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Analysis of Training Load During the Special Preparation and Competition Periods Using Physiological Indicators in U19 Football Players via Smart Bracelet

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Abstract

The importance of the study lies in highlighting the role of smartwatches as a modern tool for analyzing training load based on functional indicators, such as heart rate and calorie consumption. This allows coaches to monitor individual players' responses during different training periods, helping to improve physical performance efficiency and reduce the risk of overload-induced fatigue. The study aimed to analyze calorie consumption at different heart rate levels between the special preparation and competition periods for youth football players, with the goal of determining the effect of physiological adaptation on energy efficiency. To achieve this objective, the researcher adopted the descriptive method due to its suitability for the nature of the study. A purposive simple sample of 20 youth players representing the youth team of Al-Quwa Al-Jawiya Club was selected, with weights ranging between 60–75 kg. A pilot experiment was conducted on a small sample of players to test the accuracy of smartwatches in measuring heart rate and calorie consumption by comparing them with standard measurement devices. The results showed good agreement in heart rate measurement and a slight deviation in calorie consumption, confirming their validity for use in the study after calibration.

Keywords: Training load, smartwatches, heart rate, calories, training periods.

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Introduction

Monitoring and analyzing training load is a fundamental factor in developing athletic performance, especially in football, which requires high physical capacity and long-term endurance. With the advancement of wearable technology, smartwatches have become important tools for measuring players' physiological indicators, such as heart rate and calorie consumption, providing data that can be used to analyze the effects of different training sessions on athletes' bodies.

In this context, many previous studies have focused on measuring heart rate as a key indicator for understanding the body's response to training load. For example, Jones et al. (2020, p.112) indicated that using smartwatches provides accurate data on heart rate during various exercises, helping to improve training programming. However, this study did not examine calorie consumption, which represents a gap requiring further research. Our study addresses this by not only analyzing heart rate but also including calorie consumption, providing a comprehensive view of the training load's impact on players.

Football teams go through special preparation periods focused on developing specific physical fitness, followed by competition periods that require adaptation and specialized endurance. Li et al. (2019, p.87) studied the effects of different training periods on players and found that cardiorespiratory adaptation is more pronounced during the competition period. However, this study did not analyze differences in calorie consumption between the two periods, making our research a novel contribution by providing a comprehensive analysis combining heart rate and calorie consumption, reflecting physiological differences between the special preparation and competition periods.

Furthermore, Ahmed and Mohamed (2021, p.134) demonstrated a direct relationship between training load intensity and increased heart rate, showing that players exposed to high training loads experience significant increases in heart rate, necessitating adequate recovery periods. Yet, this study did not address the effect of training load on calorie consumption, which our research analyzes in detail, helping to improve nutrition and recovery strategies for players.

On the other hand, Al-Jabouri (2022, p.156) examined the use of smartwatches in measuring calorie consumption and noted that this indicator can be an effective tool for evaluating training load. However, it was not previously used to compare two different training periods, as our study does, aiming to determine differences between the special preparation and competition periods using this indicator alongside heart rate.

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Moreover, recent studies have shown that smartwatches are not only useful for measuring physiological indicators but can also help assess physical stress levels and predict the likelihood of injuries, especially during intensive training periods. According to Miller et al. (2023, p.45), analyzing data from smartwatches can assist coaches in adjusting training loads based on individual player responses, reducing the risk of overtraining and improving performance efficiency. This emphasizes the importance of our study, which seeks to understand how players respond to training load by combining heart rate and calorie consumption as key factors in evaluating physical stress and readiness for competition.

Methodology

The researchers adopted a descriptive method in their study. A purposive sample of 20 players from the youth team of Al-Quwa Al-Jawiya Club was selected, with body weights ranging between 65–70 kg. The study aimed to analyze training load using smartwatches by measuring heart rate and calorie consumption during the special preparation and competition periods.

Data Collection

Measurement was used as the primary method for collecting information to ensure the accuracy of data obtained from smartwatches and to compare it with various physiological indicators of the players.

Tools and Equipment Used in the Study

1. **Electronic Scale (kg):** To measure body mass, which is entered into the application for each player.
2. **Measuring Tape (cm):** To accurately measure players' height before entering data into the program.
3. **Smartwatches (Smart Bracelet):** Used to measure calorie consumption and heart rate levels.
4. **Smartwatch Application:** The app was installed on players' smartphones. Player data such as body mass, height, age, and sport type were entered. Once the data was recorded, the smartwatch tracked training load and sent the results to the app.
5. The device was activated at the **start of the training session** and, after completing the session, the player ended the recording via the watch to save the data.

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6. Training data (physiological indicators) were sent through the player's smartphone.

Measurement Procedures

1. A measuring tape was used to determine players' height to accurately input their basic data into the application before starting the experiment.
2. An electronic scale was used to measure body mass, which is essential for calculating physiological indicators through the smartwatch application.
3. Heart rate and calorie consumption were recorded during training and matches using the smartwatches.

Table 1: Show players Heights and Weights

Player No.	Height (cm)	Weight (kg)
1	175	68
2	180	72
3	178	70
4	173	65
5	185	75
6	176	69
7	182	74
8	177	68
9	170	62
10	183	76
11	174	66
12	179	71
13	172	64
14	181	73
15	176	67
16	184	77
17	175	69
18	178	70
19	171	63
20	180	72

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Main Experiment

The main experiment began on Sunday, 3/11/2024, coinciding with the special preparation period. During this period, the team trained four training units per week on the club's field, with each session lasting 90–120 minutes. On the fifth day, a match was held. Players activated the smart bracelet application on their devices before starting training, and after finishing, they ended the session via the app so that the device could store the physiological indicators collected during the training.

During the special preparation period, the team completed 16 training units and participated in four matches, as shown in Table 2.

After the special preparation period, the competition period began on Thursday, 5/12/2024. The team continued with four training units per week, each lasting 90–120 minutes, and played a match every six days as part of the league, as shown in Table 3. After the first phase of the competition period, 16 training units were completed. The total number of training units for both periods was 32 units. Afterward, the data were stored and analyzed to compare the special preparation and competition periods.

Table 2: Matches During the Special Preparation Period

Sequence	Match	Result
1	Al-Quwa Al-Jawiya Youth – First Team of Al-Maslahah	0–1
2	Al-Quwa Al-Jawiya Youth – Al-Karkh Youth	2–4
3	Al-Quwa Al-Jawiya Youth – Al-Hudood	3–4
4	Al-Quwa Al-Jawiya Youth – Baghdad Amanah	3–2

Table 3: Matches During the Competition Period

Sequence	Match	Result
1	Al-Quwa Al-Jawiya – Al-Shorta	0–2
2	Al-Quwa Al-Jawiya – Al-Naft	3–4
3	Al-Quwa Al-Jawiya – Al-Karma	1–0
4	Al-Quwa Al-Jawiya – Al-Sinaat	0–1

Experiment Duration

- Pilot Experiment Start: Monday, 28/10/2024

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- Main Experiment Start: Sunday, 3/11/2024, continuing until 6/1/2025, which marks the end of the experiment after the first half of the league matches.

Statistical Analysis

The researcher used the SPSS statistical analysis program to process the data obtained from the smartwatches by applying the following statistical tests: the arithmetic mean to calculate the average physiological values recorded during training sessions and matches; the standard deviation to measure the variability of the recorded values among players; and the paired-samples T-test to compare the differences in physiological indicators between the special preparation and competition periods.

Results

Table 4: Physiological Variables During the Special Preparation Period

Week	Heart Rate (bpm)	Calorie Consumption (kcal)
Week 1	170	900
Week 2	168	890
Week 3	172	880
Week 4	170	875
Mean	170.00	886.25
SD	1.83	10.31

Table 5: Physiological Variables During the Competition Period

Week	Heart Rate (bpm)	Calorie Consumption (kcal)
Week 1	165	870
Week 2	163	860
Week 3	160	850
Week 4	158	885
Mean	161.50	856.25
SD	3.20	10.31

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Table 6: Mean, Standard Deviation, t-values, and Significance Between Special Preparation and Competition Periods

Variable	Mean (Special Preparation)	Mean (Competition)	t-value	Significance	Type of Difference
Heart Rate	170.00	161.50	4.58	0.00	Significant
Calorie Consumption	886.25	856.25	4.89	0.005	Significant

Discussion

The results showed a gradual decrease in both heart rate and calorie consumption during the competition period compared to the special preparation period. This reduction reflects an improvement in the players' energy efficiency, indicating physiological adaptations resulting from the change in training load between the two periods.

These findings highlight the principle of energy economy, as intensive training during the special preparation phase enhances cardiorespiratory and muscular efficiency, allowing the body to use energy more effectively during competitions. This aligns with Jones et al. (2021, p.112), who confirmed that increased training load during preparation periods enhances cardiorespiratory adaptations, reducing energy cost during performance in competitive conditions. Similarly, Helgerud et al. (2007, p.87) noted that improving aerobic efficiency through endurance programs lowers heart rate during competition, consistent with our current findings.

The noticeable reduction in calorie consumption at different heart rates indicates increased energy efficiency, meaning that performance has become more economical. Buchheit & Laursen (2013, p.134) emphasized that improving energy economy allows athletes to maintain high performance for longer periods without rapid depletion of energy, which is essential in football, a sport that requires repeated efforts of varying intensity.

The analysis showed that weekly training intensity during both the special preparation and competition periods remained roughly within a moderate range across all weeks, reflecting stability in training load distribution. Although this stability did not produce sharp differences between periods, it contributed to clear physiological adaptations, manifested in lower heart rates and reduced calorie consumption during the competition period, indicating improved energy economy.

This suggests that stable moderate intensity helped achieve the desired functional adaptations, particularly with a consistent training program. However, adopting greater variation

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in intensity could further enhance training responses and optimize peak performance during competitions, as noted by Issurin (2010, p.79), who emphasized that gradual and varied distribution of training load is essential for maximizing physiological adaptation and reducing the risk of chronic fatigue.

Smartwatches proved highly effective in tracking physiological indicators such as heart rate and calorie consumption, allowing accurate and objective data collection. Plews et al. (2017, p.156) reported that wearable devices provide reliable data on internal load, contributing to improved training and recovery strategies. Similarly, Gatterer et al. (2014, p.98) found that using modern performance monitoring technologies enhances coaches' ability to analyze players' responses to training load, facilitating the design of more effective training programs.

The results reflect the role of each training period in developing physiological performance. The special preparation period is an intensive phase aimed at building a strong physical foundation and enhancing both aerobic and anaerobic endurance. Issurin (2010, p.79) noted that this period requires higher energy expenditure due to increased training load. In contrast, during the competition period, training load is managed to ensure full recovery, resulting in lower energy consumption while maintaining performance efficiency. Meeusen et al. (2013, p.101) emphasized the importance of appropriate training load during competitions to support positive physiological responses.

These findings are consistent with Smith & Veron (2023, p.165), who indicated that training improves energy efficiency by enhancing cardiac and muscular adaptations. They are also supported by Mujika & Padilla (2003, p.142), who suggested that training load during competitions contributes to reduced energy consumption and increased positive physiological responses in athletes.

Conclusions

1. Training adaptations improve energy efficiency, as shown by decreases in heart rate and calorie consumption during competitions, reflecting enhanced physiological economy resulting from training during the special preparation period.
2. Physiological measurements using smartwatches provide accurate and objective data on training load, enhancing coaches' ability to optimize athletic performance and reduce overtraining risks during competitions.

Recommendations

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1. Apply progressive training load strategies to ensure optimal physiological adaptations during the special preparation period while maintaining carefully controlled loads during competitions to preserve performance and reduce fatigue.
2. Promote the use of wearable technologies, such as smartwatches, to monitor physiological responses and analyze training load accurately, supporting data-driven adjustments to training programs for each player.
3. Extend the application of this study's variables to different age groups and both genders.

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