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ORIGINAL RESEARCH

The relationship between acute-chronic training load and wellness & fatigue status in football

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Abstract

This study aimed to examine the effects of acute and chronic training loads (ACWR) on wellness and fatigue levels in young football players. Twenty-one players competing in the Turkish Football Federation Elite Academy leagues participated in the study, and during a four-week training period, training loads, subjective wellness parameters, and neuromuscular fatigue measurements were monitored. ACWR calculations were determined using the Rating of Perceived Exertion (RPE) method, while wellness parameters were collected through daily questionnaires. Pearson correlation analysis was applied to determine the simple linear relationship between the data. The findings revealed a strong positive relationship between weekly training load and ACWR, while no significant relationship was found between wellness parameters and ACWR ($p<0.05$). However, high training monotony and strain were found to have an effect on players' fatigue levels and stress levels ($p>0.05$). Especially after match days (MD+2 and MD+3), players' fatigue levels were found to be high, emphasizing the importance of recovery processes. The results of the study suggest that ACWR alone may not be sufficient in training load management in football players and that additional physiological and subjective parameters should be considered. Accordingly, it is recommended to make planning that reduces training monotony and to individualize load management.

Introduction

In modern football, meticulous management of training loads is required to preserve players' physical and physiological capacities, ensure the sustainability of their performance, and minimize the risk of injury (Claudino et al., 2016; Hulin et al., 2014). The high physical and mental demands of football expose athletes to intense training programs; this makes it crucial to understand the physiological and performance-related responses to acute (short-term) and chronic (long-term) training loads (Clemente et al., 2019; Nobari et al., 2020). Acute workload generally refers to the total training and match load applied within a one-week period, whereas chronic workload represents the average load over a longer period (e.g., four weeks) (Hulin et al., 2014). In this context, the acute: chronic workload ratio (ACWR) has recently gained importance in the literature as a key parameter for training management and injury prediction (Malone et al., 2017). Particularly, a sudden and disproportionate increase in acute load compared to chronic load (e.g., >1.5) can create excessive stress on the musculoskeletal system, increasing the risk of non-contact injuries (McCall et al., 2018; Djaoui et al., 2017; Saw et al., 2016). However, excessively low training loads may also negatively affect athletes' optimal physiological adaptation processes, leading to performance declines (Claudino et al., 2016). Therefore, not only total workload but also the structure, intensity, and continuity of training are considered determining factors for the sustainability of player performance and effective recovery processes (Clemente et al., 2019).

Monitoring wellness and fatigue states is of great importance in understanding football players' responses to training loads. Wellness is a subjective assessment method that includes parameters such as perceived well-being, sleep quality, muscle soreness, fatigue level, and psychological stress levels of players (Saw et al., 2016). Research has shown that wellness assessments are an effective tool for evaluating players'

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responses to training loads (Clemente et al., 2019; Nobari et al., 2020). Especially, high training loads and intensive match schedules can lead to musculoskeletal strain, accumulation of fatigue, and deterioration in overall well-being (McCall et al., 2018). In the study conducted by Nobari et al. (2020), it was stated that during the season, increases in workload were accompanied by increases in players' fatigue levels and muscle soreness. This indicates that monitoring wellness in football players is a critical tool not only for performance but also for training and injury management. A systematic review by Saw et al. (2016) emphasized that subjective wellness metrics are more sensitive than physiological and biochemical measurements and offer important insights for monitoring post-training recovery processes. In particular, perceived fatigue levels have been directly associated with training load and physical recovery processes (Djaoui et al., 2017).

It is known that the balance of ACWR in football players has a strong relationship with wellness parameters. According to the research by Nobari et al. (2020), increased fatigue, poor sleep quality, and high muscle soreness levels were observed during high workload periods throughout the season. Similarly, Hulin et al. (2014) reported that injury rates increased and players' physical well-being significantly declined during weeks of sudden increases in acute load. On the other hand, it is stated that an optimal ACWR range (ACWR = 0.8 – 1.3) minimizes the risk of injury and ensures more stable performance (Malone et al., 2017). However, when this ratio exceeds 1.5, particularly in lower extremity muscle groups, excessive fatigue, delayed recovery processes, and a marked increase in injury risk are observed (McCall et al., 2018).

Additionally, in the study conducted by Nobari et al. (2020) on young football players, it was found that high training monotony and high training strain values negatively affected players' subjective wellness scores. These results reveal that applying the load-assess-regulate principle in training management is critical for both maintaining performance and reducing the risk of injury in football players. Current studies clearly demonstrate the effects of high workload on wellness and fatigue levels in football players (Saw et al., 2016; Clemente et al., 2019; Nobari et al., 2020). However, more research is needed to understand how the balance between acute and chronic workloads interacts with subjective wellness variables.

The aim of this study is to examine in detail the relationships between acute and chronic workloads and wellness and fatigue in football players and to offer applicable recommendations in terms of training management. This study aims to contribute to the development of scientifically based load management strategies to better understand players' responses to training loads, improve performance, and prevent injuries.

Methods

Participants

A total of 21 football players (age: 18 ± 0.5 years; height: 172 ± 3 cm; weight: 65.2 ± 6.7 kg) playing in the Turkish Football Federation Elite Academy leagues voluntarily participated in this study. It was set as a criterion that participants have at least 5 years of training experience. All participants and their parents signed a written informed consent form before the study. The voluntary participants were informed about the benefits and risks of the study. The study was conducted in accordance with the Declaration of Helsinki and with the signed consent of the participants. Ethical approval for the study was obtained from the Ethics Committee of Istanbul Rumeli University with the decision number 2024/06 in the ethics committee meeting dated 28.08.2024.

Measurement

In this study, the training loads resulting from the perceived fatigue of athletes, their wellness status, and their neuromuscular fatigue levels were monitored. The aim of the study was to examine the relationship between these variables. The training conditions of the football players were tracked for 28 days. The athletes participating in the study consisted of those who trained four days a week and played league matches on weekends. All measurements were conducted during the competition period. The participants' training sessions were held at 15:30 from Monday to Thursday, while matches were played at 12:00 on Saturdays. Additionally, the athletes traveled for away matches every two weeks on Fridays. Training monitoring was conducted according to the microcycle structure in football, with training days categorized as MD+2, MD+3, MD-3, and MD-2. The microcycle was implemented in accordance with a standard football training plan, as shown in Table 1.

In all training sessions, session rating of perceived exertion (sRPE) and countermovement jump (CMJ) measurements were recorded. Wellness questionnaires created via Google Forms were sent to athletes every morning before training, and they were asked to complete the questionnaire before attending the session. Prior to the measurements, the athletes were provided with detailed information on the meaning and completion of all data.

Calculation of Acute-Chronic Workload Ratio (ACWR)

The internal load of participants was determined using the session rating of perceived exertion (sRPE) method. The sRPE scale was based on the 10-point Foster scale (Foster et al., 2001). Fifteen minutes after the end of each training session, participants responded to the question, "How difficult was the training for you?" and provided a rating. This rating was assigned separately for each section of the training, rather than for the entire session. Participants rated the warm-up and the main session separately, and the total score for each participant represented their internal training load. The duration of each section was multiplied by the sRPE response to calculate the internal load for each athlete. For instance, if the warm-up lasted 15 minutes and the athlete rated it as 4, the load for that section was recorded as 60. If the first part of the main session lasted 20 minutes and the athlete rated it as 6, the load for that section was recorded as 120. The sum of all sections represented the individual's internal training load. All football players in the study evaluated each training session separately. The sum of all players' scores constituted the total daily internal training load.

ACWR represents the ratio of an athlete's short-term (acute) training load to their long-term (chronic) training load (Akyıldız & Akarçeşme, 2020). Generally, acute load is calculated as the total training load of the last 7 days, while chronic load is determined as the average of the last 21 or 28 days. This ratio indicates how an athlete's current training load has changed compared to previous periods, as sudden increases in load are believed to elevate the risk of injury. For instance, an ACWR value between 0.8 and 1.3 is considered to indicate a lower injury risk, whereas values exceeding this range are associated with increased risk (Clement et al., 2019). ACWR is used alongside subjective perceived exertion (sRPE) to monitor fatigue levels in performance sports and minimize injury risk (Damji et al., 2023).

ACWR = Acute Load (Average Training Load of the Last 7 Days) / Chronic Load (Average Training Load of the Last 28 Days)

Exponentially Weighted Moving Average (EWMA)

EWMA is an advanced version of ACWR that places greater weight on recent loads, allowing for more sensitive analysis and more accurate detection of sudden load increases and cumulative fatigue (Murray et al., 2017). Consequently, EWMA is thought to help maintain an optimal training load by preventing performance declines due to excessive or insufficient training.

Formula: EMWA_t = (Yük_t × λ) + (EMWA_{t-1} × (1 - λ))

- EWMA_t: Current exponentially weighted moving average
- Load_t: Current training load
- EWMA_t-1: Previous day's EWMA value
- λ: Smoothing factor (commonly 0.33 for acute load and 0.07 for chronic load)

Training Monotony and Training Strain

Training monotony evaluates the variability in daily training loads to determine whether a training program is diverse or monotonous (Clemente et al., 2019). Low monotony indicates variation in training, while high monotony suggests that an athlete is consistently exposed to the same load, which may increase the risk of overtraining or exhaustion. Training strain is a metric derived from the combination of total training load and training monotony, representing the overall stress imposed on an athlete by their weekly training program (Oliveira et al., 2021).

- Training Monotony = Weekly Average Load / Standard Deviation of Daily Loads
- Training Strain = Weekly Total Load * Monotony

Table 1
Weekly training cycle.

Week	Monday (MD+2)	Tuesday (MD+3)	Wednesday (MD-3)	Thursday (MD-2)	Friday (MD-1)	Saturday (MD)	Sunday (MD+1)
1	Recovery	Strength	Endurance	Speed	Off	Match	Off
2	Recovery	Strength	Endurance	Speed	Travel	Match	Off
3	Recovery	Strength	Endurance	Speed	Off	Match	Off
4	Recovery	Strength	Endurance	Speed	Travel	Match	Off

Collection of Wellness Data

Participants were asked to complete a Google Form wellness questionnaire before the training start time of 15:30 for 28 consecutive days. The questionnaire consisted of 5 items: lower and upper extremity fatigue, stress, sleep, and resting heart rate. The questionnaire was designed using a 5-point Likert scale ranging from 1 (very low) to 5 (very high), as used in previous studies in the literature (Clement et al., 2020; Nobari et al., 2020). Details of the questionnaire are shown in Table 2. The concept of fatigue was considered a natural response characterized by a decrease in the body's energy level, a decline in performance, and the need for rest. Lower and upper extremity fatigue was defined as the sensation of pain in joints or muscle groups in these areas.

Table 2
Wellness questionnaire.

	1	2	3	4	5
Fatigue					
Lower Extremity Muscle Fatigue					
Upper Extremity Muscle Fatigue					
Sleep Quality					
Stress					

Neuromuscular Fatigue Test

Neuromuscular fatigue was assessed using the countermovement jump (CMJ) test (Bourdon et al., 2017; Sawczuk et al., 2018). CMJ measurements were taken immediately before training sessions. The CMJ test is considered a reliable indicator of neuromuscular fatigue (Kızıltoprak, 2020). Reductions in CMJ performance following training or competition may indicate neuromuscular fatigue (Claudino et al., 2017). Thus, CMJ testing is an important tool for monitoring recovery processes and optimizing training programs.

To avoid potential post-activation potentiation (PAP) effects, no warm-up was performed before the CMJ test (Sawczuk et al., 2018). Participants were instructed to keep their knees straight, maintain an upright torso, and position their feet shoulder-width apart at the starting position. They were then asked to descend rapidly to a 90-degree knee flexion position before jumping as high as possible. Each measurement was repeated three times, and the highest value was recorded (Holsgaard et al., 2007). CMJ height was analyzed using a smartphone camera fixed to the ground. The My Jump Lab mobile application was used for measurements, which has been validated as a reliable tool for vertical jump testing (Coban et al., 2018; Işıkdemir et al., 2024).

Data Analysis

Pearson correlation analysis was applied to determine the simple linear relationships between the data. Weekly and daily correlation analyses were conducted, examining the relationships among variables such as training load, fatigue, muscle fatigue, sleep quality, and stress. By presenting separate analyses for each week and day, the aim was to reveal the dynamic structure of variable relationships during different periods. However, adjustments for multiple comparisons (e.g., Bonferroni correction) were not applied in this study. The main reason for this is that the primary aim of this study is exploratory in nature. The findings are intended to observe potential relationships rather than to test hypotheses. Pearson correlation is used to evaluate the direction and strength of the relationship between two variables. According to the correlation coefficient, the strength of the relationship is classified as follows: 0–0.29 weak, 0.30–0.64 moderate, 0.65–0.84 strong, and 0.85–1 very strong (Ural & Kılıç, 2018). The obtained correlation coefficients were assessed to interpret the degree of relationships between variables.

Results

During the four-week data collection period, positive, strong, and very strong significant relationships were found between fatigue and lower and upper extremity parameters in all weeks and in weekly averages. The highest correlation between fatigue and lower extremity in weekly averages was observed in the fourth week, while the highest correlation with upper extremity occurred in the third week.

Positive and significant correlations of varying levels were observed between fatigue and sleep across all weeks. This relationship was moderate in the second and third weeks and strong in the fourth week. Additionally, positive and moderate to strong correlations were identified between the stress variable and fatigue on certain days and weeks. This relationship became more pronounced particularly on MD-2 and MD+2 days and in the fourth week.

The relationships between load and CMJ varied depending on weeks and days. In weekly averages, this relationship was mostly negative, while on some days, positive and significant correlations were found. In the second and third weeks, positive and significant correlations were found on MD+2 and MD+3 days, whereas in the first and fourth weeks, negative and significant correlations were identified in the weekly averages. Furthermore, positive or negative significant relationships were observed between CMJ and stress and between CMJ and lower extremity on specific days.

Different weeks revealed positive, negative, and weak correlations between load and fatigue. A negative and significant relationship was found in the third week; in other weeks, the direction and strength of the relationship varied on a daily basis. However, the relationship between load and fatigue in weekly averages was mostly not found to be significant.

Positive and significant relationships were found between the lower and upper extremities in all weeks. Moreover, a weak but significant relationship was identified between sleep and stress only in the first week. For other variable pairs, statistically non-significant relationships were observed on some days and weeks. All correlation coefficients and p-values are presented in the relevant tables separated by week and day.

Table 3

Correlation analysis of variables by match days in the first week.

Variables	1	2	3	4	5	6	7	8
1-MD+2 Load	1							
2-MD+2 Fatigue	.022	1						
3-MD+2 Lower Extremity	.164	.787**	1					
4-MD+2 Upper Extremity	.050	.819**	.595**	1				
5-MD+2 Sleep	.185	.661**	.632**	.642**	1			
6-MD+2 Stress	.193	.610**	.680**	.447**	.638**	1		
7-MD+2 Resting HR	.240	.024	.027	-.183	-.251	-.293	1	
8-MD+2 CMJ	-.148	-.182	-.026	-.022	-.140	-.165	-.175	1
1-MD+3 Load	1							
2-MD+3 Fatigue	-.046	1						
3-MD+3 Lower Extremity	-.002	.780**	1					
4-MD+3 Upper Extremity	.105	.594**	.594**	1				
5-MD+3 Sleep	-.201	.252	.480*	.327	1			
6-MD+3 Stress	.099	.635**	.440	.311	.305	1		
7-MD+3 Resting HR	-.112	-.164	-.164	-.422	-.016	-.243	1	
8-MD+3 CMJ	.608**	.097	-.027	.272	-.319	.150	-.389	1
1-MD-3 Load	1							
2-MD-3 Fatigue	-.179	1						
3-MD-3 Lower Extremity	.108	.623**	1					
4-MD-3 Upper Extremity	-.172	.623**	.310	1				
5-MD-3 Sleep	.284	.244	.486*	.284	1			
6-MD-3 Stress	.057	.280	.139	.604**	.491*	1		
7-MD-3 Resting HR	.135	-.111	-.189	-.282	.092	-.261	1	
8-MD-3 CMJ	.040	.222	.908	.208	.317	.559	.396	1
1-MD-2 Load	1							
2-MD-2 Fatigue	-.064	1						
3-MD-2 Lower Extremity	.031	.936**	1					
4-MD-2 Upper Extremity	-.289	.609**	.613**	1				
5-MD-2 Sleep	.613	.684**	.597**	.629**	1			
6-MD-2 Stress	-.106	.777**	.774**	.737**	.827**	1		
7-MD-2 Resting HR	.419	-.267	-.125	-.363	-.401	-.449*	1	
8-MD-2 CMJ	-.503*	-.050	.030	.332	.109	.162	-.252	1

***p<0.01; *p<0.05; MD: Matchday; HR: Heart Rate; CMJ: Counter Movement Jump.*

Table 4
Correlation analysis of variables by match days in the second week.

Variables	1	2	3	4	5	6	7	8
1-MD+2 Load	1							
2-MD+2 Fatigue	.174	1						
3-MD+2 Lower Extremity	.174	1.000**	1					
4-MD+2 Upper Extremity	.095	.714**	.714**	1				
5-MD+2 Sleep	.160	.681**	.681**	.310	1			
6-MD+2 Stress	.167	.470*	.470*	.359	.506*	1		
7-MD+2 Resting HR	.036	.175	.175	.125	.340	.010	1	
8-MD+2 CMJ	.584**	.066	.066	-.282	.146	-.118	-.068	1
1-MD+3 Load	1							
2-MD+3 Fatigue	.113	1						
3-MD+3 Lower Extremity	.322	.808**	1					
4-MD+3 Upper Extremity	.088	.819**	.502*	1				
5-MD+3 Sleep	-.021	.507*	.519*	.438*	1			
6-MD+3 Stress	-.056	.179	.349	.010	.550**	1		
7-MD+3 Resting HR	.044	.037	.010	.180	.040	-.155	1	
8-MD+3 CMJ	.045	-.177	-.240	.010	-.203	-.581**	.250	1
1-MD-3 Load	1							
2-MD-3 Fatigue	.197	1						
3-MD-3 Lower Extremity	.208	.768**	1					
4-MD-3 Upper Extremity	.327	.650**	.383	1				
5-MD-3 Sleep	-.065	.079	-.055	.433*	1			
6-MD-3 Stress	.125	-.132	-.046	.181	.657**	1		
7-MD-3 Resting HR	-.111	-.226	-.040	-.052	-.051	-.299	1	
8-MD-3 CMJ	-.304**	.200	-.010	.047	.204	.082	-.126	1
1-MD-2 Load	1							
2-MD-2 Fatigue	-.416	1						
3-MD-2 Lower Extremity	.131	.372	1					
4-MD-2 Upper Extremity	-.434*	.884**	.406	1				
5-MD-2 Sleep	-.279	.286	.355	.324	1			
6-MD-2 Stress	.423	.106	.669**	.138	.172	1		
7-MD-2 Resting HR	.048	-.320	.000	-.283	.046	-.339	1	
8-MD-2 CMJ	.692*	-.282	.083	-.348	-.140	.498*	-.142	1

$^{**}p<0.01$; $^{*}p<0.05$; MD: Matchday; HR: Heart Rate; CMJ: Counter Movement Jump.

Table 5
Correlation analysis of variables by match days in the third week.

Variables	1	2	3	4	5	6	7	8
1-MD+2 Load	1							
2-MD+2 Fatigue	.004	1						
3-MD+2 Lower Extremity	.241	.830**	1					
4-MD+2 Upper Extremity	.064	.973**	.829**	1				
5-MD+2 Sleep	.201	.671**	.541*	.762**	1			
6-MD+2 Stress	.275	.586**	.657**	.681**	.695**	1		
7-MD+2 Resting HR	-.048	.059	.153	-.027	-.106	-.218	1	
8-MD+2 CMJ	.903**	-.091	.107	-.029	.113	.200	-.071	1
1-MD+3 Load	1							
2-MD+3 Fatigue	-.193	1						
3-MD+3 Lower Extremity	.217	.778**	1					
4-MD+3 Upper Extremity	-.156	.869**	.736**	1				
5-MD+3 Sleep	-.102	.617**	.505*	.699**	1			
6-MD+3 Stress	-.325	.506*	.588**	.500*	.599**	1		
7-MD+3 Resting HR	.256	.102	.140	.064	.071	-.246	1	
8-MD+3 CMJ	.510*	.241	.431	.171	.252	.249	.111	1

Table 5 - Continued

Correlation analysis of variables by match days in the third week.

Variables	1	2	3	4	5	6	7	8
1-MD-2 Load	1							
2-MD-2 Fatigue	-.289	1						
3-MD-2 Lower Extremity	.577**	.398	1					
4-MD-2 Upper Extremity	-.349	.769**	.265	1				
5-MD-2 Sleep	-.330	.745**	.202	.633**	1			
6-MD-2 Stress	.213	.301	.571**	.429	.523*	1		
7-MD-2 Resting HR	.143	-.075	.010	-.150	-.073	-.084	1	
8-MD-2 CMJ	.485*	-.220	.529*	-.159	-.204	.326	.215	1

$^{**}p<0.01$; $^{*}p<0.05$; MD: Matchday; HR: Heart Rate; CMJ: Counter Movement Jump.

Table 6

Correlation analysis of variables by match days in the fourth week.

Variables	1	2	3	4	5	6	7	8
1-MD+2 Load	1							
2-MD+2 Fatigue	-.108	1						
3-MD+2 Lower Extremity	-.050	.938**	1					
4-MD+2 Upper Extremity	.078	.628**	.609**	1				
5-MD+2 Sleep	-.323	.327	.321	.437*	1			
6-MD+2 Stress	.038	.603**	.609**	.232	.121	1		
7-MD+2 Resting HR	.158	.088	.158	-.221	-.176	.341	1	
8-MD+2 CMJ	-.156	-.007	.036	.070	.124	.056	-.149	1
1-MD+3 Load	1							
2-MD+3 Fatigue	-.060	1						
3-MD+3 Lower Extremity	.109	.810**	1					
4-MD+3 Upper Extremity	-.316	.584**	.343	1				
5-MD+3 Sleep	.069	.525*	.548*	.382	1			
6-MD+3 Stress	.116	.705**	.722**	.440*	.703**	1		
7-MD+3 Resting HR	-.069	-.097	-.075	-.215	-.275	.109	1	
8-MD+3 CMJ	.719**	.192	.279	.103	.135	.299	-.056	1
1-MD-3 Load	1							
2-MD-3 Fatigue	.049	1						
3-MD-3 Lower Extremity	.184	.782**	1					
4-MD-3 Upper Extremity	.120	.418	.241	1				
5-MD-3 Sleep	.247	.200	.287	.544*	1			
6-MD-3 Stress	.279	.450*	.340	.404	.676**	1		
7-MD-3 Resting HR	.040	-.271	-.176	-.509*	-.271	-.152	1	
8-MD-3 CMJ	-.408**	.183	.158	.250	.112	.223	-.118	1
1-MD-2 Load	1							
2-MD-2 Fatigue	.432	1						
3-MD-2 Lower Extremity	.373	.909**	1					
4-MD-2 Upper Extremity	.270	.898**	.808**	1				
5-MD-2 Sleep	.369	.629**	.436*	.541*	1			
6-MD-2 Stress	.116	.730**	.542*	.808**	.473*	1		
7-MD-2 Resting HR	-.052	-.247	-.244	-.176	.061	-.027	1	
8-MD-2 CMJ	-.591**	.026	-.010	.112	-.142	.023	-.133	1

$^{**}p<0.01$; $^{*}p<0.05$; MD: Matchday; HR: Heart Rate; CMJ: Counter Movement Jump.

Table 7
Correlation analysis of variables based on four-week averages.

Variables	1	2	3	4	5	6	7	8
1-Week1 Load	1							
2-Week1 Fatigue	.291	1						
3-Week1 Lower Extremity	.347	.905**	1					
4-Week1 Upper Extremity	.301	.804**	.723**	1				
5-Week1 Sleep	.063	.512*	.591**	.502*	1			
6-Week1 Stress	.210	.762**	.736**	.709**	.733**	1		
7-Week1 Resting HR	.192	-.132	-.097	-.298	-.234	-.341	1	
8-Week1 CMJ	-.557**	.233	.235	.513*	-.055	.101	-.065	1
1-Week2 Load	1							
2-Week2 Fatigue	-.127	1						
3-Week2 Lower Extremity	.175	.869**	1					
4-Week2 Upper Extremity	-.175	.544*	.383	1				
5-Week2 Sleep	-.099	.732**	.639**	.543*	1			
6-Week2 Stress	.058	.351	.249	.066	.443*	1		
7-Week2 Resting HR	.023	-.075	.061	.041	.148	-.267	1	
8-Week2 CMJ	-.265**	.151	.060	.162	-.152	-.122	-.168	1
1-Week3 Load	1							
2-Week3 Fatigue	-.340	1						
3-Week3 Lower Extremity	.381	.613**	1					
4-Week3 Upper Extremity	-.294	.921**	.556**	1				
5-Week3 Sleep	-.280	.735**	.358	.762**	1			
6-Week3 Stress	.040	.445*	.566**	.499*	.657**	1		
7-Week3 Resting HR	.152	.010	.131	-.027	-.071	-.221	1	
8-Week3 CMJ	-.279**	-.055	.217	.165	-.099	.024	-.116	1
1-Week4 Load	1							
2-Week4 Fatigue	.158	1						
3-Week4 Lower Extremity	.194	.932**	1					
4-Week4 Upper Extremity	.090	.781**	.726**	1				
5-Week4 Sleep	.281	.746**	.684**	.729**	1			
6-Week4 Stress	.311	.743**	.669**	.559**	.905**	1		
7-Week4 Resting HR	.042	-.187	-.119	-.333	-.051	.042	1	
8-Week4 CMJ	-.494**	.218	.245	.191	.073	.105	-.047	1

***p<0.01; *p<0.05; MD: Matchday; HR: Heart Rate; CMJ: Counter Movement Jump.*

Acute-Chronic Workload Calculations

As a result of analyzing the four-week training load data, the ACWR was determined as 0.94, the ACWR (EWMA) as 0.95, training monotony as 4.71, and training strain as 5975. A strong and significant relationship was observed between Weekly Total Load and ACWR ($r = 0.97$; $p = 0.029$). The correlations between Weekly Total Load and ACWR (EWMA), monotony, and strain variables were not found to be significant ($p > 0.05$).

Discussion

This study comprehensively examined the relationships between the acute-chronic workload ratio (ACWR) and subjective wellness and fatigue levels in football players. The findings revealed a positive and strong correlation between ACWR and weekly average training load, while no significant relationship was found between training monotony and strain with ACWR. In contrast, strong relationships were observed between training loads and subjective wellness parameters, and particularly positive correlations were identified between training load and fatigue levels. This indicates that load management should be evaluated not only in physiological but also in psychological components.

The study period coincided with the competition process, and the highest weekly training load was observed in the second week, while the highest daily load occurred on MD+2. This finding shows that players continued to experience fatigue effects even in the days following matches; this can be explained by the fact that non-playing players compensated for the missing match load with high-intensity training. In this context, it can be stated that the training planning was arranged both according to match performance and individual needs. On the other hand, the ACWR value of 0.94 obtained in the study and the compatibility of the EWMA modeling suggest that the loading was within ideal limits.

However, despite this positive indicator, the high values of training monotony (>2.0) and strain (5975) are remarkable. In the literature, high values of these two parameters are associated with burnout, injury, central nervous system fatigue, and loss of motivation (Nobari et al., 2020; Oliveira et al., 2021; Clemente et al., 2019). These findings support the statistical and methodological criticisms of the ACWR model made by Impellizzeri et al. (2020). Indeed, although ACWR remained at an ideal level in our study, the high levels of monotony and strain show that relying on this model alone may not be sufficient. Therefore, it is recommended that different strategies of intensity, volume, and recovery be integrated for effective training load management.

Another notable result of the study is the relationships between DOMS (Delayed Onset Muscle Soreness) and training load. A negative relationship was observed in the pre-match period (MD-3, MD-2), while a positive relationship was observed in the post-match period (MD+2, MD+3). This indicates that DOMS is more related to match-induced fatigue. There are different results in the literature on this issue; while some studies have identified a positive relationship between training load and DOMS (Claudino et al., 2016; Roe et al., 2017; McLaren et al., 2018), others have not found a significant relationship (Malone et al., 2015; Akyıldız & Yıldız, 2021). The fact that football is a sport focused on the lower extremities and injuries are concentrated in this area increases the importance of DOMS; the low levels of perceived fatigue in young athletes explain this difference.

In terms of wellness data, no direct significant relationship was found with ACWR. However, a strong correlation was observed between lower and upper extremity pain and fatigue. Especially, increasing stress and decreasing sleep quality as the match day approached led to a significant increase in fatigue levels. The difference between the RPE felt by the athletes during training and the fatigue levels experienced the next day reveals the distinction between physiological and psychological responses. Sawczuk et al. (2018) and Akyıldız & Yıldız (2021) did not find a significant relationship between ACWR and wellness, but significant relationships have been reported in studies conducted with elite-level athletes (Buchheit et al., 2013; Thorpe et al., 2017). This difference can be explained by elite athletes managing recovery processes more effectively and providing more accurate feedback on training. Finally, although Hulin et al. (2014) found a positive relationship between ACWR, fatigue, and injury in a study conducted in the sport of cricket, it should be considered that inter-sport differences limit the generalizability of these findings.

Our study is limited to data from 21 young football players. Although there are players at the professional level among the participants, it should not be overlooked that they are young and in a monotonous training and competition period. Although our study was conducted during the competition period, it can be considered that players competing at the elite level may have higher training quality, concentration, and consequently a higher sense of professionalism. Therefore, this study should be supported with data from football players competing at the professional level. In addition, increasing the number of participants may change the statistical significance. Another limitation is that ACWR calculations were made solely based on RPE. ACWR calculations based on physical and physiological parameters along with RPE may produce different results. Although RPE is a valid and reliable method for determining training intensity, the fact that athletes are professional, amateur, or youth, the stage of the competition period they are in, and their social living conditions may affect the answers they give. In this regard, our study should be supported not only by RPE but also by training load calculation methods based on physiological and physical parameters.

Conclusion

This study examined the effects of acute and chronic training loads (ACWR) on wellness and fatigue levels in young football players. Although a positive relationship was found between ACWR and weekly training load, no acute positive relationship was detected. Additionally, ACWR was not found to significantly impact wellness and fatigue parameters. Training monotony and strain may be key factors contributing to fatigue and stress in football players.

It is suggested that coaches should not rely solely on ACWR calculations based on sRPE to assess fatigue and injury risk in football players, as this approach may lead to misleading conclusions. Incorporating physical and physiological data into these calculations could facilitate more accurate load monitoring.

Furthermore, solely relying on ACWR values while neglecting training monotony and strain may increase stress levels among players. Therefore, in micro-periodization phases of football training, greater variability should be introduced, and load fluctuations should be increased. The importance of proper load management and training variety, particularly in post-match recovery and pre-match preparation, should be emphasized. In monthly periodization, managing weekly loads correctly and appropriately determining overload and deload periods are considered essential.

Authors' Contribution

Study Design: AEK; Data Collection: AEK; Statistical Analysis: AEK; Manuscript Preparation: AEK; Funds Collection: AEK.

Ethical Approval

The study was approved by the Istanbul Rumeli University Ethical Committee (2024/06) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

References

Akyıldız, Z., & Akarçeşme, C. (2020). Monitoring training load and data analysis methods in football. *Physical Education and Sport Sciences Journal*, 14(3), 481-493. doi: 10.55929/besad.1638831

Akyıldız, Z., & Yıldız, M. (2021). Is training load correlated to neuromuscular fatigue and well-being status? A new window in wrestlers. *Spormetre Journal of Physical Education and Sport Sciences*, 19(4), 57-71. doi: 10.33689/spormetre.891471

Buchheit, M., Racinais, S., Bilsborough, J. C., Bourdon, P. C., Voss, S. C., Hocking, J., Cordy, J., Mendez-Villanueva, A., & Coutts, A. J. (2013). Monitoring fitness, fatigue and running performance during a pre-season training camp in elite football players. *J Sci Med Sport*, 16(6), 550-555. doi: 10.1016/j.jsams.2012.12.003

Claudino, J. G., Cronin, J., Mezêncio, B., McMaster, D. T., McGuigan, M., Tricoli, V., Amadio, A. C., & Serrão, J. C. (2016). The countermovement jump to monitor neuromuscular status: A meta-analysis. *J Sci Med Sport*, 19(3), 123-129. doi: 10.1016/j.jsams.2016.08.011

Clemente, F. M., Clark, C. C. T., Castillo, D., Nikolaidis, P. T., Rosemann, T., & Knechtle, B. (2019). Analyzing seasonal changes in training load and wellness indexes among professional soccer players. *Int J Environ Res Public Health*, 16(16), 2900. doi: 10.3390/ijerph16162900

Clemente, F. M., Clark, C., Castillo, D., Sarmento, H., Nikolaidis, P. T., Rosemann, T., & Knechtle, B. (2019). Variations of training load, monotony, and strain and dose-response relationships with maximal aerobic speed, maximal oxygen uptake, and isokinetic strength in professional soccer players. *PLoS One*, 14(12), e0225522. doi: 10.1371/journal.pone.0225522

Damji, F., MacDonald, K., Hunt, M. A., Taunton, J., & Scott, A. (2021). Assessing acute: chronic workload ratio methodologies for the prediction of knee pain in men's elite volleyball. *Transl Sports Med*, 4(6), 677–683. doi: 10.1002/tsm2.250

Djaoui, L., Haddad, M., Chamari, K., & Dellal, A. (2017). Monitoring training load and fatigue in soccer players with physiological markers. *Physiol Behav*, 181, 86–94. doi: 10.1016/j.physbeh.2017.09.004

Holsgaard Larsen, A., Caserotti, P., Puggaard, L., & Aagaard, P. (2007). Reproducibility and relationship of single-joint strength vs multi-joint strength and power in aging individuals. *Scand J Med Sci Sports*, 17(1), 43–53. doi: 10.1111/j.1600-0838.2006.00560.x

Hulin, B. T., Gabbett, T. J., Blanch, P., Chapman, P., Bailey, D., & Orchard, J. W. (2014). Spikes in acute workload and injury risk in elite cricket fast bowlers. *Br J Sports Med*, 48(8), 708–712. doi: 10.1136/bjsports-2013-092524

Işıkdemir, E., Yavuz, M., Çetindemir, A., Köklü, Ö., & Uzlaşır, S. (2024). Investigation of the validity and reliability of MyJump Lab application used to measure vertical jump height simultaneously with OptoJump. */ Hacettepe Journal of Sport Sciences*, 35(4), 187–196. doi: 10.17644/sbd.1543790

Malone, J. J., Murtagh, C. F., Morgans, R., Burgess, D. J., Morton, J. P., & Drust, B. (2015). Countermovement jump performance is not affected during an in-season training microcycle in elite youth soccer players. *J Strength Cond Res*, 29(3), 752–757. doi: 10.1519/JSC.0000000000000701

Malone, S., Owen, A., Mendes, B., Hughes, B., Collins, K., & Gabbett, T. J. (2017). High-speed running and sprinting as an injury risk factor in soccer: Can well-developed physical qualities reduce the risk? *J Sci Med Sport*, 20(S1), S109–S110. doi: 10.1016/j.jsams.2017.05.016

Malone, S., Owen, A., Mendes, B., Hughes, B., Collins, K., & Gabbett, T. J. (2018). High-speed running and sprinting as an injury risk factor in soccer: Can well-developed physical qualities reduce the risk? *Journal of Science and Medicine in Sport*, 21(3), 257–262.

Matos, S., Clemente, F. M., Brandão, A., Pereira, J., Rosemann, T., Nikolaidis, P. T., & Knechtle, B. (2019). Training load, aerobic capacity and their relationship with wellness status in recreational trail runners. *Front Physiol*, 10, 1189. doi: 10.3389/fphys.2019.01189

McCall, A., Jones, M., Gelis, L., Duncan, C., Ehrmann, F., Dupont, G., & Duffield, R. (2018). Monitoring loads and non-contact injury during the transition from club to national team prior to an international football tournament: A case study of the 2014 FIFA World Cup and 2015 Asia Cup. *J Sci Med Sport*, 21(8), 800–805. doi: 10.1016/j.jsams.2017.12.002

McLaren, S. J., Smith, A., Bartlett, J. D., Spears, I. R., & Weston, M. (2018). Differential training loads and individual fitness responses to pre-season in professional rugby union players. *J Sports Sci*, 36(21), 2438–2446. Doi: 10.1080/02640414.2018.1461449

Murray, N. B., Gabbett, T. J., Townshend, A. D., & Blanch, P. (2017). Calculating acute: chronic workload ratios using exponentially weighted moving averages provides a more sensitive indicator of injury likelihood than rolling averages. *Br J Sports Med*, 51(9), 749–754. doi: 10.1136/bjsports-2016-097152

Nobari, H., Aquino, R., Clemente, F. M., Khalafi, M., Adsuar, J. C., & Pérez-Gómez, J. (2020). Description of acute and chronic load, training monotony and strain over a season and its relationships with well-being status: A study in elite under-16 soccer players. *Physiol Behav*, 225, 113117. doi: 10.1016/j.physbeh.2020.113117

Oliveira, R., Martins, A., Nobari, H., Nalha, M., Mendes, B., Clemente, F. M., & Brito, J. P. (2021). In-season monotony, strain and acute/chronic workload of perceived exertion, global positioning system running based variables between player positions of a top elite soccer team. *BMC Sports Sci Med Rehabil*, 13(1), 126. doi: 10.1186/s13102-021-00356-3

Rebelo, A., Brito, J., Seabra, A., Oliveira, J., Drust, B., & Krustrup, P. (2012). A new tool to measure training load in soccer training and match play. *Int J Sports Med*, 33(4), 297–304. Doi: 10.1055/s-0031-1297952

Roe, G., Darrall-Jones, J., Till, K., Phibbs, P., Read, D., Weakley, J., & Jones, B. (2017). To jump or cycle? Monitoring neuromuscular function in rugby union players. *Int J Sports Physiol Perform*, 12(5), 690–696. doi: 10.1123/ijspp.2016-0273

Şahin, L., Altundağ, E., Kurt, S., Pişkin, N. E., Yavuz, G., & Kutlu, Z. (2021). Following professional football players' training internal load rating of perceived exertion and fitness status. *Physical Education and Sport Sciences Journal*, 15(3), 379–386.

Saw, A. E., Main, L. C., & Gastin, P. B. (2016). Monitoring the athlete training response: Subjective self-reported measures trump commonly used objective measures: A systematic review. *Br J Sports Med*, 50(5), 281–291. doi: 10.1136/bjsports-2015-094758

Sioud, R., Hammami, R., Gene-Morales, J., Juesas, A., Colado, J. C., & Van den Tillaar, R. (2022). Effects of game weekly frequency on subjective training load, wellness, and injury rate in male elite soccer players. *Int J Environ Res Public Health*, 20(1), 579. doi: 10.3390/ijerph20010579

Thorpe, R. T., Strudwick, A. J., Buchheit, M., Atkinson, G., Drust, B., & Gregson, W. (2017). The influence of changes in acute training load on daily sensitivity of morning-measured fatigue variables in elite soccer players. *Int J Sports Physiol Perform*, 12(S2), S2-107. doi: 10.1123/ijspp.2016-0433

Turgut, A., Çoban, G. Ö., & Gelen, E. (2018). Can iPhone application be used to determine vertical jump performance? *International Journal of Sport Exercise and Training Sciences*, 4(2), 79–83. doi: 10.18826/useeabd.437153

Ural, A., & Kılıç, İ. (2018). Bilimsel araştırma süreci ve SPSS ile veri analizi. Ankara: Detay Publishing. (In Turkish)