International Journal of Scientific Research Updates

Journal homepage: https://orionjournals.com/ijsru/

ISSN: 2783-0160 (Online)

(RESEARCH ARTICLE)

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Intensity of training workouts and match in professional soccer players

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International Journal of Scientific Research Updates, 2022, 04(01), 057–063

Publication history: Received on 18 June 2022; revised on 23 July 2022; accepted on 22 July 2022

Article DOI: https://doi.org/10.53430/ijsru.2022.4.1.0086

Abstract

The aim of this study was to compare the internal and external loading between official matches and the in-season qualitative trainings in soccer. Nine professional soccer players (N=9) aged 29.5±2.75yrs, with body mass of 74.9±5kg, stature 180±14cm and body fat of 7±1.6% participated in the study. The selected parameters were recorded by the use of a Polar Team Pro GPS system in both two official matches and in two of the most demanding trainings in a period of 4 microcycles. The players' loads duration in a max heart rate (HR_{max}), the covered distance and the amount of accelerated/decelerated runs were measured. The paired samples t-test revealed that the load time (min) with heart rate close to 50–59.9 and 60–83.9 $\%HR_{max}$ was significantly greater during trainings, rather than the match. On the contrary, when the players' heart rate corresponded to 84–89.9 and 95–100 the values of HR_{max} were significantly greater during the match. In addition, the covered distance with a playing intensity of 19.8-24.99km.h^{-1} and >25km.h^{-1} was lower while the amount of accelerated and decelerated runs was greater during training, in comparison to the match. These findings suggest that, to become the soccer players able to respond in match conditions, coaches should replace the low intensity loads with higher, simulating as close as possible the demands of the official match.

Keywords: Soccer; Training; GPS; Heart rate; Covered distances; Match

1. Introduction

The soccer players' performance during a match depends, among others, on their physical condition, technique and tactics [1,2]. All these parameters should not be treated separately, but should be considered as a whole, because they constantly interact with each other [3]. For this reason, simulated games are used nowadays during training, in small sided games (SSGs) with a limited number of players, in order the players to receive specific stimuli and to practice simultaneously their physical condition and the various technical and/or tactical skills [4].

Moreover, although SSGs comprise a very effective training method, there is evidence that they are not the proper tool to trigger high intensity and repeated sprints as it is observed in the matches, and there is a conflict between experts on this issue [5]. In addition, using the SSGs, the "speed barrier" phenomenon may occur, during which players with high aerobic capacity and technical abilities experience difficulties to achieve high workout intensity in the above training [6]. Thus, it is suggested, during the competitive microcycle, the interchange of matches with limited, medium and large number of players, so they become be able to improve all the parameters of the physical conditioning and simultaneously practice according to the model and principals of the match [7, 8]. In addition, Payet *et al.* [9] recording small, medium and high sided games (5 vs 5 - 6 vs 6 - 7 vs 7 & 9 vs 9) and comparing them to matches, found that not only the total covered distance per min (all speeds included), but also the distances covered with high (16-23km.h^{-1}) and very high intensity per min (>23km.h^{-1}) were greater during the matches than the various competitive training

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games. Thus, the question raised is whether the use of the various competitive training games can fully replicate the competitive model of a match.

For the above reasons and aiming to improve competitive performance of soccer players, it would be helpful to identify the most important elements that could increase the success rate. In this regard, a detailed match analysis plays a very important role in team sports [10,11,12]. Especially in soccer, advanced technology offers the opportunity for a more qualitative match analysis, through internal (*e.g* heart rate) and external exertion records (through the recordings of covered distances with different running intensities, acceleration or deceleration, change of direction, energy cost, etc.) [13]. To date, several studies have attempted to detect these elements of exertion in soccer matches and training [9,14,15,16] in order to highlight the necessary parameters for a more qualitative team and individual preparation.

However, to the best of our knowledge, there is no relevant information about the overall exertion of the players during the in season microcycle, compared to their own exertion in the match. Consequently, the question remains, whether a soccer player is appropriately prepared during a week to meet the requirements of a match, since a soccer match in terms of duration (25–30min warm-up & 90+min match) and intensity sets high psychological and physical conditioning demands on the professional soccer players. Thus, it was hypothesized that, the internal and external loadings during training and match will not be identical. Therefore, the aim of the current study was to investigate if during the training, in a microcycle of the competitive period, the internal and external exertion of the soccer players during official match is reproduced.

2. Methods

2.1 Experimental design

The current study recorded and compared the loads in professional soccer players during their training in the competitive period microcycles and in official matches. A number of training load parameters during the two most intense trainings of a week (Wednesday & Thursday), for a 4-week period, have been compared with the corresponding parameters that were recorded in 2 official matches. The concise contents of the training management presented in Table 1. The remaining weekly trainings of this team during the competitive period (Tuesday, Friday, Saturday) were excluded from the study, because they focused of the players' physical and psychological discharging, in official match tactical preparation and contained low training loads.

Table 1 Content and quantity of the trainings per week and matches

Days	Strength/ Activation	Warm-up	Main training	Main training	Pitch Dimensions
Wednesday	20min: (Mini band, core stability)	15min: Passing game	15min: Agility	4x4min: 6vs6+2GK	50x40=2000m^2 166.6 m^2/player
Thursday	20min: (Functional training, flexibility)	15min: 6vs2, 5vs2, 3vs1	15min: Tactics: (defensive/ offensive)	30 min: 10vs10+2GK	88.5x68=6018m^2 300.9m^2/player
Sunday		20min: technical skills, 5vs5, sprints	2x45min+ Official match		105x68=7140m^2 357m^2/player

2.2 Participants

The sample of this study consists of nine (N= 9) professional soccer players of a team which participated in the *Super league 2* (Greek 2nd Division League) in 2017-18 season. The players aged of 29.5±2.75yrs, with body mass of 74.9±5kg, stature 180±14cm and body fat of 7±1.6%. They had at least 15 years of training experience and the majority of them were members of Greek *Super League* teams in the past.

2.3 Procedures

During the trainings and matches, each participant wore in a personal vest a portable transmitter for the real-time recording of selected parameters. The transmitter was a Polar Team Pro system (©*Polar Electro, Sports instruments, Kempele, Finland*), with high-frequency 10 Hz GPS and 200 Hz MEMS motion tracking sensor. The above console recorded:

- Time (min) in which the players' heart rate ranged from: 50–59.9, 60–83.9, 84–89.9, 90–94.9 & 95–100 $\%HR_{max}$
- Covered distance (m) with running intensity of 0–7.99km.h^{-1}, 8–14.39km.h^{-1}, 14.4–19.79km.h^{-1}, 19.8–24.99 km.h^{-1} and running intensities greater than 25km.h^{-1}
- Amount of accelerations (<1m/sec^2, 1–1.99m/sec^2, 2–2.99m/sec^2 & >3m/sec^2)
- Amount of decelerations (<-1m/sec^2, -1 to -1.99m/sec^2, -2 to -3m/sec^2 & >-3m/sec^2).

2.4 Statistical analysis

The normal distribution of the data was verified using the *Shapiro–Wilk* test and the paired samples *t*-test was applied to compare the trainings and matches data recorded from the Polar Team Pro System console. The level of significance was set as $p < 0.05$.

3. Results

The statistical treatment of the data revealed that the load time with heart rate close to 50–59.9 and 60–83.9 $\%HR_{max}$ was significantly greater during training, rather than during the match. On the contrary, when the heart rate corresponded to 84–89.9 and 95–100 $\%HR_{max}$ the values were significantly greater during the match, in comparison with the two competitive trainings per week. When the heart rate corresponded to 90–94.9 $\%HR_{max}$, the greater values were also observed in the matches. However, this difference was not statistically significant (Table 2).

Table 2 Time (min) with relative intensities ($\%HR_{max}$) during match and training (mean±SD)

$\%HR_{max}$	Time in match (min)	Time in training (min)	*t*-values
50–59.9	10.66±4.94	25.37±8.26	5.752*
60–83.9	41.55±9.81	60.39±12.25	5.525*
84–89.9	22.34±4.99	16.20±2.48	3.470*
90–94.9	15.19 ± 9.49	13.21±3.19	0.548
95–100	6.89 ± 4.23	3.09±3.52	2.391*

*p< 0.05

Table 3 Covered distances (m) in various playing intensities (km.h-1) in match and training (mean±SD)

Intensities km.h^{-1})	Match (m)	Training (m)	*t*-values
0.7-7.99	4267.22±760.38	4308.56±218.30	0.152
8–14.39	3010.33±708.40	2740.69±235.62	1.259
14.4–19.79	1193.11±360.45	982.54±205.86	2.085
19.8–24.99	433.78±186.50	271.90±106.82	4.457 *
>25	126.67±76.42	53.01±49.87	3.600 *
Total	9365.22±1080.78	8373.61±596.78	2.459 *

*p< 0.05

The covered distances with playing intensities between 19.8 and 24.99km·h^{-1} and over 25km.h^{-1} were significantly shorter during training. On the contrary, the differences between training and match were not statistically significant when the playing intensity was lower, with the exception of the intensity of 0.7–7.99km·h^{-1}, despite the fact that the

covered distances by the players were longer during the matches. In addition, the total covered distances during training were significantly shorter, in comparison with the corresponding distances during the official matches (Table 3).

Regarding the acceleration and deceleration parameters, the *t*-test revealed that the number of the accelerated and decelerated runs was significantly greater during the training, in comparison with the match. The only exception was the runs with deceleration >-3m/sec^2, where no significant differences were observed (Table 4).

Table 4 Acceleration and deceleration runs in match and training (mean±SD)

Runs (number)	Match	Training	*t*-values
Acceleration <1m/sec^2	322.22±59.05	498.46±59.76	6.738 *
Acceleration 1–1.99 m/sec^2	204.89±34.15	293.68±36.19	6.699 *
Acceleration 2–3m/sec^2	66.67±12.81	91.93±10.87	4.854 *
Acceleration >3m/sec^2	13.67±5.63	22.08±4.37	4.329 *
Deceleration <-1m/sec^2	335.78±62.53	597.59±68.86	9.133 *
Deceleration -1 to -1.99m/sec^2	197.56±45.07	296.49±29.56	6.382 *
Deceleration -2 to -3m/sec^2	69.56±14.26	83.38±10.96	3.089 *
Deceleration >-3m/sec^2	27.56±8.52	24.11±5.03	1.357
Acceleration runs (total)	607.44±101.16	908.47±95.71	6.781 *
Deceleration runs (total)	630.44±110.80	1003.32±98.70	7.745 *

*p< 0.05

4. Discussion

4.1 Players' heart rate in match/training

From the results of the current study, regarding the behavior of the heart rate, it was found that most of the time of a match was conducted with an exertion corresponding to 60–90% of the HR_{max}. This is consistent well with previous studies. For instance, Dellal *et al.* [17] found that 65% of the total duration of a match is carried out at an intensity ranging from 70 to 90% of the HR_{max} Salvo [5], observed also that 63% of a match-time took place with an exertion corresponded from 73 to 92% of the HR_{max} and Little and Williams, [18] reported that the 77 % of HR_{max} was recorded at 66% of the total match-time. Moreover, in the current study it was observed that the HR was maintained over 84% of the HR_{max} for approximately one-half of the match. This finding is in line with the results of Coelho [19] and Di Salvo *et al.* [20]. In addition, from the first Coelho [19] reported that the HR remained above 85% of HR_{max} for more than a half while later Dellal *et al.* [17] observed that in the 40% of the match-time, the HR was above 85% of the HR_{max}. In this study approximately 23% of the match-time was conducted with extensions corresponded to 85–90% of the HR_{max}, while about 22% were held with extensions above 90% of the HR_{max}. According to Olthof *et al.* [21], the 45% of the match-time is carried out with a HR corresponding to 85–90% of the HR_{max} and 30% with an intensity corresponding to a HR greater than 90% of the players' HR_{max}.

In the present study, the time span of low exertion with a heart rate in the range of 50–59.9 and 60–83.9 $\%HR_{max}$ was significantly longer during training, than during matches, where significantly greater values were recorded in the range of 84–89.9 and 95–100 $\%HR_{max}$. This finding coincides well with the observations of Asci [22] who studying the time of exertion with 70–100 $\%HR_{max}$ in official matches and SSGs, such as 3 vs 3, 4 vs 4, 5 vs 5, 7 vs 7 & 9 vs 9, reported significant differences between match and 9 vs 9 SSCs concerning the intensity of 95–100 $\%HR_{max}$, with the higher values to be noted in the official match. However, the results of the current study are not in agreement with the findings of Dellal *et al.* [17], where comparing friendly and official matches with SSGs 4 vs 4 (with one, two and free ball contacts) it was ascertained that the players' HR was significantly higher in the SSGs, rather than during the matches, while according to Casamichana *et al.* [16], no significant differences were observed between matches and various SSGs, such as 8 vs 8 (80x48m), 6 vs 6 (60x36m) and 3 vs 3 (30x18m).

According to Asci [22], the time of exertion with a HR in the range of 90–94 $\%HR_{max}$, is greater in the SSGs 3 vs 3, in relation to the match. However, this could not be verified from the results of this study, since the SSGs of 3 vs 3 was not

included in the training program. As far as the lower loads of 70–84 $\%HR_{max}$ is concerned, a greater amount of time is consumed during the match, while in the current study more time is expended during training. In addition, Allen *et al.* [23] drove to a similar result, that there is a greater time span (min) in training loads greater than 85% of the HR_{max} during 5 vs 5 SSGs, in relation to 11 vs 11 (18min vs. 4.5min). In this study, the opposite tendency is prevailing since it is deduced that, during the match, there is a greater duration of loads over 84 of the $\%HR_{max}$, in relation to the training. This phenomenon occurs possibly due to the different characteristics of the SSGs relating to the numbers of players, their age and level of technical acquisition, the dimensions of the field and the duration of the games.

4.2 Players' covered distance in match/training

The overall covered distance during match was statistically longer than the corresponding distance during training. Casamichana *et al.* [16], came to a similar conclusion. Additionally, Gabbett and Mulvey [15], reported longer covered distance in the official match, in comparison with the SSGs 3 vs 3 and 5 vs 5 and Casamichana *et al.* [16], in comparison with the SSGs format of 6 vs 6. Regarding the covered distances in a variety of intensities, significant differences were found between the official match and training when the training intensity ranged between 19.8–24.99km.h^{-1} and >25km.h^{-1}, where the longer distances were covered during the official match. Similarly, the findings of Casamichana *et al.* [16] deduced that the covered distance with playing intensity >21km.h^{-1} was significantly longer in the official matches, compared to the trainings with SSGs (3 vs 3, 5 vs 5 & 7 vs 7). The above researchers concluded that longer distances were covered during the match with speed of 18–20.9km.h^{-1}. Although the above findings were not statistically significant, in the current study where differences were observed between the match and the SSGs when the distances were covered with a playing intensity of 19.8–24.99km.h^{-1}.

In addition, Ferretti *et al.* [24] ascertained statistically longer covered distances with high intensity (>16.2km.h^{-1}) during the matches, than during the 6 vs 6 format. Ispyrlidis *et al.* [25], although did not found any statistically significant difference between the SSGs (3 vs 3, 6 vs 6 & 8 vs 8) and the official matches, regarding the covered distances with a training intensity greater than 14.976km.h^{-1}, observed statistically significant differences concerning the covered distances with a playing intensity higher than 24.948km.h^{-1}, which is in accordance with the findings of the current study. Furthermore, Payet *et al.* [6], comparing the data of official match and the various SSGs (5 vs 5, 6 vs 6, 7 vs 7, 9 vs 9), such as the total covered distances per min with an intensity of 16–23km.h^{-1} and >23km.h^{-1}, reported statistically significant differences, confirming the findings of this study.

Moreover, Holouani *et al.* [26] in an attempt to emphasize the differences in performance between the official matches and the SSGs (11 vs 11), reported that the highest loads were presented in the official matches and concerned not only about the total covered distance per min, but also about the frequency of sprints per min (≥25km.h^{-1}). These findings are similar with the observations of the current study, certifying the fact that during an official match the players cover overall longer distances in high intensity than in training. Gaudino *et al.* [27] studying, among others, the effect of pitch dimensions in the SSGs, concluded that the amount of the players' covered distance, their covered distance with running intensities >14.4km.h^{-1}, 14.4–19.8km.h^{-1}, 19.8–25.2km.h^{-1} and >25km.h^{-1}, were increased proportionally according to the increased size of the courts (10 vs 10, 7 vs 7, 5 vs 5). The above was also observed in the current study, since the longer covered distances with the highest intensity were recorded in bigger (in the matches) than in smaller pitch (during the training).

4.3 Players' number of accelerations/decelerations in match/training

Regarding the amount of accelerations and decelerations, significant differences were recorded between the training and the official match, with the highest values to be observed during training. This finding is in accordance with the results of Castellano and Casamichana [28] who, comparing matches and trainings with SSGs (3 vs 3, 5 vs 5 & 7 vs 7), recorded statistically significant higher number of accelerations during the training. Similar results with the current study are also presented [25], where a significantly lower number of maximal accelerations was observed in the official match (3.2±0.4), in comparison with the 3 vs 3 (7.6±2.1). In the above study, a significant lower number of sub-maximal accelerations was also found during the official match (12.2±0.19), in comparison with the SSGs 8 vs 8 (16.5±0.5), 6 vs 6 (20.3±2) and 3 vs 3 (28.8±2). According to Gaudino *et al.* [27] the larger court dimensions in the trainings, such as 10 vs 10, induces a significant increase in the total amount of maximal accelerations and decelerations, in comparison with the limited space SSCs of 5 vs 5 and 7 vs 7, while the restricted lied dimensions cause an increase of the medium accelerations and decelerations. This observation is in agreement with the findings of this study, where the soccer players used smaller-sized games during competitive training, in comparison with the official match. This fact, which is also in accordance with the study of Osgnach *et al.* [29], increases the neuromuscular load and the energy cost during the training, in comparison to the match [27].

Summarizing the findings of the present study a considerable amount of training time is performed under low (50–59.9 %HR_{max}) or medium intensities (60–83.9%HR_{max}), which affect only the aerobic endurance. On the contrary, the training stimuli with higher intensities (>84-89.9 %HR_{max}) seems to be applied less in the training, in comparison to the match. In addition, from the covered distances it is derived that during training with competitive SSGs in confined spaces, the proper distances of high intensity or sprint cannot be covered. This fact should be taken into consideration during the planning of the microcycle of the soccer training, otherwise the players will not be able to follow the covered distances of a soccer match in high intensities. Moreover, a significantly greater number of accelerations and decelerations are performed during training. Because, the decelerations are characterized by an eccentric muscular contraction [30], they become an important factor that can lead to fatigue and increase the possibility of muscles injuries [31,32].

5. Conclusion

Consequently, coaches should not only plan and organize the training procedures in a manner that prevents the loss of quality time during training, but should also define properly the training games (court dimensions), choose the players' ratio and determine the proper training loads (intensity–rest interval) in order to simulate the conditions of a match loadings during the training. Nevertheless, the current study is not without limitations. The main limitation was that, all the participants were professional players of only one team and therefore, it is suggested for future studies the assessment of a greater number of soccer players, from various soccer teams, with different ages and gender for the safest generalization of this study findings.

Compliance with ethical standards

Acknowledgments

Deepest appreciation is expressed to the studied team's president and board of directors for providing the opportunity to carry out this research. Sincere gratitude also to the coaches of the team for the unlimited assistance and cooperation.

Disclosure of conflict of interest

All authors declare that they have no conflict of interest in this manuscript.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

Funding

This research did not receive any funding.

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