 2015; Dellal, Lago-Peñas, Rey, Chamari, & Orhant, 2013; Dupont, Nedelec, McCall, McCormack, Berthoin, & Wisløff, 2010). The actual extent that players are exposed to these periods has been suggested to be less than initially perceived (Carling, McCall, Le Gall, & Dupont, 2015). However, in Australian football, small squad sizes and reduced salary caps create difficulties for teams competing in a congested schedule and often results in players being exposed to frequent multi-match weeks.

Previous evidence suggests that 72h is the minimal timeframe for post-match recovery (Nédélec, McCall, Carling, Legall, Berthoin, & Dupont, 2012); though not all studies report 72 h post match as long enough to completely restore homeostatic balance (Silva, Rumpf, Hertzog, Castagna, Farooq, Giard, & Hader, 2018). However, Rowell, Aughey, Hopkins, Esmaeil, Lazarus, & Cormack, (2017) concluded that neuromuscular performance measured via counter movement jump is recovered 42 h post-match in Australian professional football players. Despite these mixed findings, the concern with congested schedules is the reduced recovery that may be caused by successive matches (Carling et al., 2012), which may result in an increased injury risk. For example, increased non-contact injuries have been reported during congested schedules of 2 vs 1 match weeks in professional French football players, (Dupont et al., 2010). Further, total injury rates were 25.6 versus 4.1 injuries per 1000 hours for 2 v 1 match weeks and one of the primary explanations for this observation relates to the reduced recovery time between matches (Dupont et al., 2010; Carling et al., 2012). Regardless, whilst congested schedules are suggested to heighten the risk of injury (Lago et al., 2011), the explicit effects of multiple matches on post-match recovery remain unknown.

With recovery central to above theories regarding the effect of congested schedules; recovery is considered to have occurred when a player is able to reach, if not exceed, a particular benchmark related to performance or physiological and perceptual states following training or matches (Ispirlidis, Fatouros, Jamurtas, Nikolaidis, Michailidis, Douroudos, Margonis, Chatzinikolaou, Kalistratos, Katrabasas, Alexiou, & Taxildaris, 2008; Mohr, Draganidis, Chatzinikolaou, Barbero-Alvarez, Castagna, Douroudos, Avloniti, Margeli, Papassotiriou, Flouris, Jamurtas, Krustrup, & Fatouros, 2016). Appropriate recovery from a match is suggested to require >72 h, with exercise-induced inflammatory responses and reductions in physical performance apparent for ≈96 h (Nedelec et al., 2012). However, such timelines represent single rather than consecutive matches, and thus the effect of an ensuing match within that 96h on recovery remains to be reported in professional players. In youth players undertaking 7 matches within 7 days, a significant decrease in the salivary concentration of both testosterone and Salivary IgA was observed without changes in cortisol between the start and end of the schedule (Morgans et al., 2014). However, no contextual or a baseline non-playing comparison group was reported and such a schedule in youth players does not represent the demands of professional football. Recent research (Wollin, Thorborg, & Pizzari, 2018) on hamstring strength, pain and lower limb flexibility has shown that measures remain suppressed following 48 h post-match during congested schedules in elite youth athletes.

Thus far no study has explicitly examined perceptual (ie. wellness, TQR) or outcome measures (joint mobility, muscle strength) of recovery at a standardised timeframe following single or multiple matches in a weekly microcycle in professional football (Ispirlidis et al., 2008). Consequently, the aim of this study was to examine the 48h post-match recovery profile between the 1st and 2nd match of a week during congested scheduling in professional footballers. It was hypothesised that multiple matches per week would reduce the recovery profile of players 48h following the 2nd match.

Methods

The current study examined an Australian professional football team competing concurrently in the domestic A-League (AL) competition and Asian Football Conference (AFC) Champions League. Data was collected from a total of 42 contracted players during this time, excluding goal keepers and those without match time. The players had a mean and standard deviation (SD) of age of 26.4±5.1 y, stature of 181.3±7.1 cm, and body mass of 74.5±12.1 kg. During periods of data collection, players were participating in 3-5 football-specific field-based training sessions, 1-2 gym sessions, 1-2 recovery sessions, and 1-2 competitive matches per week. All players volunteered to participate and prior to the commencement of the study were informed of any risk associated with their involvement and provided consent before being included. The study was approved by the institutional Human Research Ethics Committee (2014000355).

Data was collected as a prospective cohort study over two A-League seasons from 2013-2015 (pre-season and competition). Both seasons included AFC Champions' League matches (n=37), leading to regular multi-match weeks (n=40). Multi-match weeks were frequent during these seasons with regular acute periods of fixture congestion occurring from February

– May 2013, August – November 2014 (including ACL final), December – January 2015 and February – May 2015. Multi-match weeks were defined as weeks with 2-matches separated by <4 days (96h) of recovery (Lago et al., 2011). A 'typical' week was considered as Monday-Sunday throughout the duration of the study. Therefore, multi-match weeks consisted of a mid-week game (eg. Wednesday) followed by another (<4 days) over the weekend typically between 72 and 96 h post match 1. Data were only included from players who completed >75 min in a comparable single-match (SM) or multi-match (MM) to compare the 48h post-match outcome measures. Specifically, outcome measures included 1) 5-item subjective wellness questionnaire, 2) total quality recovery (TQR) scale, 3) hip adduction squeeze test, 4) ankle knee to wall (AKW) test, and 5) active knee extension (AKE) flexibility test. The outcome measure profiles of SM and MM players were compared 48h following each match and compared to a pre-season training baseline to further understand the recovery profile in the presence (MM) and absence (SM) of the consecutive weekly match load. Consequently, 86 data points were collated for MM whereby players had 48h post-match recovery measures from the two matches in the same week with >75min playing time in both matches. Similarly, SM had 79 data points where players completed >75 min in the 1st match within the week and did not compete in the 2nd match. Furthermore, as a proxy for a comparable baseline, the same outcome measures were collected from the first session of the week during pre-season training weeks where no training or match had occurred within the previous 48h i.e. first session of the week following a recovery day (n=19±5 weeks from 2 seasons). A mean value for each individual player for each measure was used as a baseline per player to then compare to measures 48h following 1 and 2 matches within a week. All outcome measures were collected at a standardised time in the morning at the first designated training session 48 h following each respective match.

Internal match loads, reported as arbitrary units (AU), were calculated by multiplying each players match duration (min) by their session rating of perceived exertion (sRPE) using a 0-10 scale and recorded approximately 30 min following each match (Foster, 1998).

A 5 item psychometric questionnaire, based on previous recommendations (Mclean, Coutts, Kelly, & Cormack, 2010; Gastin, Meyer, & Robinson, 2013) and with which players had extensive familiarity, was used to assess player wellness. The questionnaire comprised of questions relating to perceived fatigue, sleep quality, general muscle soreness, stress levels and mood with each question scored on a five-point Likert scale (values of 1–5 with 0.5 point increments - 1 and 5 representing anchor points relating to poor and very good ratings, respectively). Total wellness was determined by summing the 5 questions together for a score out of 25 (Hooper, & Mackinnon, 1995). Subjective ratings of wellness were collected from players upon arrival at training or matches each day. Although these scores were collected from players each day during the study period, only questionnaires completed at 48h post-match at the first training session of the week were used for analysis. A visual analog scale (VAS) was also used to determine perceived total quality recovery (TQR) using a 1 – 10 scale, with 1 being the worst possible recovery and 10 being the best possible recovery following the match (Osiecki, Rubio, Coelho, Novack, Conde, Alves, & Malfatti, 2015).

Objective outcome measures from matches were assessed 48 h post-match, which was the commencement of the first returning post-match training session. These measures included: 1) hip adduction squeeze test, 2) ankle knee to wall (KTW) test, 3) active knee extension (AKE) flexibility test and 4) sit and reach. These tests were part of the club recovery and rehabilitation inventory, and all players had extensive familiarity and practice with the test battery. It should also be noted that players were sufficiently warmed up prior to performing each test after completing the clubs prehab protocol. All measures were collected throughout the duration of the study by the principal investigators, thus minimising variation from multiple testers. Specifically, the hip adduction squeeze test and AKE flexibility test were performed by the clubs physiotherapist on all occasions for each athlete. While all testing for the ankle KTW test and sit and reach across each participant were performed by the sports scientist. Hip adduction squeeze was assessed with the player lying in the supine position with feet flat on a physiotherapy bench in 45^{o} of hip flexion. Previous research (Delahunt, McEntee, Kennelly, Green, & Coughlan, 2011) suggests that this position for the test has the smallest amount of error (SEM =1.60%). Player's hands were crossed against their chest, and head flat against the bench and performed multiple warm up efforts. Following these 'warm up' efforts, players produced a single maximum adductor squeeze on a commercially available aneroid sphygmomanometer (Code 4549, Astir, Australia) with peak pressure recorded to the nearest mmHg (Light & Thorborg, 2016). Whist not a direct replication of the procedures of previous research, such warm up and single effort procedure fit with the constraints of testing within club environments to improve efficiency and player compliance (Light & Thorborg, 2016). Unlike previous research (Toohey, 2017), the current study did not have any participants in the data set who reached the maximal reading on the sphygmomanometer.

Ankle KTW test was used to determine maximal ankle dorsiflexion range of motion (ROM) (Konor, Morton, Eckerson, & Grindstaff, 2012). Measures of ankle dorsiflexion are used to assess calf range of motion (Fong, Blackburn, Norcross, Mcgrath, & Pradua, 2011; Söderman, Alfredson, Pietilä, & Werner, 2001), given previous research suggesting that reduced calf ROM is related to an increased risk of injury (Soderman et al., 2001). A weight-bearing lunge was performed in a standing position with the players' heel in contact with the ground, the knee in line with the second toe, and the great toe starting 10 cm away from the wall. The foot was progressively moved away (or toward) from the wall 1cm at a time until they are unable to touch the wall with their knee and without lifting the heel from the ground. Player's final position was determined using a metric tape affixed to the floor with 0.1 cm increments. Ankle KTW measures using a tape measure are shown to have intra-rater reliability of r=0.98 and 0.99 for the right and left foot respectively, with SEM ranging from 0.4 - 0.6cm and minimal detectable change (MDC) between 1.1 and 1.5 cm (Konor et al., 2012). This method is also proven to be a reliable measure of ankle dorsiflexion when compared to other methods such as goniometer and inclinometer (Fong et al., 2011).

AKE flexibility test measures were obtained using a commercially available digital inclinometer (Acumar, Lafayette, IN, USA). AKE testing has previously been reported as an accurate method to assess hamstring flexibility (ICC) r=.96, (SEM=1.82) for intra-tester reliability (Worrell, Sullivan, & DeJulia, 1992). Players' were tested while lying in a supine position before raising their leg to a 45^{o} angle flexing at the hip. From this position, players' straightened their leg from the knee until reaching full extension. Players' were given 3 attempts to reach full extension before the angle of their leg was assessed using the inclinometer. While holding position at maximal extension, the investigator placed the inclinometer at the anterior crest of the tibia to measure the obtuse angle between the lower leg and knee (Worrell et al., 1992) to determine the angle of knee extension.

Finally, the sit and reach test was used to assess hamstring flexibility (Mayorga, Merino, & Viciana, 2014), with research indicating moderate mean criterion-related validity for estimating hamstring extensibility (r = 0.46-0.67), but low association with lumbar extensibility (r = 0.16-0.35) (Mayorga et al., 2014). The 'modified' sit and reach testing protocol was used to remove bias, as all players started from individual zero marks. Sit and reach was obtained using a Flex-Tester box (Power systems, Knoxville, TN, USA), which required player's to be seated with legs fully extended. Players started in a position with their head and back flat against a wall before extending the arms fully (without stretching) to determine a zero mark. Shoes were removed and feet placed flat against the measurement device, after several warm up attempts players reaching out flexing at the hip joint with both hands pushing the device forward from a zero starting mark.

Statistical Analysis

Data are presented as a mean ± standard deviation (SD). Respective two way analyses of variance (ANOVA) was performed on log transformed data to determine within-player differences in all objective and subjective recovery measures between a mean of baseline measures (ie 48h recovery during pre-season) and 48h following 1 and 2 matches within the same week (for >75min match time). Post hoc Tukey tests were performed to determine the location of significance. Statistical significance set at $p<0.05$ and the Statistical Package for Social Sciences (SPSS v22.0, Chicago, IL) was used to perform all statistical analyses. Effect sizes (ES) and 95% confidence intervals were also calculated to determine the magnitude of difference between respective 48h post-match recovery. The ES was classified as trivial (<0.2), small (>0.2-0.6), moderate (>0.6-1.2), large (>1.2-2.0) and very large (>2.0-4.0), based on classification provided by Batterham and Hopkins (2006).

Results

As presented in Table 1, match duration between SM and MM for match 1 ($p=0.61$) were not significantly different (ES: −0.05 [95% CI: −0.12, .01], trivial), nor were durations different between match 1 and 2 for MM ($p=0.56$, ES: −0.02 [95% CI: −0.09, .02], trivial). No significant differences existed for match RPE between SM and MM in match 1 ($p=0.70$, ES: 0.10 [95% CI: −1.3, .42], large) or between match 1 and 2 for MM ($p=0.63$, ES: −0.10 [95% CI: -1.12, .66], large). Accordingly, match loads also did not significantly differ between groups for match 1 ($p=0.72$, ES: 0.70 [95% CI: −0.78, .16], moderate) or between match 1 and 2 in MM ($p=0.62$, ES: −0.90 [95% CI: −0.22, .09], small).

Total wellness was significantly reduced compared to baseline following match 1 in both SM and MM ($p=0.02$, ES: 0.90 [95% CI: −0.82, 3.11], very large), without significant differences between groups ($p=0.68$, ES: −0.03 [95% CI: −0.12, .43], small). Following match 2, Total wellness was further reduced in MM compared to Baseline ($p=0.001$, ES: 1.54 [95% CI: −0.97, 3.87], very large), match 1 ($p=0.01$, ES: −1.12 [95% CI: -1.12, 1.96], large), and non-playing SM match 2 ($p=0.01$, ES: −0.10 [95% CI: -1.78, 3.11], very large). However, wellness following match 2 for non-playing SM returned to Baseline values ($p=0.10$, ES: −0.23 [95% CI: -0.21, .10], small). In explanation, the above pattern of a significant reduction from Baseline following match 1 in SM and MM ($p<0.05$) and a further reduction following match 2 in MM ($p<0.05$), but not SM ($p>0.05$), was evident for ratings of fatigue, sleep and soreness. However, significant differences were not evident for stress and mood when comparing between Baseline, match 1 ($p=0.71$, ES: 0.09 [95% CI: 0.14, 0.89], moderate) and match 2 ($p=0.69$, ES: 0.07 [95% CI: -0.70, 0.56], large) for SM week players. Conversely, following match 2 both stress and mood were reduced when compared to Baseline ($p=0.001$, ES: 0.82 [95% CI: -0.23, 2.16], very large) and non-playing SM match 2 ($p=0.001$, ES: 1.14 [95% CI: 1.19, 2.11], large) in MM players. For the TQR score (Table 2), following match 2 in MM there was a significant reduction compared to Baseline ($p=0.01$, ES: 0.91 [95% CI: 0.89, 2.16], large) and non-playing SM match 2 ($p=0.02$, ES: 1.34 [95% CI: 1.10, 3.54], very large). However, no significant differences were evident when comparing TQR scores between Baseline and SM match 1 ($p=0.77$, ES: -0.64 [95% CI: 0.19, 0.91], moderate) or match 2 ($p=0.61$, ES: -0.27 [95% CI: 0.15, .69], small).

Hip adduction squeeze test was significantly reduced compared to Baseline following match 1 in both SM and MM ($p=0.01$, ES: 1.37 [95% CI: -1.26, 3.69], very large; $p=0.01$, ES: 1.22

[95% CI: -1.17, 3.23], very large; Table 3), without significant differences between groups (p=0.60, ES: -0.07 [95% CI: 0.25, .72], small). Following match 2, hip adduction squeeze test was further reduced in MM match 2 when compared to baseline (p=0.01, ES: 1.81 [95% CI: -1.76, 2.72], very large), match 2 non-playing SM (p=0.02, ES: 0.87 [95% CI: -1.76, 1.92], very large) and match 1 MM (p=0.01, ES: 1.09 [95% CI: -0.91, 1.99], very large). In contrast, no significant differences were evident in hip adduction squeeze test for non-playing match 2 SM when compared to Baseline (p=0.01, ES: -0.21 [95% CI: -0.76, .13], moderate). No significant differences were evident for KTW (L), KTW (R) and Sit and Reach when comparing between or within SM, MM and Baseline ($p<0.05$). AKE (L) and (R) were significantly reduced when comparing between MM match 2 and SM match 1, however when comparing SM and MM to Baseline no significant differences were evident ($p>0.05$).

Discussion

This study is the first to examine the 48h post-match recovery of subjective wellness, TQR and selected outcome measures of hip adduction squeeze test, ankle KTW test, and AKE flexibility test for elite Australian footballers (soccer) during periods of fixture congestion. Not unexpectedly, multiple matches with <96h recovery results in suppressed 48h post-match subjective wellness and TQR, along with reductions in hip adduction squeeze test. Conversely, all other outcome measures and the majority of subjective wellness measures (except fatigue and soreness) demonstrate a return to baseline for players who didn't play in the second match within a week.

Given recovery is related to the imposed load, it is important to recognise the match loads of players when interpreting recovery state. Accordingly, no differences existed in match duration or internal match loads between the first and second match in a multi-match week who had >75min playing time in both. Whilst internal match loads and match duration were comparable, it is acknowledged the lack of external load measures are a limitation to the interpretation of the current recovery data. Given international football regulations at the time prevented use of in-match monitoring systems at the time of collection, no external load variables are available, and this is duly acknowledged as a unavoidable limitation. However in support, running-based movement variables do not change between matches within congested schedules (Arruda et al., 2015). For example, whilst acceleration profiles are altered throughout congested schedules, no differences for total or mean distance, high-intensity running or peak running speed are evident (Arruda et al., 2015). Consequently, the lack of difference between matches in congested schedules for external load in previous studies, and similar internal load responses in the current study, suggest comparable match loads with which to then contrast the 48h post-match recovery profile.

Measures of subjective wellness provide an insight into the internal response and are known to be responsive to training load (Ispirlidis et al., 2008; Gastin et al., 2013; Thorpe, Strudwick, Buchheit, Atkinson, Drust, & Gregson, 2016). In the present study, subjective wellness was reduced 48h following the first match in both groups, but was further reduced following match 2 in MM. Previous research (Thorpe et al., 2016) demonstrates wellness to be reduced 48 h post-match compared to pre-match values for English Premier League players in a ‘standard’ 1 match week. Furthermore, wellness has been shown to recover to pre-match values by 96h post-match in Australian rules football players (Cormack, Lorenzen, Tania, & Gabbett, 2017). Despite similar trends observed here for SM players, those competing in MM showed further reductions in subjective wellness following the 2nd match. Such responses suggest that the congested scheduling exacerbates the poorer recovery state in the context of maintained match loads. More specifically, the sub-components of subjective wellness most responsive to these match loads were fatigue, sleep and soreness, which have also shown responsiveness in Australian rules footballers (Cormack et al., 2017). In the present study, these responses are likely explained by the engagement in repeated match demands and predominant night fixtures disturbing sleep patterns and possibly air travel (Fowler, Duffield, & Vaile, 2014). Collectively, these findings show the usefulness of subjective wellness to monitor post-match recovery, particularly fatigue, sleep and soreness.

Perceived recovery via TQR values in the current study remained unchanged compared to Baseline 48h following the 1st match of both SM and MM, and then decreased only after MM match 2. Previous research (Gjaka, Tschan, Francioni, Tishkuaj, & Tessitore, 2016; Osiecki, Rubio, Coelho, & Malfatti, 2015) using TQR in response to training load (session and match) has also been primarily used for acute time periods of 4 weeks in youth (Gjaka et al., 2016) and following 1 match in elite Brazilian soccer players (Osiecki et al., 2015). However, Gjaka et al., (2016); recently reported TQR scores were unchanged in youth soccer players participated in either 1 or 2 matches/week over a 4-week period, regardless of differences in match loads. The lack of change in TQR following matches reported here could suggest this scale is less responsive than wellness measures. However, the reductions in TQR following MM match 2 could suggest players only start to perceive suppressed recovery when multiple matches have occurred. Consequently, perceived recovery tools such as TQR can be useful to monitor recovery during congested schedules.

Hip adduction squeeze test was the only objective outcome measure of strength or range of motion to show responsiveness to either a single or multi-match schedule. Specifically, hip adduction was reduced following match 1 in both SM and MM players and match 2 in MM but not SM. Previous evidence suggests a time course of post-match muscle damage and functional impairments to be 72 – 96 h, and the current data supports such propositions (Nedelec et al., 2012; Silva et al., 2018). The further addition of another match within 96h of the first match may explain the further reduction in hip adduction reported here; likely due to the physical match demands placed upon a muscle group (adductors) thought to be weaker in a region dominated by larger muscle groups of the hip/gluteal region (Osiecki et al., 2015). Comparable data in the literature is scarce, though recent research (Wollin, Pizzari, Spagnolo, Welvaert, & Thorborg, 2017) reports congested football in youth players reduced hip adduction with individual varying magnitude, with some players showing peak force reductions of up to 40% throughout a 7 match tournament. The authors also observed that peak force resulting from the hip adduction squeeze test was reduced for every 100 unit increase in match load (Wollin et al., 2017). When considering these results and the findings of the current study it appears that a simple hip adduction squeeze test may be an appropriate objective assessment to monitor player recovery during times of increased match scheduling.

Although the hip adduction squeeze test showed post-match reductions in the current study, ankle KTW, AKE flexibility test and sit and reach tests were unchanged 48h post-match. At present, limited research exists on the use of ankle KTW tests to assess post-match recovery of ankle dorsiflexion (Wollin et al., 2017); rather, studies have focused on identification of risk factors for lower body injuries (Soderman et al., 2001). Knee extension tests have shown (Ispirlidis et al., 2008), joint ROM was suppressed for 96 h post-match in elite soccer players compared to a non-playing control group. The present study did not observe any change in AKE flexibility, though the context of testing time points may have resulted in such findings. Similar findings were also recently reported (Charlton, Raysmith, Wollin, & Rice, 2018), which suggested that despite hamstring flexibility being reduced post match in semi-professional Australian rules football players, reductions were not clinically meaningful.

Finally, sit and reach did not show any significant differences from Baseline or between matches in the current study. Previous research (Dawson, Gow, Modra, Bishop, & Stewart, 2005) in Australian rules football investigated different post-match recovery modalities and also reported equivocal changes in post-match sit and reach tests. Consequently, despite the regular use of AKE flexibility and other flexibility tests in football, these measures were unresponsive when measured 48h post-match during congested scheduling in professional soccer.

It should be acknowledged that a potential limitation of the current study is the use of 'pre-season' outcome measures as a baseline. This was used as a proxy given the inability to collect pre-match measures within ecological environments of professional football. Whilst not ideal due to the potential for higher training loads during pre-season weeks; it is likely players had the best chance at a "trained", yet fully recovered state to use as a comparative baseline. A further limitation is the use of players completing >75min of match time for analysis and not players completing a full 90min match. As some justification, during increased periods of fixture congestion players are frequently rotated and have their playing times reduced, as a consequence participant numbers for players completing 90mins would be extremely low.

Conclusion

This study examined the 48h post-match recovery profile of single and multi-match weeks in professional footballers. The findings show that congested schedules result in self reported subjective measures of wellness (particularly fatigue, sleep and soreness), and TQR, as well as hip adduction squeeze test for players who accumulate >75 min of match-play time in both matches. Comparably, outcome measures for players who only undertook one match returned to baseline values at 48 h following the 2nd match in which they did not play. Therefore, the current research suggests that congested scheduling resulting in MM weeks impacts on players post-match recovery by prolonging the duration for return to baseline.

Practical Applications

- Players competing in congested schedules exhibited reduced hip adduction squeeze peak pressure and TQR at 48h following the 2nd match within a week compared to players competing in 1 match per week.
- Athlete monitoring could use subjective (fatigue, sleep, soreness) and objective (hip adduction squeeze) measures in the identification and management of players with reduced function [due to fatigue] and possibly health during congested match schedules.

Acknowledgements

The authors would like to thank the Western Sydney Wanderers football club, their coaching staff and participant's for making the current study possible.

References

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. *Int Journal Sports Physiology Performance, 10*(2), 248-252.

Ascensão, A., Rebelo, A., Oliveira, E., Marques, F., Pereira, L., & Magalhães, J. (2008). Biochemical impact of a soccer match—analysis of oxidative stress and muscle damage markers throughout recovery. *Clinical Biochemistry, 41*(10), 841-851.

Batterham, M. A., & Hopkins, G. W. (2006). Making meaningful inferences about magnitudes. *Int Journal Sports Physiology and Performance, 1*(1). 50-57.

Bengtsson, H., Ekstrand, J., Hagglund, 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 Sports Medicine, 47*(12). 743-747.

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? *Int Journal Sports Medicine, 33*(1), 36-42.

Carling, C., Orhant, E., & LeGall, F. (2010). Match injuries in professional soccer: inter-seasonal variation and effects of competition type, match congestion and positional role. *Int Journal Sports Medicine, 31*(04), 271-276.

Carling, C., McCall, A., Le Gall, F., & Dupont, G. (2015). What is the extent of exposure to periods of match congestion in professional soccer players? *Journal Sports Science, 33*(20), 2116-2124.

Charlton, C. P., Raysmith, B., Wollin, M., & Rice, S. (2018). Knee flexion strength is significantly reduced following competition in semi-professional Australian Rules football athletes: Implications for injury prevention programs. *Physical Therapy in Sport, DOI: 10.1016/j.ptsp.2018.01.001*

Cormack, S., Lorenzen, HC., Tania, F. G., & Gabbett, J. T. (2017). Self-Reported Wellness Profiles of Professional Australian Football Players During the Competition Phase of the Season. *Journal of Strength Conditioning Research, 31*(2), 495-498.

Dawson, B., Gow, S., Modra, S., Bishop, D., & Stewart, G. (2005). Effects of immediate post-game recovery procedures on muscle soreness, power and flexiblity levels over the next 48 hours. *Journal Science Medicine Sport, 8*(2), 210-221.

Delahunt, E., McEntee, B. L., Kennelly, C., Green, B. S., & Coughlan, G. F. (2011). Intrarater reliability of the adductor squeeze test in gaelic games athletes. *Journal Athletic Training, 46*(3), 241-245.

Dellal, A., Lago-Peñas, C., Rey, E., Chamari, K., & Orhant, E. (2013). The effects of a congested fixture period on physical performance, technical activity and injury rate during matches in a professional soccer team. *British Journal Sports Medicine, 49*(6), 390-394.

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. *American Journal of Sports Medicine, 38*(9), 1752-1758.

Fong, C.-M., Blackburn, J. T., Norcross, M. F., McGrath, M., & Padua, D. A. (2011). Ankle-dorsiflexion range of motion and landing biomechanics. *Journal of Athletic Training, 46*(1), 5-10.

Foster, C. (1998). Monitoring training in athletes with reference to overtraining syndrome. *Medicine and Science in Sports and Exercise, 30*(7), 1164-1168.

Fowler, P., Duffield, R., & Vaile, J. (2014). Effects of Domestic Air Travel on Technical and Tactical Performance and Recovery in Soccer. *Sports Physiology and Performance, 9*(1). 378-386.

Gastin, P. B., Meyer, D., & Robinson, D. (2013). Perceptions of wellness to monitor adaptive responses to training and competition in elite Australian football. *Journal of Strength & Conditioning Research, 27*(9), 2518-2526.

Gjaka, M., Tschan, H., Francioni, F. M., Tishkuaj, F., & Tessitore, A. (2016). Monitoring of loads and recovery perceived during weeks with different schedule in young soccer players. *Kinesiologia Slovenica, 22*(1), 16.

Hooper, S. L., & Mackinnon, L. T. (1995). Monitoring overtraining in athletes recommendations. *Sports Medicine, 20*(1), 321–327.

Ispirlidis, I., Fatouros, I. G., Jamurtas, A. Z., Nikolaidis, M. G., Michailidis, I., Douroudos, I., Katrabasas, I. (2008). Time-course of changes in inflammatory and performance responses following a soccer game. *Clinical Journal of Sport Medicine, 18*(5), 423-431.

Konor, M. M., Morton, S., Eckerson, J. M., & Grindstaff, T. L. (2012). Reliability of three measures of ankle dorsiflexion range of motion. *International Journal of Sports Physical Therapy, 7*(3), 279.

Lago-Peñas, C., Rey, E., Lago-Ballesteros, J., Casáis, L., & Domínguez, E. (2011). The influence of a congested calendar on physical performance in elite soccer. *Journal Strength & Conditioning Research, 25*(8), 2111-2117.

Leung, A. W. S., Chan, C. C. H., Lee, A. H. S., & Lam, K. W. H. (2004). Visual analogue scale correlates of musculoskeletal fatigue. *Perceptual and Motor Skills, 99*(1), 235-246.

Light, N., & Thorborg, K. (2016). The precision and torque production of common hip adductor squeeze tests used in elite football. *Journal of Science and Medicine in Sport, 19*(11). 888-892.

Mayorga-Vega, D., Merino-Marban, R., & Viciana, J. (2014). Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: A meta-analysis. *Journal of Sports Science & Medicine, 13*(1), 1.

Mclean, D. B., Coutts, J. A., Kelly, V., & Cormack, S. (2010). Neuromuscular, Endocrine, and Perceptual Fatigue Responses During Different Length Between-Match Microcycles in Professional Rugby League Players. *Int Journal Sports Physiology Performance, 5*(3). 367-383.

Mohr, M., Draganidis, D., Chatzinikolaou, A., Barbero-Alvarez, J. C., Castagna, C., Douroudos, I., Avloniti, A., Margeli, A., Papassotiriou, I., Flouris, A. D., Jamurtas, A. Z., Krustrup, P., & Fatouros, I. G. (2016). Muscle damage, inflammatory, immune and performance responses to three football games in 1 week in competitive male players. *European Journal Applied Physiology, 116*(1). 179-193.

Morgans, R., Orme, P., Anderson, L., Drust, B., & Morton, J. P. (2014). An intensive winter fixture schedule induces a transient fall in salivary IgA in English Premier League soccer players. *Research in Sports Medicine, 22*(4), 346-354.

Nédélec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2012). Recovery in soccer. *Sports Medicine, 42*(12), 997-1015.

Osiecki, R., Rubio, T. B. G., Coelho, R. L., Novack, L. F., Conde, J. H. S., Alves, C. G., & Malfatti, C. R. M. (2015). The Total Quality Recovery Scale (TQR) as a Proxy for Determining Athletes' Recovery State after a Professional Soccer Match. *Journal of Exercise Physiology Online, 18*(3), 27-33.

Rey, E., Lago-Peñas, C., Lago-Ballesteros, J., Casais, L., & Dellal, A. (2010). The Effects of a Congested Period on the Activity of Elite Soccer Players. *Biology Sport, 27*(3), 89-95.

Rowell, A., Aughey, R., Hopkins, W., Esmaeil, A., & Lazarus, B. (2018). Effects of Training and Competition Load on Neuromuscular Recovery, Testosterone, Cortisol, and Match Performance During a Season of Professional Football. *Frontiers in Physiology, 7*(9), 668-669.

Silva, J. R., Rumpf, M. C., Hertzog, M., Castagna, C., Farooq, A., Girard, O., & Hader, K. (2018). Acute and Residual Soccer Match-Related Fatigue: A Systematic Review and Meta-analysis. *Sports Medicine, 48*(3). 539-583.

Söderman, K., Alfredson, H., Pietilä, T., & Werner, S. (2001). Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. *Knee Surgery, Sports Traumatology, Arthroscopy, 9*(5), 313-321.

Thorpe, R. T., Strudwick, A. J., Buchheit, M., Atkinson, G., Drust, B., & Gregson, W. (2015). Monitoring fatigue during the in-season competitive phase in elite soccer players. *Int Journal Sports Physiology Perform, 10*(8), 958-964.

Wollin, M., Pizzari, T., Spagnolo, K., Welvaert, M., & Thorborg, K. (2017). The effects of football match congestion in an international tournament on hip adductor squeeze strength and pain in elite youth players. *Journal Sports Science, 36*(10), 1-6.

Wollin, M., Thorborg, K., & Pizzari, T. (2017). Monitoring the effect of football match congestion on hamstring strength and lower limb flexibility: Potential for secondary injury prevention? *Physical Therapy in Sport, 29*(1). 14-18.

Worrell, T. W., Sullivan, M. K., & DeJulia, J. J. (1992). Reliability of an active-knee-extension test for determining hamstring muscle flexibility. *Journal of Sport Rehabilitation, 1*(3), 181-187.

Table 1: Mean ± SD Match and Load data from single and multiple matches.

Variable	Single match	Multiple match	
	Match 1 (n=79)	Match 1 (n=86)	Match 2 (n=86)
Match Duration	90 ± 12	90 ± 14	89 ± 12
RPE	8.4 ± 0.9	8.4 ± 0.7	8.4 ± 0.8
Match Load	758 ± 140	759 ± 140	749 ± 128

Note: no significant differences between or within conditions.

Table 2: Mean ± SD perceived wellness and total quality recovery 48h following matches for group pre-season baseline, and the 1st and 2nd match in a week for players who only played the 1st, and players who played both matches within congested weeks.

Variable	Baseline (n=19)	Single match		Multiple matches	
		Post-match 1 (n=79)	Post-match 2 (n=79)	Post-match 1 (n=86)	Post-match 2 (n=86)
Fatigue (AU)	3.9±0.5	3.1±0.7*	3.8±0.5#	3.0±0.5*^	2.6±0.5*#^**
Sleep (AU)	3.8±0.3	3.1±0.9*	3.6±0.8#	3.1±0.8*^	2.6±0.7*#^**
Soreness (AU)	3.8±0.4	2.9±0.8*	3.6±0.5#	3.0±0.5*^	2.5±0.5*#^**
Stress (AU)	3.9±0.8	3.8±0.4	3.8±0.6	3.7±0.5	3.3±0.5*#^**
Mood (AU)	3.9±0.4	3.8±0.5	3.9±0.8	3.8±0.5	3.5±0.6*#^**
Total Wellness (AU)	19.1±0.9	16.8±1.7*	18.3±2.1#	16.6±1.9*^	14.6±1.8*#^ **
TQR (AU)	8 ± 1	8 ± 1^	7 ± 1	7 ± 1	6 ± 1*#^

TQR = Total Quality Recovery.

*Represents significantly different to Baseline ($p<0.05$)
#Represents significant difference to SM Match 1 ($p<0.05$)
^Represents significant difference to SM Match 2 ($p<0.05$)
** Represents significant difference to MM Match 1 ($p<0.05$)

Table 3: Mean ± SD Outcome Measures 48h following matches for group pre-season baseline, group 1 playing in the 1st match within a week and group 2 playing a ‘multi-match’ week.

Variable	Baseline (n=19)	Single match		Multiple match	
		Post-match 1 (n=79)	Post-match 2 (n=79)	Post-match 1 (n=86)	Post-match 2 (n=86)
HAST (mmHg)	274 ± 34	266±35*	272 ± 29#	263 ± 30*	249 ± 34*#^**
KTW (L) (cm)	10 ± 3	9 ± 2	10 ± 2	10 ± 2	10 ± 2
KTW (R) (cm)	10 ± 3	9 ± 3	10 ± 2	10 ± 2	10 ± 2
Sit and Reach (cm)	11 ± 6	10 ± 1	10 ± 2	10 ± 2	10 ± 2
AKE (L) (degrees)	81 ± 8	84 ± 7	82 ± 7	82 ± 9	79 ± 6#
AKE (R) (degrees)	82 ± 7	84 ± 7	84 ± 6	82 ± 9	80 ± 6#

HAST = Hip Adduction Squeeze Test; KTW (L) = Knee to Wall Left; KTW (R) = Knee to Wall Right; AKE (L) = Active Knee Extension Left; AKE (R) = Active Knee Extension Right.

*Represents significantly different to Baseline ($p<0.05$)
#Represents significant difference to SM1 Match 1 ($p<0.05$)
^Represents significant difference to SM Match 2 ($p<0.05$)
** Represents significant difference to MM Match 1 ($p<0.05$)