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Exercise intensity during official soccer matches

Intensidade de exercício durante partidas oficiais de futebol

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Abstract – The aims of the study were: 1) to analyze the exercise intensity in several phases (six phases of 15 min) of soccer matches; 2) to compare the match time spent above anaerobic threshold (AT) between different age groups (U-17 and U-20); and 3) to compare the match time spent above AT between players' positions (backs, midfielders, forwards and wingabcks). Forty-four male soccer players were analyzed. To express players' effort, the heart rate (HR) was continuously monitored in 29 official matches. Further, HR corresponding to the intensity at the onset of blood lactate accumulation (OBLA) was obtained in a field test. The highest exercise intensity during match was observed in the 15-30 min period of the first half (p< 0.05). Match time spent above AT was not different between players from U-17 and U-20. In the comparison among players' positions, wingbacks showed lower time above AT (p< 0.05) than players of other positions. The intensity of effort is higher in the 15 to 30 minutes of play (intermediate phase), probably because the players are more rested in the beginning and wearing out is progressive throughout the game. It is also noteworthy that the intensity of exercise (HR and time above AT) of wingbacks was lower, probably because they usually are required to run a larger number of sprints and need more time below the AT to recover.

Key words: Anaerobic threshold; Exercise test; Heart rate; Soccer.

Resumo – *Os principais objetivos do presente estudo foram: 1) comparar a intensidade de exercício em diversas fases (seis fases de 15 min) de partidas de futebol; 2) comparar o tempo de partida acima do limiar anaeróbio (LAN) entre diferentes categorias (sub-17 e sub-20); e 3) comparar o tempo de partida acima do LAN entre jogadores de diferentes posições (zagueiros, meios-campistas, atacantes e laterais). Quarenta e quatro jogadores foram analisados. A intensidade de esforço como frequência cardíaca (FC) foi monitorada em 29 jogos oficiais. A FC correspondente à intensidade do OBLA (onset of blood lactate accumulation) foi obtida em um teste de campo. A maior intensidade de exercício foi observada no período 15-30 min do primeiro tempo (p< 0,05). O tempo de partida gasto acima do LAN não foi diferente entre jogadores das categorias sub-17 e sub-20. Os laterais apresentaram menor tempo acima do LAN (p< 0,05). Pode concluir-se que a intensidade do esforço foi maior em 15 a 30 min (fase intermediária), provavelmente porque os jogadores estão mais descansados no início e o desgaste é progressivo ao longo do jogo. A intensidade de exercício (FC e tempo acima LAN) dos laterais foi menor, provavelmente porque eles executam um maior número de sprints e necessitam de mais tempo abaixo do LAN para se recuperar.*

Palavras-chave: *Frequência cardíaca; Futebol; Limiar anaeróbio; Teste de esforço.*

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INTRODUCTION

Soccer match is characterized by actions relying strength and power, such as jumps, sprints and direct dispute of ball possession[1,2]. By being conducted in no less than 90 min soccer is also considered as an endurance activity and, in official games, the athletes typically cover around 10 km of distance[3-6].

These available data in the literature reinforce the high physical demand imposed in soccer, which is more evident in the competitive level[7]. Additionally, contemporary studies have indicated the evolution of physical parameters throughout the last decades [8] and especially during the last soccer seasons[2].

In this context, the analysis of aspects as heart rate (HR), blood lactate concentration (BLC) and anaerobic threshold (AT) have been well accepted in the sportive field[9-11]. After all, these factors are very important to understand the energy metabolism and the exercise physiology involved in the game as whole[6,12-15].

Considering that these kind of scientific approach is decisive to coaching team in order to improve quality of training prescription and athletes' performance, the major aims of the present study were: 1) to analyze the exercise intensity in diverse phases (six phases of 15 min) of soccer matches; 2) to compare the match time spent above AT between different age groups (U-17 and U-20); and 3) to compare the match time spent above AT between players' positions (backs, midfielders, forwards and wingabcks)

METHODOLOGICAL PROCEDURES

Participants

Forty-four male soccer players from U-17 and U-20 year-old categories took part in this study (Table 1). Subjects had regular training sessions and competed in official events of the Brazilian Soccer Federation. Six of these players were in the national team during the year in which the study was conducted.

Athletes maintained normal routine and followed recommendations about food and fluids ingestion in accordance with the club nutritional department. They used soccer cleats in all tests, which were performed in natural grass fields. The tests were managed in the morning and about 36 hours after the last training session to ensure that fatigue does not interfere on the performance.

This study was approved by the local Research Ethics Committee (COEP) of the Federal University of Minas Gerais (ETIC-291/09) and complied with all the standards set by the National Health Council (Res. 466/12) involving research with human beings.

Anthropometric measurements

The body fat percentage was calculated from skinfold measurements[16] using a manual skinfold calliper (Lange®). The subjects were weighed in kilograms (to the nearest 0.1 kg) on a calibrated scale (Filizola®). The subjects' height was measured using a standard stadiometer connected to the scale.

Table 1. Physiological characteristics of the male soccer players, 2011.

Category	Age (Years)	VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$)	Height (cm)	Body Mass (Kg)	Body Fat (%)
U-17 n = 26	16.38 ± 0.50	56.09 ± 1.98	175.1 ± 6.81	68.12 ± 4.19	9.57 ± 2.26
U-20 n =18	18.24 ± 0.66	59.20 ± 2.89	178.3 ± 8.52	70.34 ± 4.89	8.86 ± 1.39

Values are presented as mean ± standard deviation. U-17: under 17 years old; U-20: under 20 years old; VO_{2max}: maximal oxygen consumption.

Games heart rate determination

HR was registered in 29 official matches during the season and using appropriate equipment without wrist monitor (Polar Electro Oy®, Team System®, Finland). The HR was continuously monitored with a sample recorded every 5s. The data was later transferred to a computer and analyzed with specific software (Polar Electro Oy®, Polar Precision Performance SW 3.0, Finland). The intensity of the games was analyzed in six different phases: 0-15 min, 15-30 min and 30-45 min of the first and of the second half. Figure 1 presents an example of the HR monitoring throughout a match.

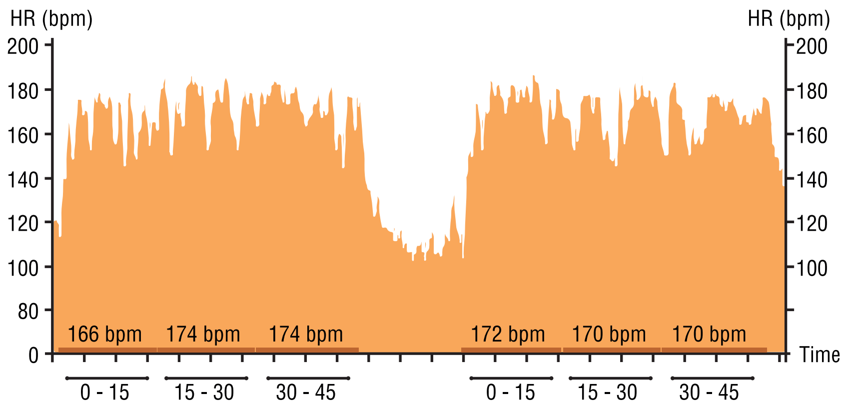

Figure 1. Heart Rate (HR) monitoring from a soccer player throughout an official match. HR average (for each phase of 15 min) is also presented.

Heart rate and Anaerobic threshold

HR corresponding to the intensity at the onset of blood lactate accumulation (OBLA) was obtained in a field test. The test consisted of 2 to 5 runs of 1000 m in a constant pace that was controlled by verbal stimulus. Between 60 and 90 seconds after each run a blood sample was collected (25 µL) to analyze the BLC using a blood lactate analyzer (Accusport®). If the BLC reached or surpassed the value of 4mM, the test was interrupted. Otherwise, the volunteer ran one more time at a faster 1 km/h speed. Each race takes place with a minimum of three minutes among themselves. The average speed of the first run was 10 km/h. The values of HR and BLC were analyzed using worksheet software (Microsoft Excel®) to determine by linear interpolation the HR corresponding to OBLA. The HR corresponding to OBLA was used to determine the percentage of the match time that was spent above the intensity of AT.

Maximal oxygen consumption test

Maximal oxygen consumption (VO_{2max}) was estimated using the field test proposed by Margaria et al.[17], which consisted of running 2400 m at the highest individual running speed. This test was applied two days after the OBLA test.

Maximum heart rate

HR values during tests were analyzed to determine the maximum heart rate (HR_{max}) of each athlete. Thus, HR_{max} was found during one of the official matches or during one of the field tests (OBLA or VO_{2max}).

The percentage of the maximum heart rate (%HR_{max}) and absolute values of HR during the games were used to express the players' effort.

Statistical analysis

One-way ANOVA and Tukey's post-hoc test were used to compare the exercise intensity among six 15-min-phases and the percentage of the match time spent above AT. The level of significance was set at 0.05.

RESULTS

All periods in the first half were more intense (HR) in comparison with the respective phases in the second half ($p < 0.05$). The highest exercise intensity during match was observed in the 15-30 min period of the first half ($p < 0.05$). Similar results are shown in the %HR_{max} analysis (Figure 2).

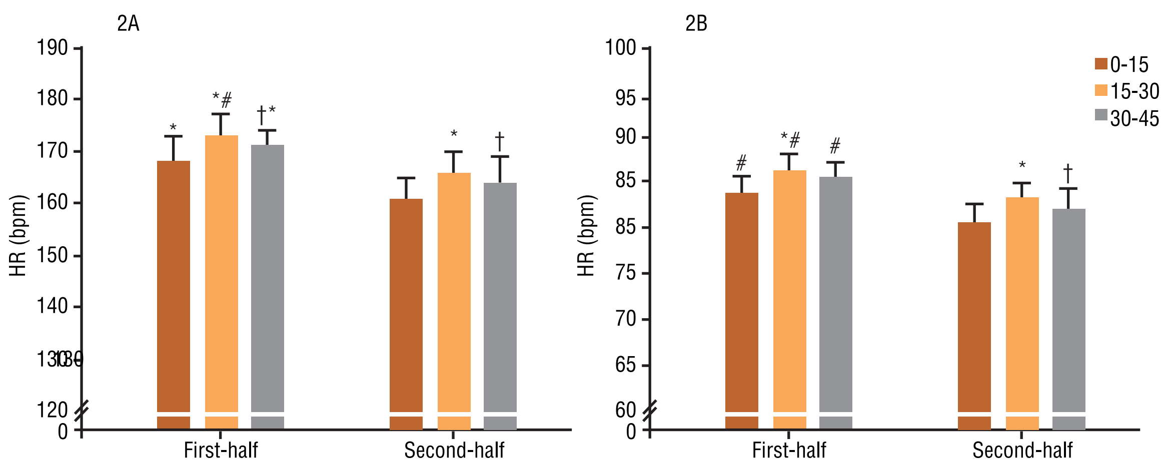

Figure 2. 2A - Intensity in the different phases of game presented as absolute heart rate (HR) (bpm). # Higher than the corresponding phase in the second half ($p<0.05$). * Higher than 0-15 and 30-45 period in the same half time ($p<0.05$). † Higher than 0-15 period in the same half time ($p<0.05$). Data presented as mean ± standard deviation. 2B - Intensity in the different phases of the game presented as relative maximum heart rate (%HR). # Higher than the corresponding phase in the second half ($p<0.05$). * Higher than 30-45 in the same half time ($p<0.05$). † Higher than 0-15 phase in the same half time ($p<0.05$). Data presented as mean ± standard deviation.

Anaerobic threshold, presented as the intensity at OBLA, was 86.20 ± 3.90 of %HR_{max} and 87.01 ± 5.10 of %HR_{max}, for U-17 and U-20, respectively. Athletes spent more time above AT in the first half ($p < 0.05$). Match time spent above AT was no statistically different between players from U-17 and U-20 (Figure 3).

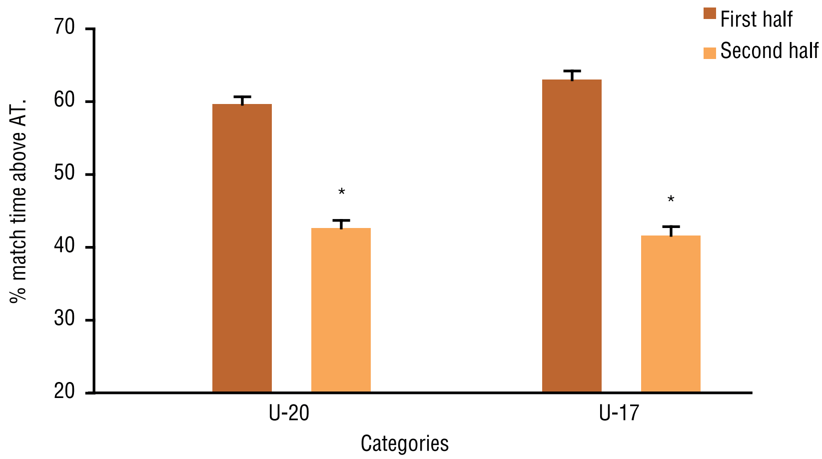

Figure 3. Match time spent above anaerobic threshold (AT). *Different from the first half ($p < 0.05$). Data presented like mean ± standard deviation.

In the comparison among players' positions, the wingbacks showed lower time above AT ($p < 0.05$) (Figure 4).

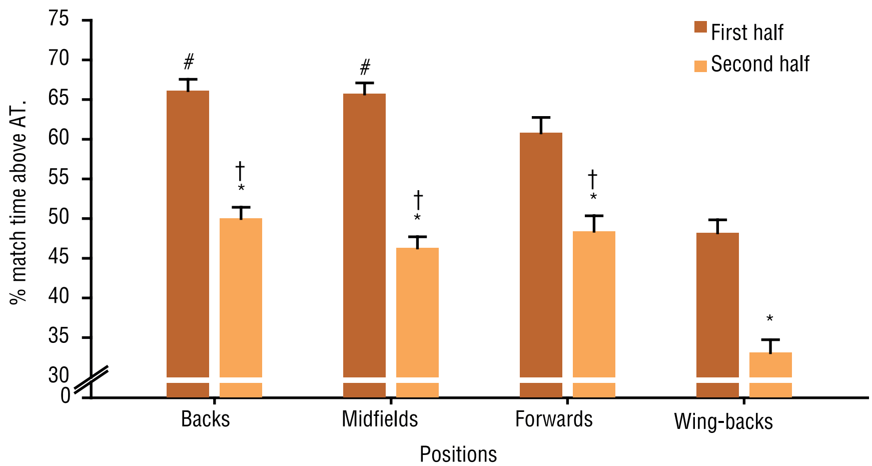

Figure 4. Match time percentage spent above the anaerobic threshold (AT) among different players' positions. *Difference between the first and second half in the same position. # Higher than wingbacks at the same half-time. † Higher than wing-backs at the same half time. Data presented as mean ± standard deviation.

DISCUSSION

Our findings revealed that the exercise intensity was highest in the first than in the second half of official soccer matches. Furthermore, it was noted a higher exercise intensity in the 15-30 min period of the first half. The comparison of the match time spent above AT did not show statistically significant differences between U-17 and U-20 athletes but revealed considerable variances among players' positions (wingbacks showed lower time above AT).

Interestingly, recent studies have proven an increase of physical demand in soccer in the last times[2,8]. An advancement in the total number of passes have been accompanied by significantly increments in sprint distance, high intensity running and number of sprints[2]. It represents an evolution in structural and tactical viewpoint of soccer and, consequently, a challenge for coaches and sport scientists to attended new physical requests.

Others researches that used HR to quantify the exercise intensity also showed that players spent less time in high intensity levels during the second half[18-20]. However, analysis of short intervals (15 min), as we did in the current paper, was not conducted in those studies. These previous data did not mention in details when the intensity shifts took place, but quantified only the time spent by players in each intensity zone over the entire match and at each half-game[21,22].

Although the VO_{2max} is undoubtedly an important element, AT might be a better indicator of aerobic endurance performance[20,23]. We confirm the difficulty of the athletes from both categories (U-17 and U-20) to maintain a high level of intensity throughout the whole game, since a less time spent above AT was observed during the second half. Previous studies indicates that reductions in exercise intensity during the second half are especially involved with muscle glycogen depletion and dehydration[7,24,25], and also with hyperthermia[26].

Curiously, in this study it was not found a "uniform" decline throughout game, since 30-45 min period was more intense than 0-15 min period in both first and second half. An explanation for this difference may be the necessary time to the athletes catch up the pace of the game and the lack of activity during interval[18,27], resulting in lower muscle temperatures in the initial phase of the second half[24]. Therefore, an interesting way to improve performance should be a well-structured warm up and keeping in activity during interval[24].

The analysis of players' position brought us another important aspect to be considered in soccer. The wingbacks showed lower time above AT compared to backs, midfielders and forwards. Surprisingly, this result was contrary with previous data in the literature, since wingbacks constantly participate in both offensive and defensive action, and are typically involved in high intensity activities[25]. Therefore, our finding can be related with a particular tactical system adopted by the team. Rather than participate actively in constant actions around the whole field, it is possible that the wingbacks have had a more specific role in the defense.

About the exercise physiology involved in soccer, it is noteworthy the importance of a well-developed aerobic system due the predominance of actions in low intensity zones (positioning maneuvers, stop periods - free kicks and ball out of play, etc.)[8]. On the other hand, the anaerobic system is determinant for game results by being direct related with the decisive actions (fast transitions from defense to attack and vice versa, kicks, jumps, sprints, etc.)[2,28]. Thus, several factors must be considered when designing soccer physical training, in order to encompass all these aspects and demands[29].

Considering that exercise intensity is one of the key components of the training load, the present results might be used by coaching staff in order to organize conditioning programs. With this information is also possible predict changes in attack or defense strategies, replacement players or even suggest technical breaks when possible. Further, it can contribute with the analysis of expected physical performance to the team.

With regard to the limitations of the study, it should be pointed out that the HR can be influenced by several aspects, such as temperature, hydration state and emotional factors. The VO_{2max} and OBLA were determined in field tests and not in the laboratory. The field tests are more specific, while the accuracy of laboratory tests is higher.

CONCLUSION

We concluded that the intensity of exercise was higher in the first half than in the second half time and that it was highest from 15 to 30 minutes into the first half of matches, probably because the players are more rested in the beginning and wearing out is progressive throughout the match. It is also noteworthy to say that the intensity of exercise (HR and time above AT) of backs, forwards, midfielders and wingbacks was not different between categories (age groups) or playing positions. However, the wingbacks remained less time above the AT probably because they usually are required to run a larger number of longer sprints and need more time below the AT to recover.

The findings of the present study highlight the intermittent nature of soccer and the different patterns of physical efforts among players' positions from a detailed analysis (short periods of 15 min) of official matches. This scientific knowledge might prove valuable for the coaching staff in tactical decisions during matches, analysis of physical performance and organization of conditioning programs.

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