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ORIGINAL

BORG SCALE AND INTENSITY IN RUNNING AND TENNIS-SPECIFIC TRAINING

ESCALA DE BORG E INTENSIDAD EN ENTRENAMIENTOS DE CARRERA Y ESPECÍFICOS DE TENIS

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ABSTRACT

The differences in intensity and rate of perceived exertion between continuous running and tennis-specific training were determined. Thirteen young male tennis players participated in three 14-minute continuous endurance training sessions: a general one consisting in continuous running (CR), a specific cross-court rally exercise (SR) and, lastly, a specific competitive point-play exercise (SC). Heart rate was recorded and blood lactate and the rate of perceived exertion were measured at the end of every test. Higher heart rate and blood lactate values were obtained in the two specific exercises, the values in SC being significantly higher than in CR (heart rate: $p > 0.0054$, blood lactate: $p > 0.0320$). Conversely, no significant differences were found in the Borg scale

values. The results suggest, for this group, that the Borg scale values may underrate the intensity of tennis-specific exercises, compared with running.

KEY WORDS: Borg Scale, heart rate, blood lactate, specific training, tennis.

RESUMEN

Se determinaron las diferencias en la intensidad y la valoración subjetiva de la fatiga en entrenamientos de carrera continua y específicos de tenis. Trece tenistas varones jóvenes tomaron parte en tres entrenamientos de resistencia de tipo continuo de 14 minutos de duración. Uno general consistente en carrera continua (CC), otro específico de peloteo cruzado (EP), y por último uno específico competitivo mediante puntos (EC). Fue registrada la frecuencia cardiaca; y se valoró, al finalizar las tres pruebas, el lactato y la percepción de la fatiga. Se registraron valores más altos de frecuencia cardiaca y lactato en los dos ejercicios específicos, siendo significativamente superiores en EC respecto a CC (Frecuencia cardiaca $p > 0.0054$. Lactato $p > 0.0320$). Sin embargo, en la Escala de Borg no hubo diferencias significativas. Este estudio sugiere, para este grupo, que los valores de la Escala de Borg en ejercicios específicos de tenis pueden infravalorar la intensidad en relación con los de carrera.

PALABRAS CLAVE: Escala de Borg, frecuencia cardiaca, lactato, entrenamiento específico, tenis.

INTRODUCTION

The perceived exertion depends on a series of signals provided by several sensory receptors. This subjective perception is very interesting due to its relationship with the player's state of mind, but also with metabolic and vegetative adaptations. Various scales have been built with the purpose to assess it, the Borg scale being the most widely used. The original version of this scale ranges up to 20 (20 scale), while a modified version resembling a classic scale ranges from 1 to 10 (Borg & Kaijser, 2006).

A relationship between heart rate and the Borg scale values has been tried to be established (table 1) and high correlation has been found in several studies (Weston et al., 2006; Coquart et al., 2009; Sinclair et al., 2009). Nevertheless, a familiarisation period is needed in order to achieve high effectiveness and accuracy when using the Borg scale to assess exertion intensity (Faulkner et al., 2007).

Table 1: Correspondence among perceived exertion (Borg scale), heart rate and percentage of maximum intensity.

Borg scale	Heart rate	Intensity %
6	60-70	10%
7 Very, very light	70-80	
8	80-100	20%
9 Very light	90-110	
10	100-120	30%
11 Fairly light	110-130	
12	120-140	40%
13 Somewhat hard	130-150	50%
14	140-160	60%
15 Hard	150-170	70%
16	160-180	
17 Very hard	170-190	80%
18	180-200	90%
19 Very, very hard	190-210	100%
20	200-220	

Based on these results, some authors have claimed it to be an effective tool to continuously monitor load in an easier, faster and less invasive manner than heart rate, blood lactate or oxygen consumption directly assessed by portable spirometry (Seiler et al., 2006; Cuadrado-Reyes et al., 2012). Therefore, it may be very useful to assess changes in training intensity alone.

It has been widely used in team sports to monitor load during both training and competition (Alexiou & Coutts, 2008; Algroy et al., 2011; Calahorro et al., 2011; Cuadrado-Reyes et al., 2012). It has also been applied in a study involving tennis players to complement the information provided by heart rate and blood lactate (Mendez-Villanueva et al., 2007).

When determining the relationship between certain physiological and psychological parameters, the response to exertion in each sport must be well known and the data obtained must be carefully examined. In fact, in several studies involving football players, higher ratings on the Borg scale have been associated with a decrease in blood lactate production during the second half of a match (Torres-Luque et al., 2011) or specific high-intensity tests (Ostojic & Mazic, 2002; Krstrup et al., 2006).

Specific exercises have been proposed in the last years as an especially convenient training method. Nonetheless, it is necessary to gain knowledge regarding the physiological behaviour and perceived fatigue produced by this type of task. We consider it very interesting to determine the possible differences between general and specific exercises based on the Borg scale rating. We hypothesise that differences among exercises may modify the rate of perceived exertion and its relationship with physiological parameters.

METHODS

The sample consisted of 13 male tennis players. Mean age was 17 ± 2 years, mean height was 176.5 ± 4.4 cm and mean body mass was 69.5 ± 3.4 kg. At the moment of the study they were training 12 ± 2 hours per week and they had been training on a regular basis for 7 ± 3 years. They were national-level players who used to train endurance by means of running and continuous or interval training. All participants were informed about the characteristics of the study, and provided written informed consent prior to their participation in the study.

Experimental protocol

Prior to the study, a Conconi test on a treadmill was performed in the laboratory, with the aim to determine the players' individual maximum heart rate.

The experimental part of the study was conducted at the regional sports centre (*Centro Regional de Deportes*) of the Principality of Asturias. The running exercises were performed on a grass football field, while the tennis-specific ones were implemented on two indoor tennis courts with a medium-speed synthetic resin surface.

Three training protocols:

- a- General continuous running training (CR)
- b- Specific rally training (SR)
- c- Specific competitive training (SC).

The study lasted two weeks: first the continuous running, then the rally training and, finally, the specific competitive training was performed. Every tennis player completed two tests with a recovery period of 72 hours between them.

CR. 14 minutes of continuous running at 90% of maximum intensity, as determined by the player. This is the optimal training duration in order to reach high intensity, as well as to improve maximum oxygen consumption (Morton & Billat, 1999).

SR. 14 minutes of single cross court rally at 90% of maximum intensity, as determined by the player. The trainer brought the ball into play right after an error was made, so that the exercise continuity was maintained.

SC. 14 minutes of single point play on the whole court. The trainer brought the ball into play, the player who won the point being the first to hit the next ball cross court. The intensity depended on the characteristics of the competitive game.

A warm up consisting in 10 minutes of light-intensity continuous running was performed before the continuous running exercise (CR) and a warm up

consisting in 10 minutes of light-intensity rally was completed before the two specific exercises (SR and SC).

Heart rate was recorded during all tests by means of Polar heart rate monitors (Polar RS400, Finland). Blood lactate was measured by means of portable blood lactate analysers (Lactate Pro 2, Arkray, Japan). Blood lactate concentration was measured at the end of every test, using samples of approximately 0.3µl. Every participant was required, at the end of every exercise, to rate their level of fatigue according to the Borg scale (20 scale). All data were subsequently organised and analysed.

For the statistical analysis, a comparison of means was conducted using a two-tailed T-test for the null hypothesis that the compared means were equal, in contrast to the alternative hypothesis that they were not. A p-value of 0.05 or lower in the test would indicate a significance level of 95%. Normality of all data samples was tested using the Kolmogorov-Smirnov test; they were all normal at a significance level of 95%. The T-test was applied due to various reasons: first, because all data groups followed a normal distribution; second, because the variances of the compared samples were equal or, at least, did not differ significantly at a level of 95%, as obtained from the F-test for equality of variances; and finally, due to the sample size.

RESULTS

Heart rate

Higher heart rate values were observed in the specific exercises (table 2). The difference between SC and CR was significant (SC > CR), both in absolute values ($p > 0.0054$) and relative to the individual maximum heart rate ($p > 0.0108$).

Table 2: Mean heart rate values and percentages relative to the individual maximum heart rate in general running and tennis-specific efforts. CR: continuous running. SR: specific rally training. SC: specific competitive training.

Significant difference in absolute values. SC > CR. $p > 0.0054$.

Significant difference in values relative to the maximum heart rate. SC > CR, $p > 0.0108$.

	CR	SR	SC
Mean HR / Percentage	175.08 / 89.08%	177.54 / 90.33%	180.50 / 91.83%

Blood lactate

Blood lactate values were higher in the specific tests (table 3), especially in the exercise that included a competitive component. A significant difference between this test and the running exercise was found (SC > CR) ($p > 0.0320$).

Table 3: Mean blood lactate values in the continuous running and the specific tests. Mean value at the end of the test. CR: continuous running. SR: specific rally training. SC: specific competitive training.

Significant difference SC > CR. $p > 0.0320$.

	CR	SR	SC
Mean blood lactate	5.00	5.63	6.63

Borg Scale

The rate of perceived exertion was lower in the specific exercises, although no significant difference was observed. Table 4 shows how the specific rally exercise (SR) yielded the lowest values, especially when compared with the general running exercise (CR) ($p > 0.0654$).

The exercise intensity was rated as hard, very hard or very, very hard. The mean value lay within the 'hard' zone for the three exercises (15-16).

Table 4: Mean Borg scale values in general running and tennis-specific efforts. CR: continuous running. SR: specific rally training. SC: specific competitive training.

No significant difference. SR < CR. $p > 0.0654$.

	CR	SR	SC
Mean Borg scale values	16.15	15.38	15.69

DISCUSSION

The distinctive features of training sessions and competition make it difficult to measure heart rate and blood lactate. This has led some authors to stand up for the use of subjective fatigue and exertion intensity assessment systems to monitor work load (Coutts et al., 2007). Nevertheless, if the intent is to monitor the real load of a specific task and not only the player's subjective perception, we must ensure that such systems actually provide information that is directly related with these physiological parameters.

Heart rate and blood lactate demands

In the present study, high intensity was reached in both running and tennis-specific training sessions. Mean heart rate was higher than 89% in the running exercises (CR), higher than 90% in the specific rally exercises (SR) and higher than 91% in the point-play exercises (SC), relative to the individual maximum heart rate (Appendix, table 1). In keeping with this, several studies regarding intermittent sports have reported high values when performing specific exercises (Hoff et al., 2002; Kemi et al., 2003; Chamari et al., 2005). Fernández-Fernández et al. (2011) observed high heart rate demands during a tennis-specific task in tennis players.

In this study, heart rate values during the specific tasks (SR, SC) were higher than during the general one. The values of SC (task involving a competitive component) were significantly higher than those corresponding to continuous running (figure 1).

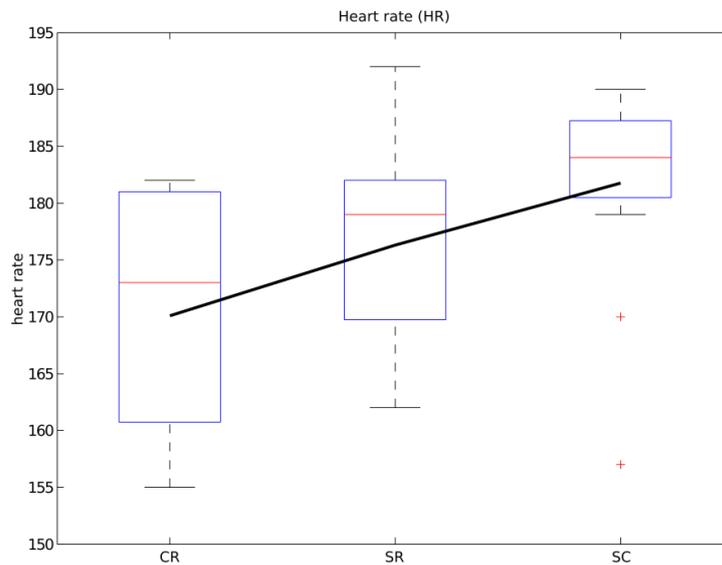


Figure 1: Distribution of the mean heart rate for the different types of exercise. CR: continuous running. SR: specific rally training. SC: specific competitive training. The box shows the data variability, determined by the 25th (lower limit) and 75th (upper limit) percentiles. The red line corresponds to the median and the end of the whiskers to the upper and lower limits, respectively, out of which data are considered as outliers. These are marked with red crosses.

As it happened with heart rate, specific exercises produced higher blood lactate values, especially when point play (SC) was performed (figure 2).

Some authors stated that when maximum oxygen consumption is reached, blood lactate concentrations get close to 8-9 mmol/l (Astrand et al., 2010). In our study these values were obtained mostly during specific competitive exercises (SC). This high lactate concentration produced by specific training has also been reported in team sports (Hill-Hass et al., 2011).

Specific exercises trigger a more intense physiological response. Consequently, stronger adaptive processes associated with the increase of maximum oxygen consumption seem to be enabled, acting locally on the tissues involved in the exercise. The greater direction and pace variability may lead, even in continuous exercises, to a larger eccentric component and a larger contribution of fast-twitch fibres. This may produce a mixed stimulus (aerobic and anaerobic), more intense in type II fibres.

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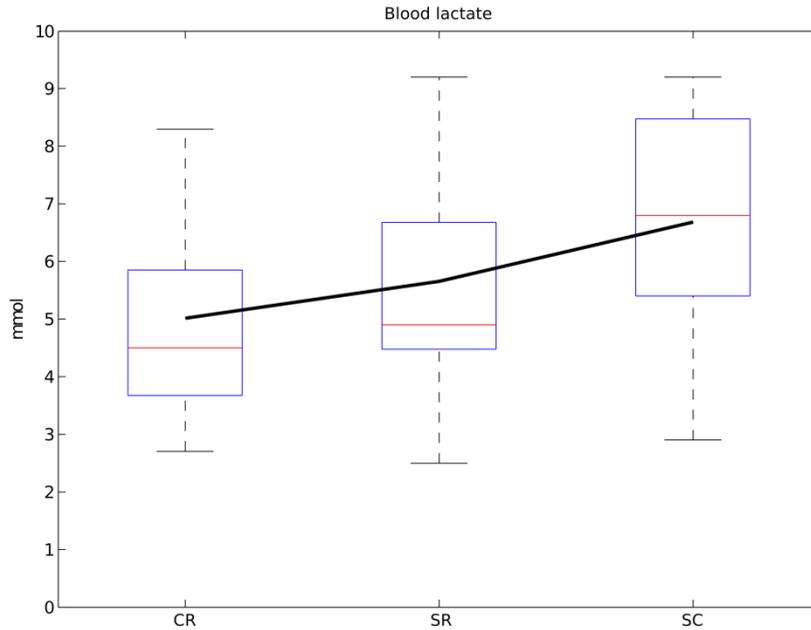


Figure 2: Blood lactate distribution for the different types of exercise. CR: continuous running. SR: specific rally training. SC: specific competitive training. The box shows the data variability, determined by the 25th (lower limit) and 75th (upper limit) percentiles. The red line corresponds to the median and the end of the whiskers to the upper and lower limits, respectively, out of which data are considered as outliers. These are marked with red crosses.

Perceived fatigue and its relationship with the physiological response

The results show a low level of fatigue perceived by the players when they performed tennis-specific exercises (figure 3). No statistically significant differences were found between SC and CR regarding the rate of perceived exertion, despite heart rate and blood lactate being significantly higher when the competitive component was involved. Actually, the perceived exertion in both specific exercises was lower than in continuous running. In line with this, the values obtained in the rally exercise (SR) were close to being significantly lower than the ones registered in the continuous running (CR) ($p > 0.0654$), while the physiological parameters were higher.

The exercise intensity was rated within the 'hard' zone in the three exercises (15-16). However, the specific exercises, which produced heart rate and intensity values associated with a rate of perceived exertion of 16, were rated as approximately 15 by the players. Likewise, the running exercise, which produced physiological values corresponding to a grade of 15, was rated above 16 by the players.

These values are in accordance with those obtained by Zouhal et al. (2013), who observed higher heart rate and blood lactate values in intermittent football-specific exercises than in intermittent running exercises. Perceived exertion was lower in the specific exercises.

A relationship between the rate of perceived exertion on the 20 Borg scale and heart rate was observed, but fatigue was overrated in general running efforts and underrated in tennis-specific ones. These possible inconsistencies must be born in mind when monitoring load, estimating exercise intensity and choosing one training method or another.

It is important to remember that, although a relationship between the physiological intensity of an exercise and the rate of perceived exertion using the Borg scale has been established (Seiler & Klerland., 2006; Weston et al., 2006; Little & Williams, 2007; Borresen & Lambert, 2008; Coquart et al., 2009; Sinclair et al., 2009), factors such as the fun or competitive components of an exercise, the motivation or the readiness level may modify this perception and its relationship with physiological parameters. Therefore, caution must be taken when trying to relate several parameters.

It seems necessary to consider all different factors when using a psychological parameter, such as the Borg scale. At the same time, the amount of experience with a certain type of drill may also impact the rate of perceived exertion by the athlete, although the Borg scale has been validated for young athletes (Impellizzeri et al., 2004). There is a logical connection between state of mind and cognitive perception, which includes from tactical decisions to the rate of perceived exertion (Skinner & Brewer, 2002; Liberal & García, 2011).

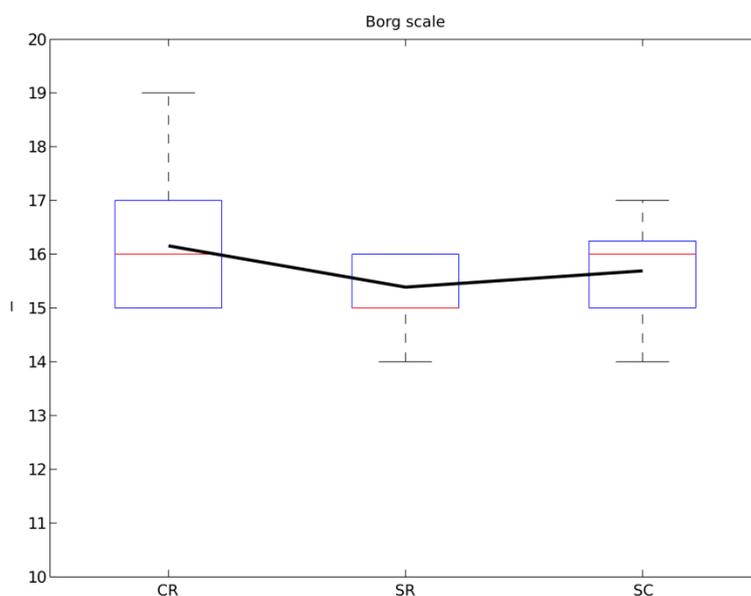


Figure 3: Distribution of Borg scale values for the different types of exercise: CR: continuous running. SR: specific rally training. SC: specific competitive training. The box shows the data variability, determined by the 25th (lower limit) and 75th (upper limit) percentiles. The red line corresponds to the median and the end of the whiskers to the upper and lower limits, respectively, out of which data are considered as outliers. These are marked with red crosses.

CONCLUSION

We can conclude that the intensity of the tennis-specific training implemented was high and also higher than the intensity of the running training, being an

appropriate mixed aerobic-anaerobic stimulus during real game situations. This was especially relevant when the competitive component was introduced. Nevertheless, we believe that the point-play training would not be the most convenient when the aim is to train at lower intensity, given the difficulty to be monitored.

Our research shows that, for this group, the rate of perceived exertion and, therefore, the effort demands in tennis-specific training may be lower than those expected based on the physiological intensity achieved. Consequently, it must be taken into account that fatigue and intensity may be underrated when using the Borg scale in competition and in tennis-specific training.

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Appendix

Table 1: Heart rate for the 13 participants. Mean HR during exercise. HRmax: individual maximum heart rate. Percentages corresponding to the means, relative to the individual HRmax. CR: continuous running. SR: specific rally training. SC: specific competitive training.

	CR	SR	SC	HRmax	CR%	SR%	SC%
Player 1	175	182	183	201	87.06	90.54	91.04
Player 2	181	192	187	200	90.50	96.00	93.50
Player 3	162	182	181	195	83.00	93.33	92.82
Player 4	164	182	188	195	84.10	93.33	96.41
Player 5	182	162	187	198	91.91	81.81	94.44
Player 6	157	164	170	196	80.10	83.67	86.73
Player 7	173	181	184	194	89.17	93.29	94.84
Player 8	168	175	190	205	77.56	85.36	92.68
Player 9	155	180	187	204	75.98	88.23	91.66
Player 10	175	174	182	198	88.58	87.87	91.91
Player 11	182	170	188	199	91.45	85.42	94.47
Player 12	156	169	157	204	76.47	82.84	76.96
Player 13	181	179	179	194	93.29	92.26	92.26

Table 2: Comparison (left) and statistical significance (right), given by the p-value, of the mean heart rate of the different exercises: CR: continuous running. SR: specific rally training. SC: specific competitive training. The null hypothesis (the means are equal) will be rejected ($H_0 = -1$ or $H_0 = 1$) with a significance level of 95% if the p-value is below 0.05. The sign given to H_0 indicates whether the mean of that column is higher (-1) or lower (+1) than of that row.

	CR	SR	SC	CR	SR	SC
CR	0	0	-1	1.0000	0.1044	0.0054
SR	0	0	0	0.1044	1.0000	0.1246
SC	1	0	0	0.0054	0.1246	1.0000

Table 3: Comparison (left) and statistical significance (right), given by the p-value, of the mean heart rate, relative to individual maximum heart rate, of the different exercises: CR: continuous running. SR: specific rally training. SC: specific competitive training. The null hypothesis (the means are equal) will be rejected ($H_0 = -1$ or $H_0 = 1$) with a significance level of 95% if the p-value is below 0.05. The sign given to H_0 indicates whether the mean of that column is higher (-1) or lower (+1) than of that row.

	CR	SR	SC	CR	SR	SC
CR	0	0	-1	1.0000	0.1458	0.0108
SR	0	0	0	0.1458	1.0000	0.1246
SC	1	0	0	0.0108	0.1458	1.0000

Table 4: Blood lactate for the 13 participants. CR: continuous running. SR: specific rally training. SC: specific competitive training.

	CR	SR	SC
Player 1	8.3	5.5	4.1
Player 2	6.6	9.1	5.7
Player 3	4.5	2.5	2.9
Player 4	5.2	4.4	6.6
Player 5	5.1	4.5	9.2
Player 6	3.1	4.1	5.5
Player 7	4.5	6.3	7.1
Player 8	3.3	4.7	8.4
Player 9	2.7	7.8	9.1
Player 10	4.4	4.9	6.8
Player 11	5.6	4.7	7.7
Player 12	3.8	5.8	5.1
Player 13	8.1	9.2	8.7

Table 5: Comparison (left) and statistical significance (right), given by the p-value, of the mean blood lactate of the different exercises: CR: continuous running. SR: specific rally training. SC: specific competitive training. The null hypothesis (the means are equal) will be rejected ($H_0 = -1$ or $H_0 = 1$) with a significance level of 95% if the p-value is below 0.05. The sign given to H_0 indicates whether the mean of that column is higher (-1) or lower (+1) than of that row.

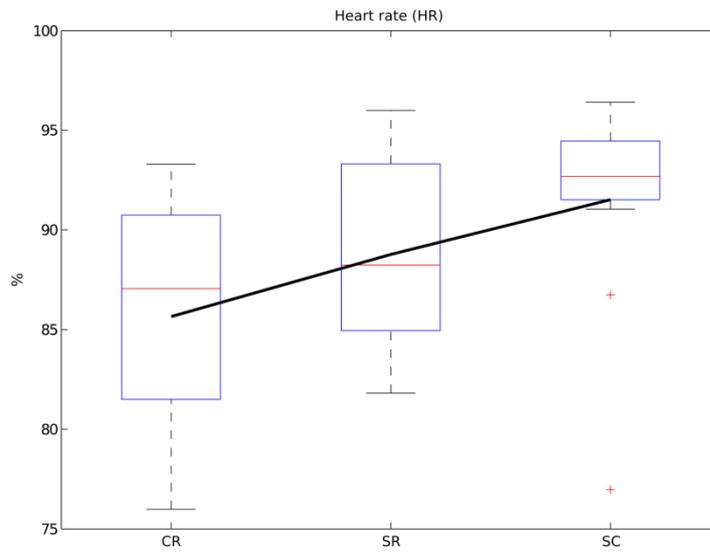
	CR	SR	SC	CR	SR	SC
CR	0	0	-1	1.0000	0.3949	0.0320
SR	0	0	0	0.3949	1.0000	0.1954
SC	1	0	0	0.0320	0.1954	1.0000

Table 6: Borg scale values for the 13 participants. CR: continuous running. SR: specific rally training. SC: specific competitive training.

	CR	SR	SC
Player 1	15	16	17
Player 2	17	15	15
Player 3	19	16	16
Player 4	15	15	17
Player 5	17	14	15
Player 6	15	15	15
Player 7	15	16	16
Player 8	17	16	16
Player 9	15	15	15
Player 10	17	16	17
Player 11	16	16	16
Player 12	15	15	15
Player 13	17	15	14

Table 7: Comparison (left) and statistical significance (right), given by the p-value, of the mean Borg scale values: CR: continuous running. SR: specific rally training. SC: specific competitive training. The null hypothesis (the means are equal) will be rejected ($H_0 = -1$ or $H_0 = 1$) with a significance level of 95% if the p-value is below 0.05. The sign given to H_0 indicates whether the mean of that column is higher (-1) or lower (+1) than of that row.

	CR	SR	SC	CR	SR	SC
CR	0	0	0	1.0000	0.0654	0.3067
SR	0	0	0	0.0654	1.0000	0.3440
SC	0	0	0	0.3067	0.3440	1.0000



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Figure 1: Distribution of the mean heart rate, relative to individual maximum heart rate, for the different types of exercise. CR: continuous running. SR: specific rally training. SC: specific competitive training. The box shows the data variability, determined by the 25th (lower limit) and 75th (upper limit) percentiles. The red line corresponds to the median and the end of the whiskers to the upper and lower limits, respectively, out of which data are considered as outliers. These are marked with red crosses.

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