

The Role of Aerobic Fitness on Session Rating of Perceived Exertion in Futsal Players

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Purpose: The aim of this study was to verify the influence of aerobic fitness ($VO_2\text{max}$) on internal training loads, as measured by the session rating of perceived exertion (session-RPE) method. **Methods:** Nine male professional outfield futsal players were monitored for 4 wk of the in-season period with regards to the weekly accumulated session-RPE, while participating in the same training sessions. Single-session-RPE was obtained from the product of a 10-point RPE scale and the duration of exercise. Maximal oxygen consumption was determined during an incremental treadmill test. **Results:** The average training load throughout the 4 wk period varied between 2,876 and 5,035 arbitrary units. Technical-tactical sessions were the predominant source of loading. There was a significant correlation between $VO_2\text{max}$ ($59.6 \pm 2.5 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) and overall training load accumulated over the total period ($r = -0.75$). **Conclusions:** The $VO_2\text{max}$ plays a key role in determining the magnitude of an individual's perceived exertion during futsal training sessions.

Keywords: team sports, training loads, maximal oxygen consumption, perception of effort

Futsal is an indoor team sport played in two periods of 20 min, involving one goalkeeper and four outfield players in each team. The outfield players maintain an average of 75–90% of maximal oxygen consumption ($VO_2\text{max}$) and maximal heart rate.¹ In addition to the high cardiovascular stress, the episodes of high intensity intermittent runs and repeated sprints elicit a great demand upon anaerobic metabolism.^{1,2} While the physiological demands of futsal and player's fitness characteristics have already been addressed in previous studies,^{1–4} further studies on the interaction between aerobic fitness and internal training load are still lacking. There are several methods to quantify the internal training load. Some of these methods are based on heart rate monitoring, providing objective units (training

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impulse [TRIMP]) imposed by training.^{5,6} However, monitoring all the athletes from a team would require numerous portable heart rate monitors to record data. Alternatively, the method based on the session rating of perceived exertion (session-RPE) proposed by Foster et al⁷ has been shown to be highly correlated with TRIMP, during continuous⁸ and more importantly, during intermittent exercise.⁹⁻¹¹ The RPE recorded after a training session has been shown to be positively correlated with blood lactate concentration, showing its sensitivity to the anaerobic as well as the aerobic contribution.¹² In this way, Coutts et al¹² stated that session-RPE can be considered a global measure of exercise intensity.

In team sports, athletes are usually submitted to similar training routines, without individualization of loads. Therefore, a wide range of internal training loads can be observed within the team. Recently, Manzi et al¹¹ reported that basketball players who performed better at the Yo-Yo IR1 test had a tendency to experience lower average training loads, as measured by session-RPE, than basketball players who performed worse at the Yo-Yo IR1 test. This suggests the need for more individualized approaches in order to provide closer matching of the internal workloads within a team. Taking into account the considerable variability in aerobic fitness among futsal players,³ it would be expected that an association exists between parameters such as gas exchange thresholds and VO_2max , with internal training loads. In other words, players with better aerobic fitness levels would perceive similar external training loads as less effortful than players with lower aerobic fitness levels.

Thus, the aim of this study is to verify the role of aerobic fitness (VO_2max) on perceived training loads. It was hypothesized that athletes with higher gas exchange thresholds and VO_2max would report lower absolute session-RPE values compared with their less fit counterparts, despite undergoing similar external training loads.

Methods

Subjects

The outfield players of a professional futsal team were enrolled in the study ($N = 9$; mean and SD: age, 22.8 ± 2.2 y; body mass, 70.6 ± 6.4 kg; height, 174.3 ± 6.0 cm). The team competed in a State first division championship in Brazil. After receiving thorough information about the procedures of this study, subjects signed a written consent form. The Institutional Ethics Committee approved the procedures and the informed consent form of this study.

Study Design

Firstly, the athletes performed an incremental running test to determine their ventilatory threshold (VT), respiratory compensation point (RCP), and maximal oxygen consumption (VO_2max). During the following 4 wk, they were monitored by means of the session-RPE method during 39 sessions of the in-season period. The training during this period comprised 21 technical-tactical sessions (futsal-specific drills, attack versus defense, training with ball, technical training, small sided games and tactical training), 9 physical training sessions (speed training, repeated sprints, interval training) and 9 resistance training sessions (whole body

exercises with free weights and isotonic machines). Besides these training sessions, they were also monitored during two official matches of the State Championship. They had official matches in weeks 1 and 4. The investigated team has finished the Championship in the fourth position.

Incremental Test

The incremental test on the treadmill (Super ATL—Inbrasport, Brazil) commenced at $6 \text{ km}\cdot\text{h}^{-1}$. The inclination was kept constant at 1%, and the speed was increased by $1 \text{ km}\cdot\text{h}^{-1}$ every minute until volitional exhaustion. Heart rate (HR) was recorded every 5 s with a short-range telemetry system (RS800, Polar Electro Oy, Finland). The pulmonary gas exchange was measured over 20 s periods using a metabolic cart (Metalyzer 3B, CPX System, Germany) that was calibrated before each test according to the manufacturer's instructions. The O_2 and CO_2 analyzers were calibrated using gases of known concentration and the volume sensor was calibrated with a 3 L syringe. The VT and RCP were determined by two independent reviewers who visually inspected the data. The VT was detected as the increase in VE/VO_2 without a concomitant increase in VE/VCO_2 and the RCP was recorded as the point of simultaneous increase in these parameters. All the players were able to meet at least two of the following criteria at exhaustion to validate the VO_2max attainment: a plateau phenomenon, RER values above 1.10 and/or HR within 5 bpm of age-predicted maximum.

Quantification of Internal Training Load

The internal training load was computed by using the session-RPE method. Approximately 30 min following the completion of every training session and two official matches, the players were required to report the intensity of the whole session by means of a modified 10-point rating of perceived exertion scale.⁷ This value was multiplied by the total duration of every training session, which consisted of technical-tactical training (TT), physical training (PT), and resistance training (RT). In addition, the match load (ML) was calculated by multiplying the postmatch RPE by the effective match duration on an individual basis. All the athletes were previously familiarized with the use of the RPE scale, as they had been using the method for approximately 2 mo before initiating the study participation. The session-RPE loads were recorded as the total daily and weekly average units.

Concurrently with session-RPE, the "strain" and "monotony" were calculated in accordance with Foster.¹³ The monotony was obtained by dividing the daily mean training load by its standard deviation, and the product of the weekly training load and the monotony was taken as a measure of strain.

Resistance training was excluded from the analysis of the relationship between VO_2max and training load because it has previously been shown that session-RPE in RT is poorly correlated with TRIMP,⁹ probably due to the high load imposed on the neuromuscular and not on the cardiorespiratory system in this kind of training. Match load was also excluded from this analysis because not all athletes played the matches.

Statistical Analyses

The training and competitive loads (TT, PT, RT and ML) and their components (each training RPE and duration) were compared by means of repeated-measures ANOVA. The same procedure was used to compare the weekly (weeks 1 to 4) training loads, and the monotony and strain indices. Post hoc analyses were carried out using the Bonferroni procedure. The training load, monotony and strain data are presented as mean \pm standard deviation (SD). The correlation between VT, RCP and VO_2max , and the magnitude of the experienced training loads was assessed by Pearson product-moment correlation. The significance level was set at 5%. SPSS (SPSS, version 17.0 for Windows; Chicago, IL) was used for all statistical calculations.

Results

The results of the incremental tests are displayed in Table 1. The VT and RCP occurred at 71% and 85% of VO_2max , respectively. The daily average training loads during the four weeks of observation were 499 ± 116 , 528 ± 127 , 839 ± 124 , 494 ± 68 arbitrary units (AU). The training load in week 3 was significantly higher than in the other weeks ($F = 56.548$, $df = 3$, $P < .001$). The weekly accumulated training load (2994 ± 696 , 2876 ± 763 , 5035 ± 744 , 2969 ± 460 AU) was also significantly higher in week 3 than in the other weeks ($F = 63.324$, $df = 3$, $P < .001$). The TT and PT (441 ± 62 and 412 ± 57 AU) were greater than the ML (248 ± 86 AU) and the RT (147 ± 24 AU) ($F = 72.810$, $df = 3$, $P < .001$). The training intensity, expressed by the session's RPE, was different between all the activities, as follows: match (7.2 ± 1.1 AU) physical (5.7 ± 0.8 AU), technical-tactical (5.1 ± 0.7 AU), and resistance (3.4 ± 0.6 AU) training modes ($F = 83.557$, $df = 3$, $P < .001$).

Table 1 Mean and standard deviation of physiological variables (n = 9)

Variable	Mean (SD)
VO_2max ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$)	59.6 ± 2.5
VO_2 at VT ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$)	42.2 ± 6.0
VO_2 at RCP ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$)	50.9 ± 4.4
HR at VT ($\text{beats}\cdot\text{min}^{-1}$)	154.0 ± 16.4
HR at RCP ($\text{beats}\cdot\text{min}^{-1}$)	176.8 ± 10.6
HRmax ($\text{beats}\cdot\text{min}^{-1}$)	190.4 ± 6.4
Velocity at VT ($\text{km}\cdot\text{h}^{-1}$)	11.3 ± 1.1
Velocity at RCP ($\text{km}\cdot\text{h}^{-1}$)	13.7 ± 1.1
Maximal velocity ($\text{km}\cdot\text{h}^{-1}$)	17.4 ± 0.8

The average training monotony during weeks 1 (2.03 ± 0.32 AU) and 3 (4.93 ± 1.69 AU) was greater than during weeks 2 (1.48 ± 0.07 AU) and 4 (1.41 ± 1.77 AU) ($F = 31.597$, $df = 1,1$, $P < .001$). Strain (6007 ± 1544 , 4189 ± 944 , 24926 ± 9437 , 4215 ± 861 AU, respectively) was significantly higher in week 3 than in the other weeks ($F = 45.100$, $df = 1$, $P < .001$).

We found significant negative correlations between daily average ($r = -0.78$ [-0.24 to -0.95]) and overall (ie, accumulated over the 4 wk) ($r = -0.75$ [-0.17 to -0.94]) TL and $VO_2\max$ (Figure 1A and 1B, respectively). The correlations between overall and daily average TL and VT ($r = -0.25$ [-0.78 to 0.50] and -0.26 [-0.79 to 0.49]) and RCP ($r = -0.44$ [-0.85 to 0.32] and -0.40 [-0.84 to 0.36]) were not significant ($P > .05$).

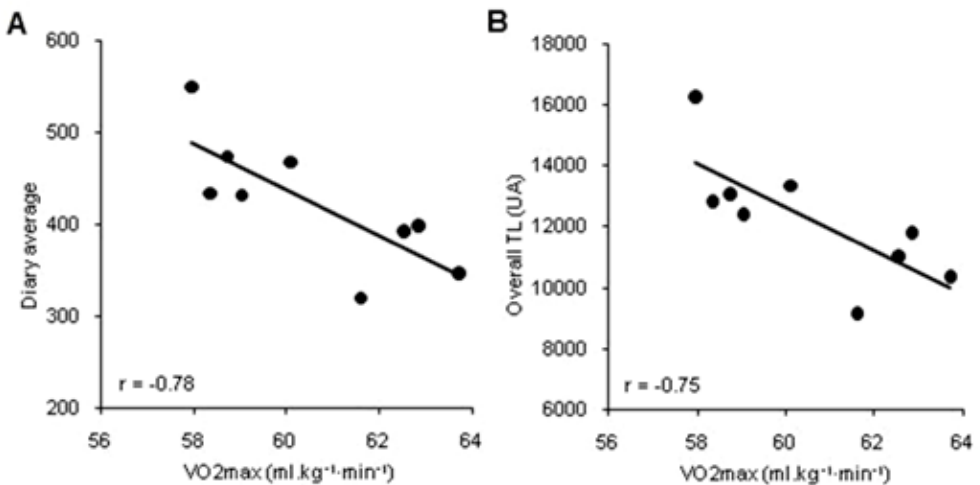


Figure 1 — Correlations between maximum oxygen uptake ($VO_2\max$) and daily average (A) and weekly accumulated (B) training loads.

Discussion

The major finding of this study is that $VO_2\max$ is inversely associated with internal training loads, implying that high aerobic fitness (> 60 $mL \cdot kg^{-1} \cdot min^{-1}$) is associated with lower perception of effort during the daily sessions and the entire mesocycle. Consequently, this relationship between aerobic fitness and the reported internal workload, in predominantly aerobic training sessions, suggests that the transduction of external to internal workloads is dependent upon the aerobic status of the athletes as reflected by the $VO_2\max$.

Maximal aerobic power is an essential fitness component for futsal playing. Recently, it has been suggested that $VO_2\max$ values of at least 55 – 60 $mL \cdot kg^{-1} \cdot min^{-1}$ would be advisable for professional players due to the demanding time-motion characteristics of the sport.^{1–3,14} The athletes who took part in the present study had $VO_2\max$ values (59.6 ± 2.5 $mL \cdot kg^{-1} \cdot min^{-1}$) within this range. Moreover, the

velocity ($11.3 \pm 1.1 \text{ km}\cdot\text{h}^{-1}$), VO_2 ($42.2 \pm 6.0 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) and HR ($154 \pm 16 \text{ bpm}$) at VT were slightly lower than the values reported by Castagna et al¹ and Barbero-Alvarez et al³ (12.2 and $12.1 \text{ km}\cdot\text{h}^{-1}$; 44.4 and $46.0 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$; 161 and 162 bpm , respectively). Nevertheless, the results still suggest that the athletes participating in the present study had a good aerobic capacity, since they were able to consume $42.2 \pm 6.0 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ of O_2 at VT, which is comparable to the $\text{VO}_{2\text{max}}$ of active people who are not athletes.¹⁵

Regarding the weekly accumulated session-RPE training loads reported in the present study, it is interesting to note the agreement with the values reported in the literature. Interestingly, our mean values are similar to those reported by Manzi et al¹¹ for professional basketball players during 1-per-week ($2938 \pm 303 \text{ AU}$) and 2-per-week ($2791 \pm 239 \text{ AU}$) game schedules. In the week with no game, they accumulated $3334 \pm 256 \text{ AU}$. In contrast, Coutts et al¹⁶ reported weekly accumulated session-RPE training loads from $1238 \pm 131 \text{ AU}$ to $2556 \pm 143 \text{ AU}$ in a semiprofessional rugby team training normally. The group which was experimentally induced to overreaching accumulated $1391 \pm 160 \text{ AU}$ to $3107 \pm 289 \text{ AU}$ per week. Our athletes underwent considerably higher training loads, ranging from 2876 ± 254 to $5035 \pm 247 \text{ AU}$ per week in the 4 wk of observation. This difference can be attributed to differences in both total training volume and intensity, given that the athletes of the present investigation trained on average more minutes per week (586 ± 44 week 1, 482 ± 35 week 2, 860 ± 0 week 3, 499 ± 23 week 4) and with higher RPE (RT 3.4; TT 5.0; PT 5.5; ML 6.9) than the rugby players studied by Coutts et al¹⁶ (308 – 746 min and RPE 4.1–4.6, respectively).

When contrasting the competition and different modes of training loads, the most intense activity, as expressed by the session's RPE, was found to be the match. This higher intensity load is likely due to the highly demanding time-motion characteristics of the game,^{1,2,14} in combination with emotional stress. During the games, in contrast to the training drills, the player experiences greater anxiety and general psychological stress, which are manifested objectively as disproportionate increases in salivary cortisol.¹⁷ The psychological state has been shown to influence the internal load of exercise as reflected on a RPE scale.¹⁸

In addition, Moreira et al⁴ have revealed a decrease in salivary immunoglobulin A (SIgA) in top-level futsal players after a simulated competitive match, which suggests a transient reduction in mucosal immune function even in the absence of the emotional factors related to official matches. One possible factor considered by the authors is the intensity of the exercise and the intrinsic dynamics of the futsal game. Moreira et al⁴ suggested that their data could corroborate the findings of Castagna et al¹ and Barbero-Alvarez et al² who showed that the physical demands of the futsal match are higher than for soccer and other intermittent team sports.

Regarding the major finding of our study, we found inverse and significant correlations between $\text{VO}_{2\text{max}}$ and the overall ($r = -0.75$) and daily average ($r = -0.78$) training load estimates. This implies that in futsal, as in other team sports in which the external load is similar to each player because of the collective nature of tasks,¹⁰ the fittest players perceive less effort than the less fit ones. This is in agreement with the negative relationship ($r = -0.88$) found between $\text{VO}_{2\text{max}}$ and the % of $\text{VO}_{2\text{max}}$ maintained in 4-per-side handball games.¹⁹ It is also consistent with the negative correlation ($r = -0.68$) between $\text{VO}_{2\text{max}}$ and the distance covered above the RCP in soccer matches.²⁰ Our data show that a player with a $\text{VO}_{2\text{max}}$ of $58 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$

is expected to experience approximately 34% higher overall and daily average TL, than a fitter player with a VO_2max of $63 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, while performing similar external loads. This discrepancy is probably related to the above-mentioned studies' results suggesting that players with higher aerobic power are able to cope with external training (or competitive) demands with lesser cardiovascular response and also avoiding acid-base disturbances related to exercising above RCP.

In addition, it may be suggested that a better recovery via an enhanced oxidative metabolism could allow athletes to experience less fatigue. This has previously been suggested by several studies showing a relationship between VO_2max and power output recovery within a session of intermittent exercise,^{21,22} more specifically related to PCr resynthesis.²³ Thus, a higher VO_2max , reflecting a higher oxidative capacity, could allow athletes to experience a lower internal training load and higher performance with a faster recovery, and subsequently, a lower level of fatigue. Furthermore, this finding may reinforce the previous observation of Manzi et al¹¹ who reported a tendency of basketball players with higher performance in the Yo-Yo IR1 to experience lower average internal training loads as measured by session-RPE.

Also, the results found by Manzi et al¹¹ combined with those reported in this study highlight the possibility of intersubject comparison of session-RPE derived training loads. In both studies, there was a relatively large variability in the training loads between the players of the same team, who are believed to undertake more or less the same external loads. This variability was in a great extent accounted for by differences in VO_2max , which is an objective measure. Therefore, we question the suggestion of Lambert and Borresen²⁴ that "intersubject comparisons may be inaccurate" due to the subjective nature of the session-RPE method.

It is not clear why VT and RCP were not significantly correlated with perceived training loads. One possible explanation is that these thresholds are related to submaximal aerobic fitness and account for training loads undertaken at lower intensities, like in endurance athletes.²⁵ In team sport training drills, the intermittent movement pattern often leads the athletes to exercise at high intensities (ie, close to or above the VO_2max intensity). Therefore, it is possible that, in team sport players, having a higher upper limit for oxygen consumption is more decisive in modulating acute metabolic/perceptual responses to training sessions than having high submaximal aerobic markers.

Practical Applications

Since a great variability in VO_2max levels is expected among players within the same team, we recommend the prescription of different workloads on the basis of the VO_2max levels, thereby allowing for the individualization of training loads. For instance, those athletes with a higher aerobic fitness could perform higher external workloads while those with a lower VO_2max should be cautious of very demanding training loads. It can also be suggested that for individualizing the training load some players may need additional or alternative training using exercises easier to control such as running interval training or specific circuits where the pacing can be controlled and selected. Future studies could examine whether field tests, which are easier to perform and can be included in routine assessments (eg, intermittent fitness tests like Yo Yo IRT²⁶ and FIET²⁷), may provide information similar to a VO_2max test.

Conclusions

In conclusion, aerobic fitness, as measured by VO_2max , accounts for >50% of the variance in the perceived training loads. Since they are negatively correlated, it is advisable to increase VO_2max of futsal players to levels above $60 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ in order to improve their ability to cope with high external training loads.

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