**Title of Article:** Seasonal training load and wellness monitoring in a professional soccer goalkeeper

**Preferred Running Head:** Training load of an elite goalkeeper

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**Submission Type:** Brief Report

**Abstract Word Count:** 235 words

**Text-Only Word Count:** 1823 words

**Number of Tables and Figures:** Tables = 1**;** Figures = 2

**Abstract**

The purpose of this investigation was to: (a) quantify the training load practices of a professional soccer GK, and (b) investigate the relationship between the training load observed and the subsequent self-reported wellness response. One male goalkeeper playing for a team in the top league of the Netherlands participated in this case study. Training load data were collected across a full season using a global positioning system (GPS) device and session rating of perceived exertion (session-RPE). Data was assessed in relation to the number of days to a match (MD- and MD+). In addition, self-reported wellness was assessed using a questionnaire. Duration, total distance, average speed, PlayerLoadTM and load (derived from session-RPE) were highest on MD. The lowest values for duration, total distance and PlayerLoadTM were observed on MD-1 and MD+1. Total wellness scores were highest on MD and MD-3 and were lowest on MD+1 and MD-4. Small to moderate correlations between training load measures (duration, total distance covered, high deceleration efforts and load) and the self-reported wellness scores were found. This exploratory case-study provides novel data about the physical load undertaken by a goalkeeper during one competitive season. The data suggest there are small to moderate relationships between training load indicators and self-reported wellness. This weak relation indicates that the association is not meaningful. This may be due to the lack of position-specific training load parameters we can currently measure in the applied context.

**Keywords:** Periodization, GPS, RPE, subjective, sport

**Introduction**

The role of a goalkeeper (GK) is a unique but often overlooked position within professional soccer. GKs have to perform individual actions that can have a significant impact on the final match outcome. These actions typically involve explosive, short duration movements such as diving, catching and accelerating/decelerating sharply.1 In certain match situations, these actions may also be required in repeated succession to stop the opposing team from scoring a goal. When we compare the locomotive data of goalkeepers to outfield players, GKs have been shown to cover less total distance (TD) (mean 5611m vs.10,714m) and sprint distance (mean 61m vs. 905m).2,3 Clearly, the physical requirements of GKs are significantly different between these two defined roles on the pitch. Therefore, in order for GKs to prepare appropriately for matches, they must be trained in a position-specific way.

Whilst the training practices in elite soccer have been recently examined in detail for outfield players4, such information on GKs is relatively unknown. GKs often train in small groups using position-specific training drills delivered by a GK coach, with some involvement in outfield player drills (e.g. tactical and small-sided game drills). Therefore, the training load reference values that have been previously detailed for outfield players 4 would not be applicable for GKs.

 The quantification of external training load is crucial in order to understand the training process. However, it is equally as important to understand how players respond to the load. The use of self-reported wellness questionnaires to monitor these responses are becoming increasingly used both in the applied environment and for scientific study5. Such psychometric questionnaires have been found to be sensitive to varying training load values across training microcycles.6 Previous research has investigated the wellness response in outfield soccer players5, however there is no such information available for soccer GKs.

 The purpose of this investigation was therefore to: (a) quantify the training load practices of a professional soccer GK, and (b) investigate the relationship between the training load observed and the subsequent self-reported wellness response.

**Methods**

*Case Study*

A male professional soccer GK playing for a team in the top league of the Netherlands (age = 21 yrs, height = 1.9 m, weight = 82.4 kg) agreed to participate in this study during the 2015-2016 season. The study was approved by the Ethics Committee of KU Leuven (#s57732).

*Training Load and Wellness Assessment*

Training and match load data were collected for each session across the season (n = 131 sessions). Data was collected for 43 weeks including both the pre-season (4 weeks) and the in-season period (39 weeks). The GK trained on average 5 times per week during pre-season and 4.2 times per week during in-season, respectively. The GK wore a global positioning device (GPS; Optimeye G5; firmware version 717; Catapult Sports, Australia) which has shown acceptable levels of reliability and validity for the PlayerLoadTM calculation.7 The device components are the same as used in the Catapult S5 model, which has demonstrated valid measures for velocity-based metrics.8 The data collection followed the guidelines for using GPS data in sport.9,10 GPS data were downloaded using the manufacturer’s software (Catapult Sprint, version 5.1.7) for the following parameters: duration, TD, average speed, high acceleration/deceleration efforts (ACCEL/DECEL) (> 3 m.s-2), PlayerLoadTM and PlayerLoadTM/minute. The ACCEL/DECEL data was derived via Doppler-shift velocity-based measurements through the device GPS chip as described previously in the literature10. PlayerLoadTM is an arbitrary unit derived from the tri-axial accelerometer that measures the instantaneous change in acceleration7. PlayerLoadTM/minute is calculated as the total PlayerLoadTM value divided by the total session duration in minutes.

The session rating of perceived exertion (session-RPE) was determined using the CR10 scale of Foster et al.11 The GKs session-RPE was collected 30 minutes post session and multiplied by the session duration to calculate the magnitude (termed ‘load’). The duration included the warm up and main training session periods within each session. A psychometric questionnaire was used to assess indicators of self-reported player wellness using a 5-point scale (with 1 representing poor and 5 representing very good) with 0.5 point increments.6 The questionnaire comprised of five questions related to perceived fatigue, sleep quality, general muscle soreness, stress levels and mood. The overall wellness was determined by summating the 5 scores.

*Data Analysis*

The data were analysed in relation to the number of days in relation to the match fixture (MD +/-). The GK typically trained in the four preceding days (MD-4, n = 13; MD-3, n = 10, MD-2, n = 31, MD-1, n = 37) and the day post (MD+1, n = 11) matches. Match data was collected (n = 28), with the fixture schedule varying on day of the week across the season. Data were excluded from the period September to December as the GK lost his place in the team, thus the training schedule differed. Effect sizes (ES) were calculated for the training load and subsequent wellness data in order to quantify the differences between the days (MD-4, MD-3 etc.). Effect sizes were calculated compared to the overall mean for each training load indicator. The threshold values for Cohen ES statistics were trivial (0.0–0.19); small (0.2–0.59); moderate (0.6–1.19); large (1.2–1.99); and very large (>2.0).12 Effect sizes above Cohen’s d >0.2 have been presented within the results. Pearson correlation coefficients were calculated to determine the relationships between all measures of load and the subsequent total wellness score on the following day. The coefficient of variation expressed as a percentage (CV%) was used to characterize the amount of variability in the training load data.

**Results**

Data from the training sessions revealed that the highest values for TD, average speed, DECEL, PlayerLoadTM and load were found on MD-3 (Table 1). The highest total wellness scores were observed on MD (mean: 22.5±0 au), followed by MD-3 (mean: 21.9±1.2 au; d=0.50, small) (Figure 1). The lowest wellness scores were observed on MD-4 (mean: 20.9±1.2 au; d=-0.35, small) and MD+1 (20.6±1.1 au; d=-0.65, moderate). Significant correlations (*P <* 0.05) were found between the following load indicators and total wellness: duration (r=-0.35), TD (r=-0.28), DECEL (r=-0.27) and load (r=-0.31) (Figure 2). The CV% of the training load measures were: duration = 35%, total distance = 43%, average speed = 16%, high acceleration efforts = 68%, high deceleration efforts = 70%, PlayerLoadTM = 37%, PlayerLoadTM/min = 20% and load = 49%.

**\*\*\*\*INSERT TABLE 1 NEAR HERE\*\*\*\***

**\*\*\*\*INSERT FIGURE 1 NEAR HERE\*\*\*\***

**\*\*\*\*INSERT FIGURE 2 NEAR HERE\*\*\*\***

**Discussion**

The present study provides novel data quantifying the training load and subsequent wellness response in a professional soccer goalkeeper. The main findings of the study were that the highest wellness scores were observed on MD and MD-3. The lowest wellness scores were observed on MD-4 and MD+1. Small to moderate correlations were shown between duration, TD, DECEL and load with wellness scores.

In comparison to the training practices of professional soccer outfield players, Malone et al.4 reported mean TD values of between 4034 - 6101m across in-season training microcycles. Similar distances have been found by Owen et al.13 who reported a mean TD of 6871m during the in-season microcycle phase. These values are greater compared to the present study, in which the range of values was between 2553 - 3742m. However, when we compare the high-speed distance covered between positions, goalkeepers appear to cover only around ~17% of that of outfield players.4,14 This is most likely due to the restriction in space for the majority of the goalkeeper-specific training drills that limit the ability to reach the higher speed thresholds.

The load values in the present study were found to be both lower15 and similar4 to previous work on outfield soccer players. As there are no previous studies that have reported the training load practices of professional soccer goalkeepers, it is difficult to confirm whether the loads observed in the present study are ‘typical’ for such players. As the load measure is determined by both the volume (i.e. duration) and intensity (i.e. session-RPE) of the activity, further work is required to examine these two components in more detail to explain the overall load values in GKs.

When comparing the periodisation patterns to that of outfield players4, the findings in the present study are fairly similar. Training load parameters show slight differences in values but only on certain training days. In the study of Malone et al.4, the training load was generally reduced on MD-1 but remained similar on MD-4 to MD-2. In the present study, training load data demonstrated a small to moderate increase on MD-4 and MD-3. There was already a small to moderate decrease in training load on MD-1 and MD+1. The results of both studies would therefore indicate that training periodisation planning is limited during the in-season phase.

The total wellness scores in the present study showed minimal variation across the majority of training days, with the lowest values occurring on MD+1 and MD-4. Typically, the MD-4 training session occurred within two days following a competitive match. This would suggest that the goalkeeper was still recovering from the match load at the start of the training week. This is in agreement with McLean et al.6 who found a significant reduction in self-reported well-being scores on MD+1 in rugby league players. Small to moderate correlations were found between the wellness scores and training load measures, notably duration, TD, DECEL and load. GK actions such as diving and jumping were not quantified in this study due to the limitations within the technology. Such high biomechanical loading may be missing from current monitoring strategies for practitioners16, thus future work should focus on creating and validating GK-specific loading variables.

As this is a single participant case study, it is difficult to generalise the findings of the present study. Due to the goalkeeper being on the substitute bench for the early phase of the competitive season, we chose to combine the pre-season and in-season information to track the training load response longitudinally across the full macrocycle. Ideally, we would have had larger data sets with multiple goalkeepers across different squads to make a comprehensive analysis of pre-season and in-season differences. Therefore, the authors acknowledge this as a limitation of the present case study.

**Practical Applications**

Due to the scarce information around the training load practices of professional GKs, this exploratory case study attempted to quantify the load-response relationship across a competitive season. The study revealed higher training loads on MD-4 and MD-3 in comparison to other training days, which coincided with reduced wellness response on MD-4 and MD+1. This information would suggest that soccer GKs demonstrate reduced recovery in the 24-48h post-match period. The small correlations found with training load measures indicates that current ‘traditional’ load parameters may not be sensitive to detect differences in periodisation practices.

**Conclusions**

Small to moderate correlations were shown between duration, TD, DECEL and load with wellness scores. Practitioners should look to investigate new GK-specific measures that incorporate actions closely linked to performance (such as dives and jumping). Further research with larger cohorts from different competitive leagues is required to determine best practice periodisation strategies for soccer GKs.

**References**

1. Ziv G, Lidor R. Physical characteristics, physiological attributes, and on-field performances of soccer goalkeepers. *Int J Sports Physiol Perform*. 2011;6:509-524.

2. Bradley PS, Sheldon W, Wooster B, Olsen P, Boanas P, Krustrup P. High-intensity running in English FA Premier League soccer matches. *J Sports Sci*. 2009;27(2):159-168. doi:10.1080/02640410802512775.

3. Di Salvo V, Benito P, Calderon F, Salvo Di M, Pigozzi F. Activity profile of elite goalkeepers during football match-play. *J Sports Med Phys Fitness*. 2008;48:443-446.

4. Malone JJ, Di Michele R, Morgans R, Burgess D, Morton JP, Drust B. Seasonal training-load quantification in elite English Premier League soccer players. *Int J Sports Physiol Perform*. 2015;10(4):489-497. doi:10.1123/ijspp.2014-0352.

5. Buchheit M, Simpson BM, Garvican-Lewis LA, et al. Wellness, fatigue and physical performance acclimatisation to a 2-week soccer camp at 3600 m (ISA3600). *Br J Sports Med*. 2013;47(Suppl 1):i100-i106. doi:10.1136/bjsports-2013-092749.

6. McLean BD, Coutts AJ, Kelly V, McGuigan MR, Cormack SJ. Neuromuscular, endocrine, and perceptual fatigue responses during different length between-match microcycles in professional rugby league players. *Int J Sports Physiol Perform*. 2010;5(3):367-383.

7. Barrett S, Midgley A, Lovell R. PlayerLoadTM: Reliability, Convergent Validity, and Influence of Unit Position During Treadmill Running. *Int J Sports Physiol Perform*. 2014;9:945-952.

8. Roe G, Darrall-Jones J, Black C, Shaw W, Till K, Jones B. Validity of 10 HZ GPS and Timing Gates for Assessing Maximum Velocity in Professional Rugby Union Players. *Int J Sports Physiol Perform*. 2017;12(6):836-839.

9. Malone JJ, Lovell R, Varley MC, Coutts AJ. Unpacking the Black Box: Applications and Considerations for Using GPS Devices in Sport. *Int J Sports Physiol Perform*. 2017;12:S218-S226. doi:10.1123/ijspp.2016-0236.

10. Varley MC, Jaspers A, Helsen WF, Malone JJ. Methodological Considerations When Quantifying High-Intensity Efforts in Team Sport Using Global Positioning System Technology. *Int J Sports Physiol Perform*. 2017:In Press. doi:10.1123/ijspp.2016-0534.

11. Foster C, Florhaug J a, Franklin J, et al. A new approach to monitoring exercise training. *J Strength Cond Res*. 2001;15(1):109-115.

12. Hopkins WG. A scale of magnitudes for effect statistics. *A New View Stat*. 2002;502.

13. Owen AL, Wong DP, Dunlop G, et al. High-Intensity Training and Salivary Immunoglobulin A Responses in Professional Top-Level Soccer Players: Effect of Training Intensity. *J Strength Cond Res*. 2016;30(9):2460-2469. doi:10.1519/JSC.0000000000000380.

14. Gaudino P, Iaia FM, Alberti G, Strudwick AJ, Atkinson G, Gregson W. Monitoring training in elite soccer players: Systematic bias between running speed and metabolic power data. *Int J Sports Med*. 2013;34(11):963-968.

15. Jeong T, Reilly T, Morton J, Bae S, Drust B. Quantification of the physiological loading of one week of “ pre-season ” and one week of “ in-season ” training in professional soccer players. *J Sports Sci*. 2011;29(11):1161-1166. doi:10.1080/02640414.2011.583671.

16. Vanrenterghem J, Nedergaard NJ, Robinson MA, Drust B. Training Load Monitoring in Team Sports: A Novel Framework Separating Physiological and Biomechanical Load-Adaptation Pathways. *Sport Med*. 2017. doi:10.1007/s40279-017-0714-2.

**Table 1.** Training load data represented in relation to days to the match.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **MD-4** | **MD-3** | **MD-2** | **MD-1** | **MD** | **MD+1** |
| **Duration (mins)** | 85±26 | 83±32 | 81±29 | 68±17**-0.59****(-0.90±-0.28)** | 121±14**1.30 (0.93±1.66)** | 58±20**-0.91****(-1.44±-0.39)** |
| **Total Distance (m)** | 3688±1356 | 3742±1281 | 3580±1520 | 2925±839**-0.61****(-0.92±-0.30** | 5985±940**1.38 (1.02±1.75)** | 2553± 1016**-0.80****(-1.33±-0.28)** |
| **Average Speed (m/min-1)** | 44±11 | 46±6 | 43±7**-0.26 (-0.59±0.07)** | 43±5**-0.23 (-0.53±0.08)** | 50±5**0.47 (0.13±0.82)** | 49±27**0.28 (-0.24±0.79)** |
| **High Accels****(#)** | 12±9**0.37 (-0.10±0.83)** | 9±6 | 9±8 | 9±5 | 11±5**0.25****(-0.10±0.59)** | 5±7**-0.65****(-1.17±-0.13)** |
| **High Decels (#)** | 7±5**0.59 (0.12±****1.05)** | 7±4**0.58 (0.04±****1.12)** | 5±3 | 4±3**-0.22 (-0.53±0.09)** | 5±3 | 4±4**-0.27 (-0.79±0.25)** |
| **PLTM (au)** | 380± 148 | 403± 162 | 372±149 | 328±76**-0.50 (-0.81±-0.19)** | 553±85**1.17 (0.81±1.53)** | 282±78**-0.80 (-1.32±-0.27)** |
| **PLTM/min (au)** | 4.6±1.4 | 4.8±0.5 | 4.6±0.6 | 4.9±1.2 | 4.5±0.5 | 5.2±1.9**0.41 (-0.11±0.93)** |
| **Load (au)** | 319±143 | 334±178 | 286±128**-0.21 (-0.54±0.11)** | 243±83**-0.52** **(-0.83±-0.21)** | 490±145**1.12 (0.76±1.47)** | 322±153**-0.74** **(-1.26±-0.22)** |
| \*Cohen’s d >0.2 are reported in bold text with 90% confidence intervals, values lower than the mean is reported with a minus signal. *Abbreviations*: MD, match day. Abbreviations: Accels = Acceleration efforts (> 3 m.s-2); Decels = Deceleration efforts (> 3 m.s-2); PL = PlayerLoadTM |