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High Match Load’s Relation to Decreased Well-Being During an Elite Women’s Rugby Sevens Tournament

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During rugby sevens tournaments, it is crucial to balance match load and recovery to strive for optimal performance. **Purpose:** To determine changes in well-being, recovery, and neuromuscular performance during and after an elite women’s rugby sevens tournament and assess the influence of match-load indicators. **Methods:** Twelve elite women rugby sevens players (age = 25.3 [4.1] y, height = 169.0 [4.0] cm, weight = 63.9 [4.9] kg, and body fat = 18.6% [2.7%]) performed 5 matches during a 2-d tournament of the Women’s Rugby Sevens World Series. Perceived well-being (fatigue, sleep quality, general muscle soreness, stress levels, and mood), total quality of recovery, and countermovement-jump flight time were measured on match days 1 and 2, 1 d posttournament, and 2 d posttournament. Total distance; low-, moderate-, and high-intensity running; and physical contacts during matches were derived from global positioning system–based time–motion analysis and video-based notational analysis, respectively. Internal match load was calculated by session rating of perceived exertion and playing time (rating of perceived exertion × duration).

**Results:** Well-being ($P < .001$), fatigue ($P < .001$), general muscle soreness ($P < .001$), stress levels ($P < .001$), mood ($P = .005$), and total quality of recovery ($P < .001$) were significantly impaired after match day 1 and did not return to baseline values until 2 d posttournament. More high-intensity running was related to more fatigue ($r = −.60, P = .049$) and a larger number of physical contacts with more general muscle soreness ($r = −.69, P = .013$). **Conclusion:** Perceived well-being and total quality of recovery were already impaired after match day 1, although performance was maintained. High-intensity running and physical contacts were predominantly related to fatigue and general muscle soreness, respectively.

**Keywords:** regeneration, wellness, time–motion, load indicators, performance

Match analysis of elite women’s rugby sevens shows that players cover average distances of 1066 m per match, with on average 37% of total distance at speeds above 3.5 m·s$^{-1}$ and 14% above 5 m·s$^{-1}.^1$ In addition, players spent above 80% of their maximum heart rate for over 75% of the game.$^2$-$^4$ A high number of collisions and tackles during matches are likely to contribute to these high-intensity demands.$^4$ Moreover, these moments of direct impact lead to increased muscle damage, which has been associated with decreased muscle power.$^5$

As a consequence of insufficient recovery time and residual fatigue during and after women’s rugby sevens tournaments, decreased well-being and neuromuscular function are expected in line with the literature.$^7$-$^8$ Subsequently, this might lead to decreased performance and an increased injury risk.$^2$-$^9$-$^{10}$ For subsequent training prescription or consecutive tournaments, it is therefore highly relevant to determine recovery time courses and to identify influencing factors.

Currently, recovery time courses of women’s rugby sevens tournaments are unknown. In addition, load indicators that influence recovery time courses the most are not described yet. In football, it is demonstrated that impacts at high intensity, total distance covered, and accelerations and decelerations correlate moderate to very large with creatine kinase levels and countermovement jump (CMJ) performance.$^{11}$ These results contribute to the growing body of evidence to indicate more specific time–motion parameters and their influence on objective recovery and performance outcomes. However, it is also necessary to integrate self-reported well-being and recovery as sensitive and responsive monitoring tools.$^{12}$ Furthermore, assessment during and after elite tournaments might provide crucial information for player rotation strategies within and between consecutive tournaments for optimal performance.

In summary, recovery time courses of both objective and self-reported measures during and after an elite women’s rugby sevens tournament are not examined yet. Furthermore, there is no information about which match load indicators subsequently correspond with well-being, recovery, or neuromuscular performance (NMP) in a women’s rugby sevens tournament. Considering the high demands of rugby sevens, with the potential for performance decline and increased risk of injuries within the time course of 1 tournament, there is a great need to gain more insight into how this affects the overall athlete. Therefore, the aim of this study was to determine time courses of well-being, total quality of recovery (TQR), and NMP within and after an elite women’s rugby sevens tournament and to assess the influence of match load indicators.

**Methods**

**Subjects**

Twelve elite women rugby sevens players (mean [SD]; age = 25.3 [4.1] y, height = 169.0 [4.0] cm, weight = 63.9 [4.9] kg, body fat = 18.6% [2.7%], and rugby experience = 8.8 [5.7] y) of a
national team participated in this study. The head coach, assistant coach, and strength and conditioning coach were responsible for the training program in preparation for this tournament study, which was conducted within the Women’s World Rugby Sevens Series. All participants were informed about the experimental protocol and procedures of the study, and written informed consents were obtained. The total study protocol was approved by the ethical committee of the Center for Human Movement Sciences of the University of Groningen. Before the start of the tournament, all participants were familiarized with the experimental protocols, procedures, and measurements.

Experimental Protocol and Procedures

During and after an elite women’s rugby sevens tournament, self-reported well-being and recovery and NMP were monitored. Figure 1 shows the single-group repeated-measures design with measurements in the morning (between 8:00 and 9:00 AM) on match day 1 (MD1), match day 2 (MD2), 1 day posttournament (D+1) and 2 days posttournament (D+2). In total, participants played 5 matches of which 3 on MD1 and 2 on MD2 according to the Rugby Union Laws of the Game. Participants did not have to travel and, therefore, no time zones needed to be covered. During the tournament, players did not undergo recovery-enhancing strategies (eg, massages, garments, cold-water immersion) and were instructed to avoid sun exposure between matches and to remain sufficiently hydrated. Players participated 3 days pretournament in 1 training session a day with an average rating of perceived exertion (RPE) of 11.7 (1.9) indicating fairly light exercise.

External match load was measured with global positioning system (GPS)-based time–motion analysis (JOHAN Sports, Noordwijk, The Netherlands) and video-based notational analysis. For time–motion analysis, GPS trackers were worn in a custom-made vest under regular match clothing. Navigation technology from the European Space Agency with a sample rate of 10 Hz was used. This appears to be most valid and reliable to measure distance for varying speeds across linear and team sport–simulated running. The GPS device used in this study was tested with a 2.5% ± 0.41% (error ± deviation) reliability for total distance covered. This can be considered as a good reliability. Each player wore the same tracker during all matches to limit error and to foster reliability of the measurements conducted. The time–motion parameters assessed were total distance and total distance covered during low (<2 m·s⁻¹), moderate (2–3.5 m·s⁻¹), and high (>3.5 m·s⁻¹) intensity. For notational analysis, a video camera placed on the middle of the long side of the field provided video recordings. Two analysts independently executed the notational analysis. In case of disagreement, a third analyst was asked for his observation. The number of times a player was involved in PC with other players was used for analysis. PC included the following actions: player securing a ruck, player clearing a ruck, player pushing a maul, player carrying the ball in a maul, player involved in a scrum, and player involved in other PC.

To calculate internal match load (intensity × duration, warming-up excluded), RPE on a 6 (no exertion) to 20 (extreme exertion) scale was obtained of each individual player 30 minutes after each match. The player was asked to provide her subjective perception of the match by pointing out her finger to the 6 to 20 scale with verbal anchors. Playing time (in minutes) of each player was noted from start to end of the match excluding all interruptions in the match (eg, time between the 2 halves or extra time periods, match stops, injury time). Session RPE is a valid method to assess individual exertion including disruptions and substitutions for the perception of global intensity in rugby sevens.

To assess self-reported well-being, the well-being questionnaire was individually assessed between 8:00 and 9:00 AM of that day. This questionnaire consists of 5 items (fatigue, sleep quality, general muscle soreness, stress levels, and mood), which are rated on a scale from 1 (most negative) to 5 (most positive) with 0.5 intervals. The overall well-being was calculated by summarizing the scores on these 5 items. The well-being questionnaire was based on previous recommendations and shown to be sensitive to changes of preceding load.

To measure individual characteristics of player recovery, TQR and NMP were individually assessed between 8:00 and 9:00 AM of that day. Players rated their TQR on a scale from 6 (no recovery) to 20 (maximal recovery). It is assumed that recovery is strongly related to load, and therefore, TQR has been structured around the concept of RPE to emphasize the interrelationship between load and recovery. NMP was assessed by performing CMJ between 8:00 and 9:00 AM of that day. It has been concluded that CMJ is a reliable and valid indicator of NMP in team sports. CMJ flight time was measured using a portable contact platform (ProJump; Lode BV, Groningen, The Netherlands). Players were instructed and demonstrated to perform 5 maximal vertical jumps with −3-second rest between each jump. The jump began with the player standing in upright position, followed by bending the knees to a self-selected depth, before jumping with maximal vertical height. Hands were placed on the hips during the whole procedure to exclude arm swing influence on CMJ performance. The mean CMJ flight time of 5 jumps was calculated and used for analysis, as it provided the most reliable performance measure for repeated CMJ’s (coefficient of variation = 1.9% in elite athletes).

Statistical Analysis
Means and SDs were calculated for total distance, low-, moderate-, and high-intensity running (HIR), PC, internal match load (RPE × duration), well-being, TQR, and CMJ. One player was excluded in the time–motion analysis because of missing GPS data, and one player did not participate in the fifth match because of an injury. For the purpose of investigating changes on well-being, TQR, and
CMJ, the data were analyzed using multilevel modeling with MLwiN (version 2.35 for Windows). Multilevel analysis is able to include dependent data and can handle a varying number of measurements between players, which is inevitable in a repeated-measures design. Missing values in the data set were at random. Multilevel models were created for well-being, fatigue, sleep quality, general muscle soreness, stress levels, mood, TQR, and CMJ with repeated measures within players (level 1) and differences between players (level 2). The first step was to create an intercept model with MD1 as reference value. The second step was to create a model indicating possible differences between measurements (MD1, MD2, D+1, and D+2); therefore, time points were added to the intercept model. The model fit was evaluated by comparing the −2Log Likelihood of the intercept model with the second model. Furthermore, differences between measurements were evaluated by comparing the mean of the coefficient and its SE (coefficient/SE >1.96 = significant). The possible difference between measurements was calculated for well-being, fatigue, sleep quality, general muscle soreness, stress levels, mood, TQR, and CMJ. For both match days, difference scores were used between measurements (ΔMD1_MD2 and ΔMD2_D+1) to calculate bivariate Pearson correlation coefficients to evaluate the relationship between load indicators and recovery parameters. Criteria for the interpretation of correlations were set on .0 to .3 (negligible association), .3 to .5 (low association), .5 to .7 (moderate association), .7 to .9 (high association), and .9 to 1.0 (very high association). Correlation coefficients were performed using SPSS software (version 23.0; SPSS Inc, Chicago, IL). P values lower than .05 were considered as statistically significant.

Results

Mean actual playing times for the 5 matches were 10.8 (5.98), 9.9 (4.70), 9.6 (5.61), 9.2 (5.02), and 10.4 (4.64) min, respectively. Table 1 presents descriptive results of match load.

Time Course of Recovery

Figure 2 shows the predicted time course of recovery for total well-being, fatigue, sleep quality, general muscle soreness, stress levels, mood, TQR, and CMJ flight time. Adding time to the intercept model significantly increased the model fit. Well-being (P < .001), fatigue (P < .001), general muscle soreness (P < .001), stress levels (P < .001), mood (P = .005), and TQR (P < .001) were significantly impaired after MD1 and did not return to baseline values up to D+2 posttournament. Fatigue (ΔMD1_MD2 = −1.2), general muscle soreness (ΔMD1_MD2 = −1.8), and TQR (ΔMD1_MD2 = −3.3) decreased the most after MD1.

Influence of Match-Load Indicators

For MD1, there was a moderate correlation between HIR and the increase in fatigue (r = −.60, P = .049, Figure 3). Moreover, there was a moderate correlation between PC and the increase in general muscle soreness (r = −.69, P = .013, Figure 3). No associations were found for MD2 or between other indicators and recovery parameters.

Discussion

The aim of the present study was to determine time courses of well-being, TQR, and NMP within and after an elite women’s rugby sevens tournament and to assess the influence of match load indicators. Results showed reduced well-being and recovery profiles after MD1. Well-being and recovery remained impaired up to D+2. More HIR was associated to increased fatigue (r = −.60) and a larger number of PC with more general muscle soreness (r = −.69) after MD1.

Our first main finding was that time courses of well-being, the subscales fatigue, general muscle soreness, stress levels, mood, and self-reported recovery (TQR) were significantly impaired already after MD1. In line with previous research, the largest decreases were seen in total well-being, fatigue, general muscle soreness, and TQR and not in stress and mood. Furthermore, it is known that fatigue and general muscle soreness are especially affected during fixture congestion in rugby. An explanation for the fact that these changes already became apparent after the first day might be that players’ had 3 consecutive matches with high-intensity levels on MD1. After MD1, no further decrease was demonstrated. However, well-being, fatigue, general muscle soreness, stress levels, mood, and TQR remained significantly different for MD2 up to D+2 compared with baseline levels (MD1). This might suggest that on top of challenges with the match schedule and high match intensity on MD1, players had insufficient recovery between the matches to improve for MD2 and thereafter. In addition, other contextual factors (eg, atmosphere, crowd, sponsors) may play an important role during the tournament. This remains to be determined.

Table 1 External and Internal Match Load, Mean (SD)

<table>
<thead>
<tr>
<th></th>
<th>Match 1</th>
<th>Match 2</th>
<th>Match 3</th>
<th>Match 4</th>
<th>Match 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>External match load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total distance, m</td>
<td>1450.9 (533.89)</td>
<td>1434.6 (376.12)</td>
<td>1320.2 (455.83)</td>
<td>1651.7 (350.15)</td>
<td>1471.1 (444.92)</td>
</tr>
<tr>
<td>Low intensity, m</td>
<td>630.9 (152.90)</td>
<td>651.4 (135.79)</td>
<td>561.9 (146.90)</td>
<td>859.4 (204.08)</td>
<td>581.7 (117.99)</td>
</tr>
<tr>
<td>Moderate intensity, m</td>
<td>486.1 (249.04)</td>
<td>433.9 (148.88)</td>
<td>402.8 (144.12)</td>
<td>402.9 (134.99)</td>
<td>443.1 (190.70)</td>
</tr>
<tr>
<td>High intensity, m</td>
<td>333.6 (143.02)</td>
<td>351.9 (148.39)</td>
<td>355.3 (190.18)</td>
<td>334.5 (113.50)</td>
<td>446.2 (170.69)</td>
</tr>
<tr>
<td>Number of physical contacts with others</td>
<td>7.5 (4.80)</td>
<td>5.8 (4.18)</td>
<td>6.4 (5.09)</td>
<td>6.8 (6.58)</td>
<td>5.5 (3.99)</td>
</tr>
<tr>
<td>Internal match load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session RPE × duration, AU</td>
<td>196.3 (116.77)</td>
<td>165.1 (83.51)</td>
<td>171.1 (114.78)</td>
<td>158.5 (92.17)</td>
<td>177.5 (89.36)</td>
</tr>
</tbody>
</table>

Abbreviations: AU, arbitrary units; RPE, rating of perceived exertion. Note: External match load (n = 11 for matches 1–4, n = 10 for match 5) displays total distance and distance covered at low-, moderate-, and high-intensity running during the 5 matches. Internal match load (n = 12 for matches 1–4, n = 11 for match 5) displays session RPE × duration.
Next to these explanations, one could argue that despite impairment of perceptual measures, physical output in the tournament was not reduced and therefore not meaningful. It is previously demonstrated that self-reported well-being showed to be more sensitive to acute increase in load compared with objective measures.\textsuperscript{12} Even though coaches could ignore this for performance purposes on the short term, they could consider this if, for example, multiple competitive matches are planned after the tournament. If, for example, players were able to take full recovery and avoid cumulative fatigue by taking rest after the tournament, coaches could neglect reduced scores within the tournament itself. However, if consecutive tournaments or competition are planned without a phase of rest, it does provide information that coaches should act on.\textsuperscript{8} This to avoid ongoing reduced well-being and insufficient recovery, which is not demonstrated by physical output or performance tests. Furthermore, for coaching staff, it is imperative to identify in an early stage increased stress and fatigue that may contribute to an increased injury risk.\textsuperscript{3}

For NMP, no changes were found within and posttournament. This means that players were able to maintain jump performance.

**Figure 2** — Time course of self-reported well-being, fatigue, sleep quality, general muscle soreness, stress levels, mood, TQR, and CMJ flight time on MD1, MD2, D+1, and D+2 based on predicted outcomes of the multilevel models. Error bars display SE. CMJ indicates countermovement jump; D+1, 1 day posttournament; D+2, 2 days posttournament; MD1, match day 1; MD2, match day 2; TQR, total quality of recovery. *P < .01 compared with MD1.
According to the high-demanding characteristics of the rugby game and the intense match schedule, it was expected that CMJ performance was reduced.\textsuperscript{21,25} It is expected that high exposure to intensified competition causes more accumulated fatigue leading to reduced NMP.\textsuperscript{21} However, it might be that the way jumping performance (ie, flight time with a contact plate) was measured in our study is not sensitive enough to determine subtle changes in NMP.

The second finding was that for MD1, more HIR was related to more fatigue ($r = -.60$) and larger number of PC with more general muscle soreness ($r = -.69$). Therewith, relevant match load indicators during an elite women’s rugby sevens tournament are identified. It was previously suggested that a reduction in distance covered, although not significant, reflected increased fatigue in a rugby sevens tournament.\textsuperscript{2} Our study contributes to existing knowledge in identifying HIR as influencing load indicator on fatigue responses. In addition, the influence of PC (ie, rucks, mauls, scrums) on general muscle soreness was expected according previous research,\textsuperscript{26} although not previously investigated yet in elite women’s rugby sevens.

No associations were found between match load indicators and stress levels and mood that is consistent with findings of Sawczuk et al.\textsuperscript{27} investigating the influence of exposure to match play on well-being in youth athletes. Moreover, load did not influence sleep quality in the current study. Consequently, no relationship was found with total well-being, as this parameter is the sum of the separate scales.\textsuperscript{12} Furthermore, it may be that higher match load and for a longer period of time can influence stress levels, mood, and sleep quality. This also appears to be true for TQR and NMP. To promote readiness to perform, coaches apply player rotation within the tournament itself to reduce cumulative load.\textsuperscript{21} In addition, the coaching staff reduced training load pretournament (ie, no exhaustive exercise 3 d pretournament) to prepare players for upcoming matches. These coach interventions may have influenced the relation between the load and the outcome parameters. For MD2, no significant correlations were found between match load indicators and well-being, TQR, or NMP. A likely explanation for this result is that well-being and TQR reached a floor effect after MD1.

This is the first study that demonstrated time courses of well-being, recovery, and NMP within the unique practical context in which participants were performing in the Women’s World Rugby Sevens Series. Furthermore, multilevel modeling was used to deal with the data, which was most appropriate and accurate in our repeated-measures design. Finally, this study provides knowledge about the influence of load indicators on well-being, emphasized by quantifying impact of HIR and PC on fatigue and general muscle soreness, respectively. This is crucial in the prevention of underperformance.

**Limitations and Future Research**

Limitation of the present study is that next to total distance, intensity, and match load, no biomechanical load indicators were measured.\textsuperscript{28} Even though we determined the number of PC for each player, it remains unclear what the impact was for each of these contacts. In addition, no psychosocial stressors were identified. It might be argued that psychosocial stress also contributes to the explanation of well-being and recovery profiles and directly influence performance.\textsuperscript{13} Finally, CMJ flight time might be not sensitive enough to measure alteration in neuromuscular responses in this particular tournament setting.

Future research should aim to additionally measure biomechanical load (eg, muscle-tendon forces) and try to quantify to what extent critical values are reached in maintaining well-being and recovery. Moreover, the influence of psychosocial stressors (eg, general, emotional, social stress) on well-being and recovery during tournaments or in-season intensified competition periods should be investigated. To better understand the recovery process, other measures (eg, muscle damage) could be of additional value.\textsuperscript{29} Finally, studying recovery strategies as interventions within congested playing schedules might prevent players of ongoing fatigue and muscle soreness.

**Conclusion**

Within the present elite women’s rugby sevens tournament study, total well-being, fatigue, general muscle soreness, stress levels, mood, and TQR showed a diminished recovery profile within MD1, up to D +2, while physical output was maintained. Fatigue, general muscle soreness, and TQR were most diminished after MD1. Furthermore, it can be concluded that HIR and PC predominantly influenced perceived fatigue and general muscle soreness, respectively.

**Practical Applications**

For training and coaching staff of women’s rugby sevens players, it is of utmost importance to maintain their ability to perform and let...
them deal with reduced well-being or insufficient recovery between matches during a 2-day tournament and on a prolonged timeframe. Therefore, coaches should have clear insight into individual perceived well-being and recovery of players by daily monitoring. Well-being and TQR scores add to a better understanding of recovery profiles in the tournament context because of their responsiveness to acute increased load. Although no performance decline was demonstrated in the present study, outcomes of the perceived measures can be used as early warning signals of affected players and guide coaching staff in their team management. It enables coaches to directly intervene by evidence-based recovery strategies or make adjustments to exposed individual load.

On the basis of our findings, coaches can intervene on fatigue, general muscle soreness, stress, and mood within the tournament already. For physical recovery of fatigue and general muscle soreness, effective short-term recovery modalities (eg, cold-water immersion, contrast baths, compression garments) might have a beneficial effect. For psychosocial recovery of stress and mood, relaxation techniques (eg, debriefing, power naps, systematic breathing) might be proposed. Finally, perceptual total well-being and perceived recovery can be enhanced by compression garments in combination with electromyostimulation.

Next to recovery modalities, coaches could benefit from sufficient insight into individual HIR and PC as distinctive match load indicators during women’s rugby sevens tournaments. Critical cutoffs can be determined for the individual player of the influence of HIR and PC on fatigue and general muscle soreness, respectively. Therefore, match load indicators should be monitored constantly and accurately to provide direct feedback about the most important match demands in this population.

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