Does Load Matter? The Effects of Training Load on Injury and Illness in Division I Female Soccer Players

Original Research

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Abstract

Introduction: The purpose of this study was to measure and examine the relationship between training load and the occurrence of injury and illness in collegiate women's soccer players during one competitive season.
Methods: Collegiate women's soccer players (n=24, ages 18-22) participated in data collection over one competitive season (13 weeks). Polar Team Pro GPS were used to measure heart rate and training load, while injury and illnesses were recorded and scored by the team athletic trainer. Welch's ANOVA was used to compare group means of training load across injury and illness groups.
Results: Welch's ANOVA suggested that training load did not show a statistically significant difference in injury/illness outcome means across the groups and no effect was detected, $F\ (2, 732) = 2.996$, $p = 0.05$, $\eta^2 = .004$.
Conclusions: Training load did not have a significant association with the occurrence of injury and illness in collegiate women's soccer athletes.

Key Words: exertion, recovery, competitive

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Introduction

Training loads are commonly used to measure both internal and external load in athletes. Monitoring training loads can serve as an effective method of implementing periodization strategies and optimizing athletic programming. Prolonged increases in training load may push athletes past the limits of functional overreaching (FOR) and increase the risk of injury and illness for up to one month.[1] Pushing athletes beyond the limits of functional overreaching (FOR) may increase the risk of developing non-functional overreaching (NFOR) or Overtraining Syndrome (OTS). According to Bell et al., [2] FOR involves a short-term decline in performance lasting a few days to weeks, followed by recovery and a supercompensation phase. In contrast, NFOR is marked by performance decreases that persist for several weeks to months, without supercompensation.[2] OTS is defined as a prolonged decline in athletic performance that develops over several months.[2] Both NFOR and OTS are associated with reduced performance and negative changes in mood state in athletes.[2–4] The American College of Sports Medicine (ACSM) suggests altered mood states have been associated with increases in injury and illness in athletic activity. [5]

Injuries are commonly reported in high-profile male-dominated sports such as American football, Australian Rules football and rugby; however, female sports remain underrepresented in the literature.[1,6,7] Despite minor differences between male and female sports, training loads and relative workload are similar between Division I collegiate male and female soccer players.[8] Malone et al reported 75 time loss injuries during one competitive soccer season—an average of 1.6 time loss injuries per player—due to overtraining and poor acute to chronic workload management. Players who exhibited a higher preseason weekly training load were at significantly higher risk of injury.[9] Unmanaged training loads that result in NFOR and OTS over the course of a season can impair an athlete's recovery and regeneration, consequently increasing the risk of injury and illness. Teams should monitor training load data to identify potential shifts from functional overreaching (FOR) to non-functional overreaching (NFOR) or Overtraining Syndrome (OTS), allowing for timely training modifications that support desired performance outcomes while minimizing negative effects. By recognizing and addressing signs of NFOR—and preventing progression to OTS—sports medicine teams may help reduce the risk of injury and illness in athletes.

Effective monitoring of training load is essential to identify early signs of maladaptation and to prevent progression toward non-functional overreaching (NFOR) and Overtraining Syndrome (OTS). A variety of methods are available to assess and monitor training load during activity, including heart rate–based global positioning systems (GPS), athlete-reported Rate of Perceived Exertion (RPE), Heart Rate Variability (HRV), blood lactate concentrations, and Training Impulse (TRIMP).[10] The choice of monitoring tools may depend on a team's technological resources; however, GPS systems are widely used and provide a measure of internal load during training and competition, offering valuable feedback on the athlete's individual response to external training stimuli. This information allows coaches to adjust training demands based on each athlete's physiological responses and enables athletes to optimize their recovery strategies.

A recent systematic review of training load monitoring in women's soccer players highlighted the limited amount of literature focused on this population, particularly in relation to injury and illness.[11] Therefore, the purpose of this study is to measure and examine the relationship between training load and the occurrence of injury and illness in collegiate female soccer players during one competitive season.

Methods

This longitudinal study assesses the relationship between training load on injury and illness in National Collegiate Athletic Association (NCAA) Division I female soccer players throughout one competitive season (13 weeks) totaling 69 days of training and competition.

Participants

A convenience sample of one NCAA Division I women's soccer team (24 players ages 18-22) participated in this study. Each participant was healthy and free from musculoskeletal injuries or any illness at the start of participation in the research study and physically cleared to participate in sport activities by team physicians. The University's Institutional Review Board approved this study prior to beginning, and due to the nature of research procedures and pursuant to 45 CFR 46.117 (c)(2), the requirement for signed informed consent was waived. Verbal informed consent was received to utilize data for research purposes.

Protocol

Each participant wore a Polar Team Pro GPS heart rate monitor for all team training sessions and games throughout the season. The Polar Team Pro GPS heart rate monitor uses an algorithm designed to determine the difficulty of a single training session, which measures exertion and is also referred to as training load. The training load algorithm is based on the participants' heart rate throughout the session as well as the participants' age, sex, weight, and VO_2 max.[12] The training data for each session was collected and uploaded to the Polar Team Pro website. Each athletes' training load for all team training sessions and games were exported into an excel spreadsheet.

The team athletic trainer assessed and tracked all injuries and illnesses throughout the data collection process. An injury was specified as a medical encounter with the athletic trainer in which the athlete received treatment and was monitored during any team training activity, while illnesses were specified as a medical encounter with the athletic trainer or team physician in which an athlete was provided intervention and or care for their illness. All injuries and illnesses were tracked in an excel spreadsheet, as well as the athletes' electronic medical record, and assigned a number based on the severity of injury or illness the athlete sustained. Any athlete who was not receiving medical attention for an injury or illness on a given day was assigned a zero, meaning the athlete was healthy and injury or illness free. If an athlete sustained an injury or illness that required medical attention, but was not withheld from training or competition, was assigned a one for a medical attention injury or illness (MAI). If an athlete was injured and withheld from training or competition, they were assigned a two for a time-loss injury or illness (TLI). Injuries and illnesses were convertible from a MAI to a TLI or inversely.[13] For example, if an athlete had a time-loss injury or illness but was cleared to participate in sport while still receiving medical attention, they moved from a two to a one on the data collection sheet.

Statistical Analysis

K-means clustering was used to categorize the subjects into groups, based on the number of days reported for injury or illness.[14] Clustering identified individuals' tendency to get injured or ill, and allowed for assessing the differences across the groups. To determine the optimal number of groups (*k*), the elbow method was utilized.[14] Descriptive statistics for each groups' training load are reported in mean±standard deviation. Welch's ANOVA and Tukey's post-hoc analysis were used to compare the mean training load values across the groups stratified by injury and illness incidence. A 21-day rolling average of each participant's training load was used, based on the literature of training load effects lasting up to one month.[1] The dichotomous dependent variable was measured for association with the independent variable. Effect size was calculated using eta squared (η^2) to quantify the proportion of variance in training load explained by group differences in injury/illness categorization. Data was analyzed with Statistical Package for Social Sciences (SPSS), version 25. Significance was set at $p < .05$.

Results

The within-cluster sum of square (*WSS*) was minimized when three clusters were extracted and did not notably improve when more clusters were considered. Thus, the participants were categorized in three groups: Injury/illness-free group (group 1: n = 12), moderate injury/illness occurrence group (group 2: n = 7), and high injury/illness occurrence group (group 3: n = 5). Participants within the moderate injury/illness occurrence group were listed as having an MAI or TLI for 22-69% of the training days, while those participants within the high injury occurrence group were listed as having an MAI or TLI for 70% or more of the training days. As seen in table 1, there is a small increase in the average training loads between the injury/illness-free group (roughly 119) compared to the moderate injury/illness group (roughly 130) and the high injury/illness group (roughly 134). Specific injury and illness reporting per athlete is highlighted in table 2.

Table 1. Descriptive statistics by group.

Injury/Illness Group	Average Training Load across Group	Number of days Injury/Illness Free
	M±*SD*	*n*
Injury/illness-free	118.9±99.3	796
Moderate-injury/illness	129.9±94.2	425
High-injury/illness	133.5±112.3	314

Mean (*M*), Standard Deviation (*SD*), Number (n)

Welch's ANOVA measured statistical differences in load across the three groups. Q-Q plots of residuals confirmed that each group was normally distributed. Welch's ANOVA showed training load did not have a statistically significant difference across the groups and no effect was detected, $F(2, 732) = 2.996$, $p = .05$, $\eta^2 = .004$ (Table 3). Although there is a small mean difference in training loads across groups seen in Table 1, ANOVA measured no significant effect on the outcome of injury and illness rates between groups.

Table 2. Participants' days of injury/illness.

	Number of Days (out of 69 training days)			
Participant ID	**No Injury/Illness**	**MAI**	**TLI**	**Injury/Illness Group**
1	67	2	0	1
2	36	27	6	2
3	67	2	0	1
4	61	8	0	1
5	68	1	0	1
6	68	0	1	1
7	22	23	24	2
8	43	16	10	2
9	69	0	0	1
10	53	15	1	2
11	63	6	0	1
12	69	0	0	1
13	21	45	3	3
14	20	42	7	3
15	62	6	1	1
17	14	54	1	3
18	65	4	0	1
19	13	51	5	3
20	52	17	0	2
21	54	14	1	2
22	69	0	0	1
23	53	16	0	2
24	69	0	0	1
25	30	37	2	3

1: Injury/illness-free group, 2: Mild to moderate injury/illness occurrence group,
3: Heavy injury/illness occurrence group.
MAI: medical attention injury or illness; TLI: time-loss injury or illness

Table 3. Welch's ANOVA results.

	Welch's Statistic	df_1	df_2	η^2
Training Load	2.996	2	732.148	.004

Discussion

The results of this study indicate that the training load of a women's collegiate soccer team did not have a significant association with injury and illness across groups during a competitive season. This is inconsistent with the findings from Xiao et al. [15], which found total player load was associated with injury in women's soccer players. This study was congruent in its sample and design, utilizing a sample of 65 NCAA Division I women's soccer players with wearable GPS unit tracking training load, but analyzed data collected over the course of three seasons.[15] Results may differ due to the shorter duration of data collection, which highlights as a limitation.

Other studies conducted with soccer players and wearable GPS data analyzed total distance trained over the span of 4 weeks in male athletes, with evidence indicating an increased injury risk for professional soccer players who had higher total distances[16] and a significant increase in injury risk for youth football players with high total distances covered.[17] These studies differ in sex and age, but may have a potential influence on study outcomes. Researchers encourage future studies to investigate potential moderating variables or predictive models effecting the outcome of training load on injury and illness.

Continued monitoring of training loads across all athletes is imperative for designing effective periodization and programming. Further research is needed to determine the most effective measures of exertion and acute:chronic workload ratios to inform periodization strategies and strengthen the research in this area. While ensuring adequate work-to-rest ratios is widely recommended for athlete safety and well-being, additional research is needed to better characterize the impact of training load on individual recovery processes and FOR thresholds in athletes.

Conclusions

Over the course of one competitive season, training load means across groups and injury/illness rates in collegiate women's soccer players were not found to be statistically significant. However, cumulative training load may still hold clinical relevance and monitoring it throughout the season remains a valuable practice for athlete management. Future research should focus on developing predictive models that explore the relationship between training load and injury or illness risk, incorporating variables such as total mileage and Rate of Perceived Exertion (RPE).

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