Title: Planning the microcycle in elite football: to rest or not to rest?

Running title: Days off and injuries in elite football

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Abstract

Purpose: To examine the association between the programming of days off (i.e., no pitch training, days off-feet) within turnarounds of varying length and injury rate in elite soccer. ***Methods:*** Retrospective data from 56 team-seasons, belonging to 18 elite teams performing in top leagues including the EPL, the Italian Serie A, the Bundesliga, the Scottish Premiership, the MLS and the Dutch Eredivisie from January 2018 to December 2021 were analysed (total of 1578 players, 2865 injuries, 2859 non-international matches and 12939 training session days). The turnarounds examined lasted from 3 to 8 days. Only injuries with ≥3-day time loss were retained for analysis. We then looked at the injury rate within each microcycle in relation to the presence of a day off or not, and its programming sequences in relation to the previous match (i.e., day off at D+1 vs D+2 for the day after the match or the following, respectively). ***Results:*** During 3- and 7-d turnarounds, the sequences including the day off-feet at D+2 were associated with 2 to 3 times lower overall non-contact injury rates than the other programming sequences (Cohens' d: 0.9 to 2.7). For the other turnarounds, the differences between the sequences were unclear. ***Conclusion:*** The programming of a day off (or at least 'off-feet') at D+2 may be associated with moderately-to-largely lower incidences of non-contact injuries, especially during 3- and 7-d turnarounds.

Key words: planning; programming; elite football; injuries; rest day

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Introduction

Planning the microcycle is complex in elite (soccer) football.[1] While there are some informative data now available on programming practices in soccer, [2-11] these are generally representative of single club practices and only provide quantitative information (e.g., external load dynamic based on GPS). Recently, in order to better understand the reasoning behind the choice and the drivers for planning and content selection, we surveyed 100 elite practitioners working in pro football.[1] The large majority of the responders confirmed collectively that balancing work and recovery from one day to the next across the microcycle was very likely required for optimised health and performance.[1] However, whether putting players at complete rest for one or two days affects injury rate during the same microcycle and the following match is still unknown. The question of what day to take off, and even whether to give a day off at all is something that has not been examined scientifically despite its immense importance in terms of recovery, compensation and psycho-social team dynamic.[1,12]

In order to shed light into this important topic, we examined in this descriptive study the association between the programming of days off and injury rate, using retrospective data from 18 elite teams performing in top leagues including the EPL, the Italian Serie A, the Bundesliga, the Scottish Premiership, the MLS and the Dutch Eredivisie from January 2018 to December 2021. We more precisely also looked at the timing of these day(s) off within turnarounds of varying lengths. We then looked at the influence of prior match congestions on the above-mentioned associations. While the present observational study design precludes the examination of causal relationships, we believe that the information provided could help managers and performance staff to optimise the programming of their microcycles, within their own context.

Methods

Data collection

For this study, player characteristics, participation data and injury details were extracted from an online database (i.e., Kitman Labs platform, Dublin, Ireland) commonly used by all the football teams involved in the study. Each player and club is provided with an ID number on the platform. The researchers in charge of the analysis could only pull and analyze data associated with their IDs - no names included. Then, data was transformed and coded for injury occurrence (dates only used for assessing occurrences, such as during a match vs during training and when in relation from/to the previous match) and type (contact or non-contact injury, without any more details), to provide a final dataset.

The medical staff of each team registers injury details in the platform as a part of their daily player care management, including variables such as date of injury, type of injury and injury severity (days lost). Similarly, player game and training session participation are recorded as part of the team staff's daily monitoring. Additionally, the measures of training and competitive load are also added to the platform. The fact that all clubs used the same platform ensured the standardisation and the reliability of all types of entries, from medical information to exposure measures (e.g., session duration and GPS data attached to the system calendar). We nevertheless ran a thorough data health check to ensure that all data retained for analysis met the same standard.

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Permission was granted by the teams for their inclusion in this study, therefore ethics committee clearance was not required. The study conforms nevertheless to the recommendations of the Declaration of Helsinki.

Data were extracted from 18 teams belonging to EPL, the Italian Serie A, the Bundesliga, the Scottish Premiership, the MLS and the Dutch Eredivisie from January 2018 to December 2021. This represented 82 team-seasons.

Since preliminary analysis didn't show any trends suggestive of differences between the different leagues or continents, all data were pooled together to increase sample size.

Team-seasons for which injury information was not accessible were not used for analysis. Likewise, when there was not enough information about players on the platform (e.g. no exposure for less than 15 players over the entire season), the team season was not included. The final data set included 56 team-seasons, including a total of 1578 players, 2865 injuries, 2859 non-international matches and 12939 training session days.

Data preparation

A n-d turnaround was defined as a microcycle with n days between the first and second match, where n is the count of days from the first day after a match up to and including the following match day. The shortest observed turnaround was 3 days (3-d) e.g. playing a match on Sunday and again the following Wednesday, while the longest was 8 days (8-d) e.g. playing on Saturday and again the following Sunday. In total, 1871 turnarounds were extracted and were grouped by their respective length.

Turnarounds following at least one 3-d turnaround were considered as congested.[13]

In the absence of direct access to teams calendars and schedules, we assumed that a day off was a day without a game where the main 15 players of a given team did not have any training session exposure registered in the Kitman Labs platform. We considered that an exposure took place on a given day when there was information about either workload, duration or third-party metric with a game or training session event tag. We then considered that these exposures were accurate as they were extrapolated from the metrics consistently collected by the teams. Using this classification, it is very likely that non-exposure days were rest days, but we can't rule out that some light activities may have taken place at the club (i.e., recovery, mobility, football-tennis, etc), which, given their nature, were not registered as exposure. Therefore, considering those non-exposure days as "days off-feet" is likely the most accurate description of those specific days - this terminology was consequently used throughout the manuscript.

The 15 outfield players with the highest number of both pre- and in-season games played during a given season were considered as the main players. Note that these 15 main players can be different from one season to another for a given team. Days off-feet distribution patterns were examined within each microcycle. Days were first coded as 'x' for a day trained and as 'o' for a day off-feet; all possible combinations (e.g. x/x/x, o/x/x, x/o/x, x/x/o, o/o/x, o/x/o, x/o/o, o/o/o for 4-d turnarounds) were then created for each turnaround. Only the specific sequences with ≥10 occurrences within each turnaround were retained for analysis.

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Injury is often defined as an occurrence sustained during either training or match-play which prevents a player from taking part in training or match-play for 1 or more days following the occurrence.[14] In this study we wanted to focus on non-contact injuries that substantially impact training and match participation and so only considered non-contact injuries that caused a minimum of 3 days of training/playing interruption i.e. ≥3-day time loss. In fact, we excluded all mild injuries (<2 days lost) because injuries in this category could conceivably not have an impact on the next game availability or training dynamic within the same turnaround. Overall, this choice has allowed us not to include days lost due to potential training removal as a result of player management, as it sometimes happens in clubs.[15] If the medical staff registered injuries from the start to the end of the season, we considered that they strictly did it during the whole season, so we assumed that there was no missing data for this metric in this situation.
Considering all the above, there were 511 main players and 965 time-loss injuries, including 559 non-contact ones (both match and training), as part of the 56 team-seasons.

Data analysis
Data was analysed in three consecutive steps, from a macro to a micro level.
1. Presence of a day off-feet *per se* and injury rate: we examined the potential difference in both training and match injury rates (per entire turnaround and per actual training day) with the presence or absence of at least a day off-feet in the turnaround - for all turnarounds pooled together, and then for each specific turnaround length separately.
2. Presence of match congestion (0, 1 or ≥2 of 3-d turnarounds) prior to turnarounds including a least one day off-feet, or not, and injury risk.
3. Distribution (i.e., when) of days off-feet during each turnaround length, and their association with training and match injuries.
For the later level of analysis, injuries were presented both per entire turnaround and per actual number of training days only; e.g. for x/x/x : overall non-contact injury rate per turnaround was calculated as follows: 0.15 non-contact game injuries per microcycle + 0.05 non-contact training injuries per microcycle = 0.20 non-contact game and training injuries per microcycle; overall non-contact injury rate per training + match days only: 0.15 non-contact game injuries per day + 0.025 (=0.05/2 training days) non-contact training injuries per day = 0.175 non-contact match and training injuries per day.

Statistical analysis
Results are presented as a mean and 95% confidence intervals. Substantial differences were assumed when the CIs did not overlap.[16] Cohen's d was then calculated to provide a magnitude of the differences, with thresholds of 0.2, 0.6, 1.2 and 2 considered as small, moderate, large and very large effects/differences.[17]

Results
Overall injury rate was 5 times greater during matches than during training (Table 1), with no difference between turnaround lengths, except for the 5-d turnaround which displayed fewer

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injuries than all the others.

Training injuries were slightly lower for the 3- and 4-d turnarounds compared with the longest, but those differences were almost absent when expressed in relation to the actual numbers of days of exposure (Table 1). The differences in both training and match injury rates between turnarounds with and without a day off-feet were unclear. This was observed both when all turnarounds pooled together, and also when each specific turnaround was examined separately (all CIs overlapping, data not shown).

The number of congested turnarounds preceding the turnarounds of interest didn't have a clear relationship with either training or match injury rate, with or without day(s) off-feet - irrespective of the turnaround length (all CIs overlapping, data not shown).

The most represented training and days off-feet sequences within each turnaround are shown in Table 2. For all turnarounds up to 6-d the most frequent practice was to train all days of the microcycle (30 to 80%, with the shorter the turnaround, the less frequent the days off). For all these turnarounds, if a day off was programmed it occurred more commonly on D+1. For the two longest turnarounds, 7-d and 8-d, the most common practice was to give a day off-feet at D+1, followed by training every day.

We observed some substantial differences both in non-contact training and match injuries as a function of training and days off-feet sequences within some of the typical turnarounds (Figures 1 and 2). In our sample there were no non-contact training injuries during 3-d turnarounds when a day off-feet was included (irrespective of the day). The relative frequency of these turnarounds was quite low however (Table 2). The match injury rate across the entire 3-d turnarounds with a day off-feet at D+1 was about 50% of the rate for turnarounds with training every day. There were no match injuries at all for turnarounds with a day off-feet at D+2 (Figure 1).

During 5-d turnarounds, there were no non-contact training injuries when two days off-feet was programmed at both D+1 and D+2. During 6-d turnarounds, the lowest non-contact training injury rate was observed when there was either no day off-feet, and when the latter was programmed at D+2 (with unclear difference in match injury rate). During 7-d turnarounds, both non-contact training and match injuries were lower when the day off-feet was programmed at D+2 than when not programmed at all or at D+1. During 4- and 8-d turnarounds, all injury rate differences between the different sequences were unclear.

When looking at non-contact training and match injuries together (Figure 2), and focusing on the three most common programming practices only (i.e., no day off, a day off at D+1 or D+2), the sequences including the day off at D+2 (x/o/…) were associated with 2 to 3 times lower injury rates per day (moderate-to-very large Cohen's d) than the 2 other sequences for the 3- and 7-d turnarounds. For the other turnarounds, the differences between the main 3 sequences were unclear.

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Discussion

This is to our knowledge the first study to examine the association between the programming of day(s) off (at least days 'off-feet') within the training microcycle, and both training and match injury rates. While the present observational study design precludes the examination of causal relationships, the present findings suggest that while planning a day off *per se* may not share clear associations with injury rate (results not shown and Figure 2), the programming and distribution of the day off-feet within the microcycle (i.e. when the day off is scheduled), does, especially for 3- and 7-d turnarounds. Despite some variability between the different turnaround lengths, the sequences including the day off-feet at D+2 (x/o/…) were associated with 2 to 3 times lower injury rates per day (large to very large Cohen's d) than the 2 other sequences for the 3- and 7-d turnarounds (Figure 2). These associations with injury rate weren't affected by prior match congestion, suggestive of the robustness of the association between injury rate and this specific microcycle structure (i.e., x/o/…).

While there are always many ways to program the microcycle, training at D+1 and having a day off at D+2 may offer several advantages both on the performance and injury sides of things. At D+1, while the starters of the previous match can receive treatment and perform their recovery session, all benched players and substitutes also have the opportunity to train hard to compensate for the match they didn't play. This allows everyone to 'close the previous turnaround cycle' (recovery/compensation), and then rest for all the next day (D+2) before getting back fresh at D+3 for a new 'cycle' until the next match.
Conversely, when having the day off at D+1, the opportunities to care for starters and compensate for benched and substitute players are reduced, and potentially postponed. The consequence of this is that some starters may still need some treatment at D+2 and may therefore not be able to train, and subs may have been under a reduced training regime for 2-3 consecutive days (light load at D-1, 0 to 30 min of play max on MD, and off at D+1), disturbing an optimal training dynamic and likely limiting their overall adaptation. Along these lines, when training is continually interrupted, substitutes end up lacking training stimulus, and especially with respect to some key elements of the game (e.g., sprinting distance[18]). They often tend to show reduced neuromuscular performance as the season progresses.[19] While not implying causality, our results may provide support to the common practice of having the (only) day off-feet at D+2, irrespective of the turnaround length, at least when injury is the consideration.

When looking at specific training and rest days distributions, it appeared that in all turnarounds up to 6-d the most frequent practice was to train on the pitch every day of the microcycle (Table 2). In addition, for all these turnarounds if a day off-feet was to be programmed, it was preferentially programmed on D+1. For the two longest turnarounds (7- and 8-d, Table 2), the preference was to give a day off-feet at D+1, followed by training every day. This contrasts with the results of our recent survey of 100 elite practitioners[1] where having the day off at D+2 (rather than D+1) was reported to be the optimal option. This may be related to the fact that when responding, the practitioners may have been biased toward their preferences rather than their actual practices (as per the data analysed in the present study). Therefore, the microcycle structure associated with the lowest injury rate was

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not the most commonly programmed, irrespective of the turnaround length (e.g., the occurrence of the 'x/o/x/x/x/x/x' sequence was only 10% vs 25% for the o/x/x/x/x/x/x' sequence, Table 2). It's also worth noting that coaches may not always want to consider the 'injury' argument as their first consideration when programming their microcycles; other factors including psycho-social team dynamics (players generally prefer D+1 to be off), the need to provide a greater overall training stimulus to players (very little rest or no days off at all during pre-season, returning from breaks) or to prepare tactically for important matches, and various external constraints (e.g., travels) may often need to be prioritised. Also, while having the day off at D+2 still allows for a complete training cycle post day off for the longest turnarounds e.g., 4 days left to prepare the next match during a 7-d turnaround, this may disrupt optimal match preparation during short turnarounds e.g., 1 day left to prepare the next match during a 4-d turnaround. In summary, coaches may not see the "rest at D+2 option" as a relevant alternative in their own context even though it may be ideal on paper from a physiological and biological standpoint.

Finally, the reason for the lack of clear and consistent differences in injury rates between the different sequences within the 4-, 5-, 6- and 8-d turnarounds (Figure 2) is difficult to explain with the current data limited to exposure information. A simple first explanation is likely related to the lower samples for these turnarounds (Table 2), which directly increases the breath of the CIs, making in turn some of the between-sequences differences unclear. It is also likely that other factors may share more associations with injury rate than the programming of days off *per se*, and, in turn, could have diluted/confounded the analysis. One important limitation is the univariate nature of the present analysis. While we thought to answer the simple question of the programming of rest days, it is clear that injuries are largely multifactorial in nature[20] and that different loading patterns, match exposures and minutes played within the same sequences may also directly affect injury rates. In fact, the data from the practitioners' survey[1] showed that while the current loading and training contents are pretty homogenous between teams for 7-d turnarounds, there is more variability in programming for 5- and 6-d turnarounds. This may partly explain why the association between days off-feet and injury rate was unclear for those turnarounds. We will certainly continue to investigate this and other topics related to planning the microcyle but given the lack of research in this area we encourage other researchers to think about experimental designs which would provide more insight on how best to adapt the training schedule to the fixture schedule.

Additionally, the simultaneous consideration of player profiles (e.g., age, injury history, strength, mobility or flexibility) and other measures of internal training load and responses to load should also improve the analysis - while making the current outputs less straightforward for practitioners. There is in fact a trade-off between the desire for simple questions to have simple answers (e.g, when is it best to rest?) and more sophisticated analytic approaches that may have more precision but require more effort to interpret in order to provide direct applications (i.e. results of multivariate analyses can be difficult to translate into simple yes/no answers).

Limitations

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The present observational study design precludes the examination of causal relationships. Having a proper distinction between complete rest days, days off-feet and training days would have been ideal. In the absence of direct access to teams' calendars and schedules, days off were estimated based on exposure data (workload, duration or third-party metric with a game or training session event tag) and we interpreted those days off as at least days off-feet. Whether this perfectly reflects real practices remains impossible to verify e.g. a gym-based session with no measure of external load logged into the system could have been programmed on a day that was counted as 'off'. It is also worth mentioning that the number of observations for the x/o/x… sequences was consistently lower than that for the other sequences, irrespective of the turnaround lengths (see Table 2) and this should be considered when interpreting the results. Finally, the injury records used for analysis are as good as what practitioners may have registered. Relying on injuries based on practitioners' entries is however common practice,[21] and we believe that the value of the information provided, derived from a very large sample size (> 1800 turnarounds), partly outweighs those possible limitations. Also, the present data showed a 5 x greater injury rate during match than training (Table 1), which is highly consistent with the >24 vs 4 injuries / 1000 hrs of exposure generally reported.[21] Future research based on more detailed calendar entries and larger sample size for some of the day sequences would help improve the clarity of the current findings.

Practical applications

The present study showed for the first time, using a large pool of data from elite football, that while planning a day off (at least off-feet) *per se* may not share clear associations with injury rate, its programming (i.e., when) within the microcycle. In practice, at least for the 3- and 7-d turnarounds examined, programming the (only) day off-feet of the microcycle at D+2 was associated with 2 to 3 times less overall injury rates than either not having a day off-feet, or programming the latter at D+1. Future studies should also examine, within each turnaround length, the actual load of each training day in relation to the different day off programming strategies.

Conclusion

The programming a day off (or at least 'off-feet') at D+2 was associated with a moderate to large reduction of non-contact injuries, especially during 3- and 7-d turnarounds.

Conflict of interest Statement

The authors are all employed by Kitman Labs, a sports performance company used by sports organizations around the world to collect, centralize, and analyse data from multiple sources and aid decision-making (www.kitmanlabs.com). There is no direct gain for the authors or Kitman Labs, financial or otherwise, as a result of the findings of this study, or would there be if they had been different. However the Kitman Labs Performance Intelligence Research Initiative may influence organisations in their choice of technology partner. The authors are bound by an internal research ethics code based on the European Code of Conduct for Research Integrity (https://allea.org/code-of-conduct/). Martin Buchheit was an associate editor of the IJSPP at the time of submission.

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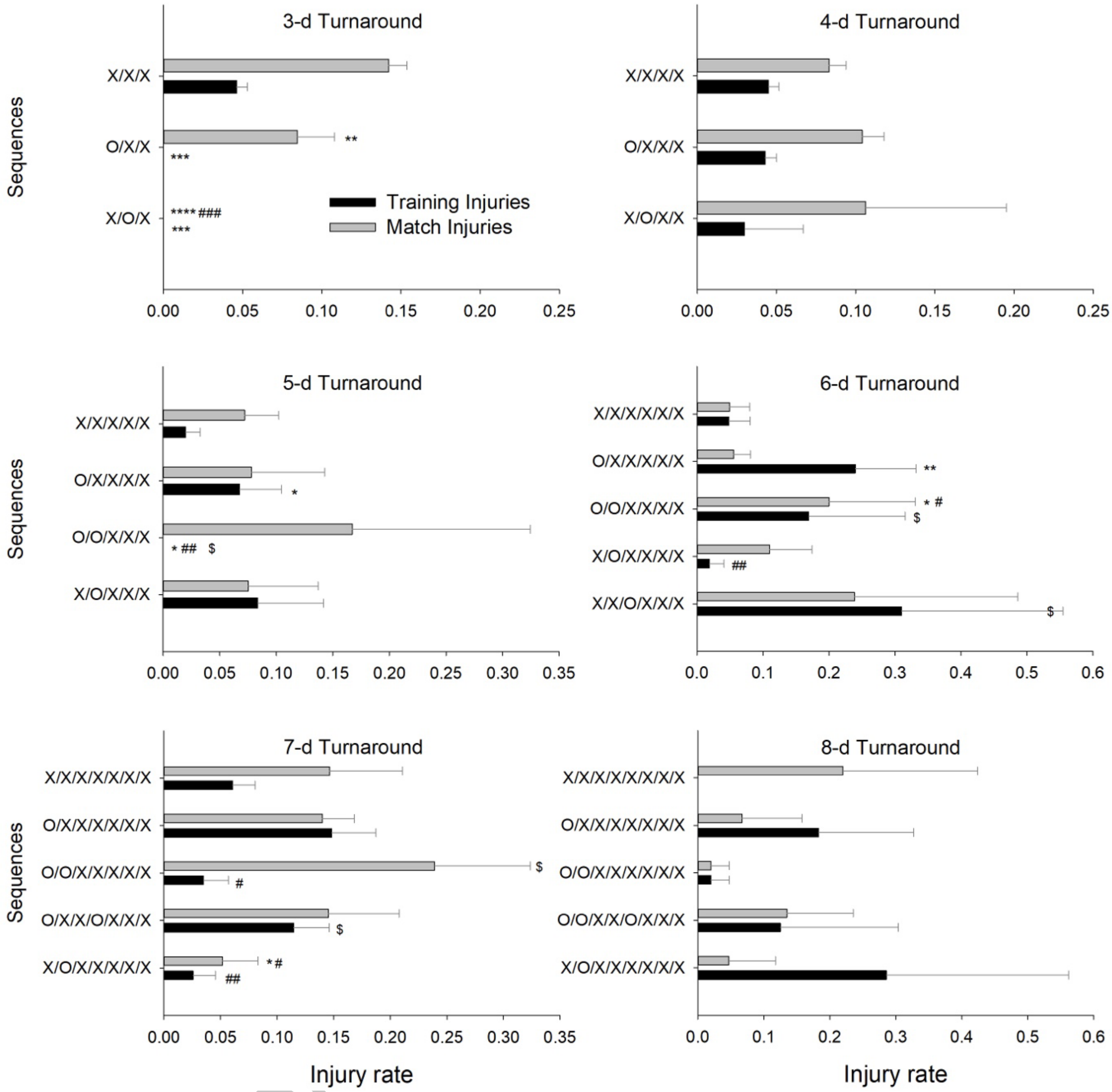

Figure 1. Average (95% CI) non-contact training and match injury rate during the main training and off-feet day patterns observed within each of the 6 match turnarounds examined in the 18 teams. *: stands for differences vs x/x/… sequence, #: vs o/x/… $: vs x/o/… The number of symbols stands for small, moderate large and very large effects/differences.

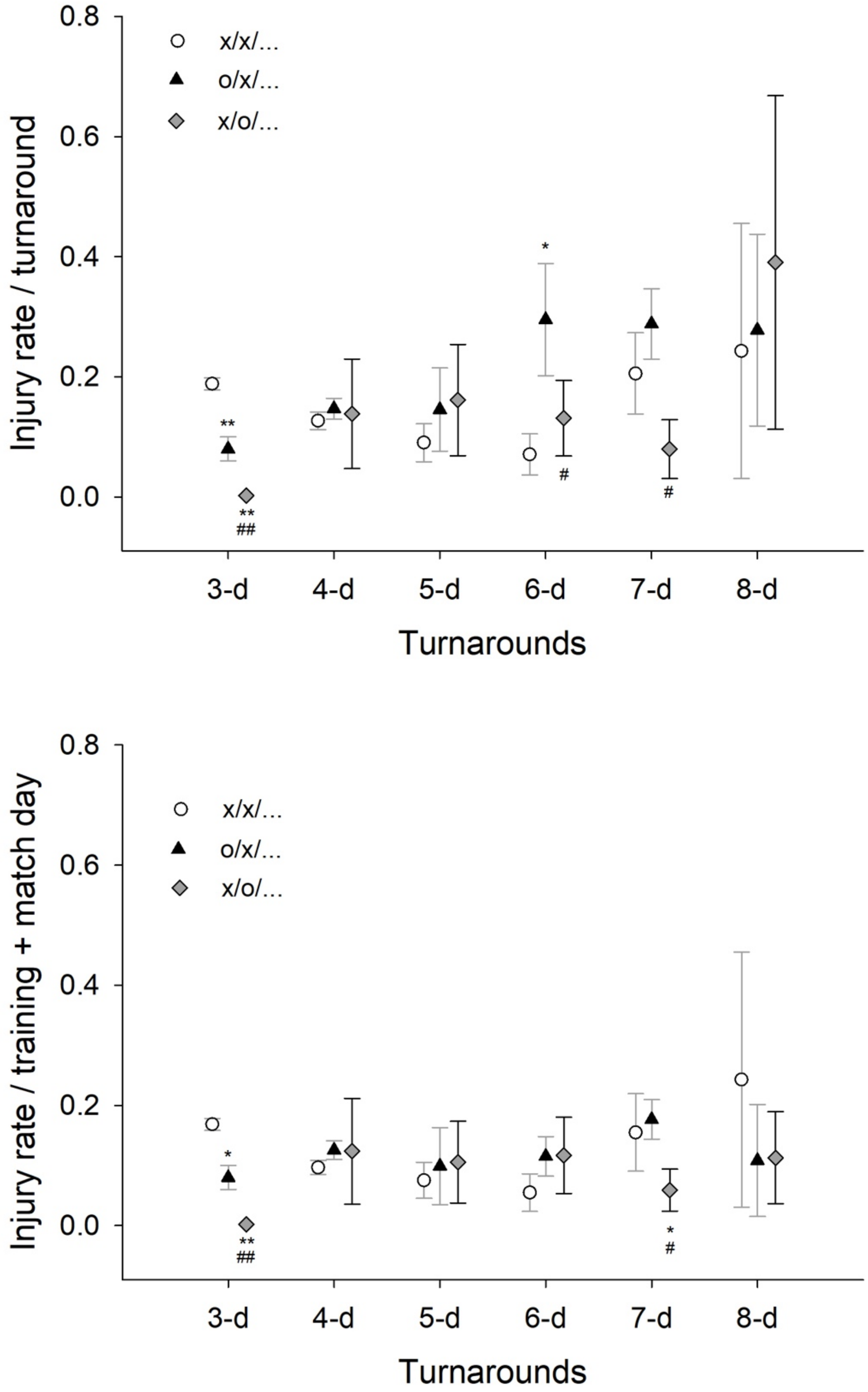

Figure 2. Average (95% CI) total (training + match) non-contact injury rate per turnaround (upper panel) and total (training + match) non-contact injury rate per training + match days only (lower panel) for the three main sequences including either no day off (x/x/…), or a unique day off either at D+1 (o/x/…) or D+2 (x/o/…) for all turnarounds. * and ** stands for moderate and large differences vs x/x/… sequence, respectively. # and ## stands for moderate and large differences vs o/x/… sequences, respectively.

Turnarounds	Turnarounds (n)	Training injuries per turnaround	Training injuries / training day	Match injuries
3 d	655	0.05 (0.01)*	0.03 (0.01)	0.25 (0.02)
4 d	577	0.06 (0.01)*	0.03 (0.01)#	0.21 (0.02)
5 d	195	0.13 (0.03)	0.04 (0.01)	0.14 (0.03)§
6 d	211	0.22 (0.04)	0.05 (0.01)	0.23 (0.05)
7 d	440	0.18 (0.02)	0.04 (0.01)	0.23 (0.02)
8 d	125	0.23 (0.06)	0.04 (0.01)	0.20 (0.06)

Table 1. Number of observations for each turnaround length, and associated overall training and match injury rate (irrespective of the presence of days off or not, both contact and non-contact injuries together). *: small substantial difference vs 5- to 8-d turnarounds. #: small substantial difference vs 6-d turnarounds. §: small substantial difference vs all other turnarounds.

FINAL DRAFT - IN PRESS IJSPP

Turnaround	Planning Sequence	Frequency	Turnaround Proportion (%)
3-d	o/x/x	94	14
	x/o/x	18	3
	x/x/x	531	80
4-d	o/x/x/x	240	41
	x/o/x/x	28	5
	x/x/x/x	276	47
5-d	o/o/x/x/x	12	6
	o/x/x/x/x	63	29
	x/o/x/x/x	30	15
	x/x/x/x/x	70	34
6-d	o/o/x/x/x/x	25	11
	o/x/x/x/x/x	64	28
	x/o/x/x/x/x	25	11
	x/x/o/x/x/x	11	5
	x/x/x/x/x/x	68	29
7-d	o/o/x/x/x/x/x	53	11
	o/x/x/o/x/x/x	83	17
	o/x/x/x/x/x/x	116	25
	x/o/x/x/x/x/x	44	10
	x/x/x/x/x/x/x	69	15

FINAL DRAFT - IN PRESS IJSPP

8-d	o/o/x/x/o/x/x/x	15	12
	o/o/x/x/x/x/x/x	20	15
	o/x/x/x/x/x/x/x	21	16
	x/o/x/x/x/x/x/x	12	9
	x/x/x/x/x/x/x/x	16	12
Totals		2005	

Table 2. Frequency and proportion of the most represented training and days off-feet sequences within each turnaround. Note that since some less frequent sequences were not shown here, the proportions (right column) don’t always sum up to 100%.

FINAL DRAFT - IN PRESS IJSPP