



## Physical Performance During Water-Polo Matches: The Effect of the Players' Competitive Level

by

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The purpose of the study was to compare playing intensity and performance changes within a water-polo match in players of different competitive levels. High-level ( $n = 7$ ) and lower-level ( $n = 7$ ) players performed a progressively increasing speed test of 5 x 200 m swimming and speed corresponding to lactate concentration of 4.0, 5.0 and 10.0 mmol•l<sup>-1</sup> was calculated. Repeated sprint ability (8 x 20 m) was tested at pre-, the middle and post-match and a 400 m swimming test was completed at pre and post in five water-polo matches. A t-test and a two-way ANOVA were used for statistical analysis. High-level compared to lower-level players presented higher speed corresponding to lactate concentration of 4.0 and 5.0 mmol•l<sup>-1</sup> ( $p < 0.05$ ). Regardless of the sports level, the mean heart rate was reduced towards the end of the match. High-level players completed a shorter amount of match time with the heart rate lower than 85% of the peak heart rate ( $p < 0.05$ ). However, when the speed corresponding to lactate concentration of 4.0 mmol•l<sup>-1</sup> was used as a covariate, no differences were observed in the heart rate between groups. Both groups decreased repeated sprint and 400 m performance at post- compared to pre-match by  $7 \pm 3\%$  and  $7 \pm 4\%$ , respectively. High-level compared to lower-level players showed better performance in repeated sprints at the middle ( $p < 0.01$ ) and in pre-, post-match 400 m tests ( $p < 0.01$ ). It was concluded that high-level compared to lower-level players completed the match at a higher playing intensity and presented a lower performance decrement across the match as a result of their higher aerobic endurance.

**Key words:** team-sports, physical fitness, match-induced fatigue.

### Introduction

Water-polo requires prolonged high intensity intermittent exercise (Platanou 2004; Platanou and Geladas, 2006; Smith 1998). Comprehensive studies examining playing intensity and physiological demands in water-polo indicate that the overall exercise intensity corresponds to lactate threshold intensity and that more than 58% of match time is played with a heart rate (HR) greater than 85% of the HR<sub>peak</sub> (Pinnington et al., 1988; Platanou and Geladas, 2006). Based on this evidence, a high aerobic capacity seems to be a crucial factor for the overall performance of a player. In this case a high swimming speed at the

lactate threshold or a high speed at a velocity corresponding to blood lactate concentration of 4.0 mmol•l<sup>-1</sup> (V<sub>4</sub>) could be beneficial for the player.

Within the men's match, the high-intensity actions are very common (range between 10-60 times) and each one lasts between 2 to 15 s (Platanou, 2004). These actions are interspersed with lower intensity movements each one lasting less than 20 s (Platanou, 2004). As such, the ability to recover and subsequently reproduce effectively these efforts is of critical importance in a water-polo match. Furthermore, it has been observed that a time of ~7.3 min per player was spent in

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repeated high-intensity activity bouts within a match, which accounted for ~22% of total playing time (Tan et al., 2009). The above indicates that repeated sprint ability is also an important performance variable.

The prolonged and high-intensity nature of the match increases the metabolic and cardiovascular perturbation and leads to a progressive reduction of playing intensity (Galy et al., 2014; Pinnington et al., 1988; Platanou and Geladas, 2006). A factor that may limit the drop of match intensity is the players' fitness level. Galy et al. (2014) showed that players' aerobic fitness ( $VO_{2max}$  and the anaerobic threshold) is a significant predictor of match intensity. Other well-known factors affecting match intensity are its duration (Pinnington et al., 1988; Platanou and Geladas, 2006), the margin of victory (Lupo et al., 2012) as well as the level of competitiveness (Lupo et al., 2010). The level of competitiveness might be also a critical factor that determines match performance (Mohr et al., 2003).

Based on the above evidence, repeated sprint ability as well as aerobic power and capacity (i.e. 400 m performance time and V4) are determinants of physical performance in water-polo. The effects of competitiveness on water-polo match induced changes in critical performance variables such as repeated sprints and 400 m performance time remain to be identified. Therefore, the purpose of this study was to investigate whether the level of competitiveness influenced some of the essential indices of match performance, such as repeated sprint (RS) performance and 400 m time before, within and at the end of a match, which may also affect playing intensity. It was assumed that high-level players would present higher RS and 400 m performance along with an attenuated performance decrement as the match time progressed.

## Material and Methods

### Participants

Two water-polo clubs of different competitive levels competing in the men's A1 division of the Greek championship took part in the study. The high-level club (HL,  $n = 7$ , age:  $25.7 \pm 5.4$  years, body height:  $188.3 \pm 5.5$  cm, body mass:  $88.3 \pm 9.2$  kg, body fat:  $13.0 \pm 3.6\%$ ) ranked fourth at the end of the previous competitive season. The lower-level club (LL,  $n = 7$ , age:  $28.5 \pm$

$4.7$  years, body height:  $182.1 \pm 6.8$  cm, body mass:  $88.5 \pm 12.9$  kg, body fat:  $14.4 \pm 2.6\%$ ) ranked 11<sup>th</sup> in the same as HL previous competitive season (totally 12 clubs competed in the A1 division). Written informed consent was obtained from all players before the commencement of the study. The study was approved by the review board of the Faculty of Physical Education and Sports Science, of the University of Athens, and conformed to the Declaration of Helsinki. One center forward, three center defenders and ten wings were tested.

### Measures

During the pre-competition training period a series of five high-competitive friendly matches was performed between HL and LL clubs always starting at the same evening time (9 pm). The matches were completed within a period of 15 days and consisted of 4 x 15 min of match time periods. A repeated shuttle swim sprint (RS) test and 400 m freestyle swimming at maximal intensity were applied before (Pre), and after (Post) each match (Figure 1). The RS test was also applied in the middle (Mid) of the match. On a different day, a week before the series of matches, the players' fitness level was evaluated through a progressively increasing speed test of 5 x 200 m swimming repetitions as previously described by Tsekouras et al. (2005).

### Procedures

In all five matches, it was pre-arranged that the participants would play the entire game-time and not be substituted. The heart rate was measured with telemetry throughout the game (Hosand, Aqua, Canada). Players were instructed to refrain from strenuous exercise on the day before testing and to consume their normal pre-training diet on the day of testing. Three days before the match series, each participant was familiarized with the testing procedures.

Repeated sprint ability was evaluated within the first three matches. The RS test was performed by all the selected players and it consisted of 8 x 20 m maximal freestyle swimming efforts with 10 s recovery in-between. Plastic landmarks were put at -1 m, 0 m, 20 m and 21 m to set the distance (a start and a finish line). After a whistle blow, players started swimming as fast as possible from -1 m to 21 m. Timing commenced when the participant's head left the 0 m landmark (the start line) and stopped when the head passed through

the 20 m landmark (the finish line). For accurate timing of each sprint and for all players, the sprints were recorded by two digital cameras at 50 Hz (Sony Digital, DCR-PC5E, Japan). Sprint time was later retrieved using slow-motion analysis (4 images·s<sup>-1</sup>). The participants' percentage decrement score [ $S_{\text{dec}}$ : (sprint 1+ sprint 2...sprint 8)/(sprint best x number of sprints) -1) x 100] for the RS test was calculated using the equation proposed by Girard et al. (2011). Within the following two matches, a 400 m test was applied at maximum intensity; the race started in the water and time was recorded by an experienced timekeeper with a digital chronograph (Eagle, Accusplit, USA).

Following a 10 min standardized warm-up, each participant swam five repetitions of 200 m, in an outdoor 50 m pool, at intensities corresponding to 60, 70, 80, 90 and 100% of maximum speed, with a 5 min passive recovery period between each effort. Fingertip blood samples were immediately analyzed using the reflectance photometry-enzymatic reaction method (Accusport, Boehringer, Germany). The speed corresponding to blood lactate concentration of 4.0, 5.0, and 10.0 mmol·l<sup>-1</sup> (V4, V5, V10) was calculated from the speed-lactate curve by interpolation of a second order polynomial function. The lactate tolerance rating was defined as the differential speed between blood lactate concentrations of 10.0 and 5.0 mmol·l<sup>-1</sup> (V10-V5; Pyne et al., 2001).

#### Statistical Analysis

Data are reported as mean ± standard deviation (SD) or 90% confidence limits (CL). Before using parametric tests, the assumption of normality was verified using the Shapiro-Wilk test. A paired t-test for independent samples was used to identify differences between HL and LL groups in V4, V5, V10 and V10-V5. A two-way analysis of variance (ANOVA) for independent samples and repeated measures was used to detect performance differences within the match as well as between HL and LL groups in mean RS and 400 m time. A Tukey's post-hoc test was employed to locate the differences between means. Both V4 and V5 were used as covariates to examine whether the different fitness level affected HR variance. The Pearson's r coefficient was used to test the associations between variables. The level of significance was set at

$p < 0.05$ .

## Results

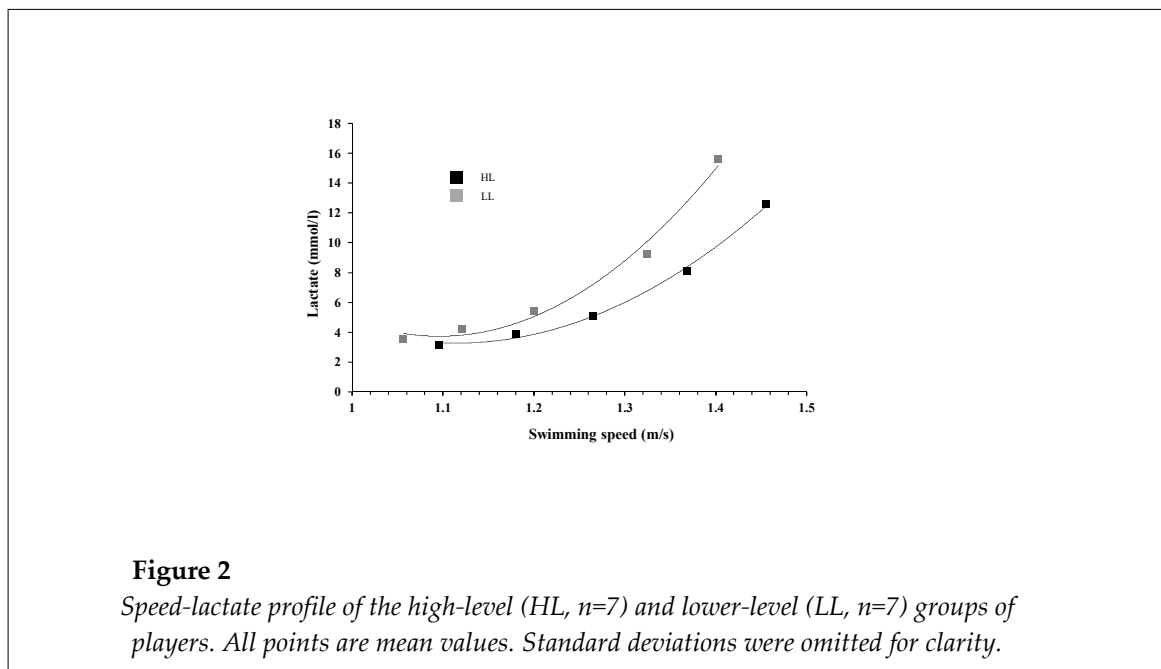
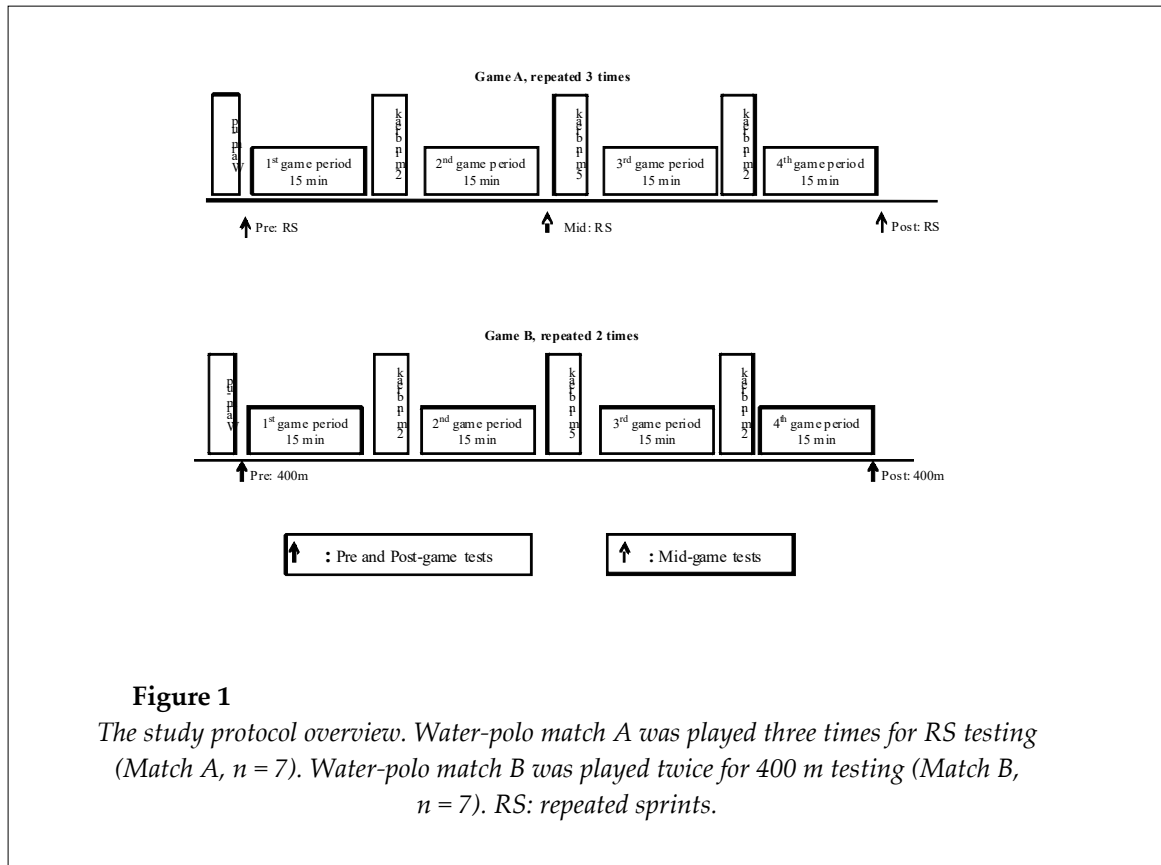
The mean speed-lactate curve of both groups is presented in Figure 2. The HL group of players showed higher V4 (HL:  $1.21 \pm 0.05$  vs. LL:  $1.13 \pm 0.04$  m·s<sup>-1</sup>,  $p < 0.01$ ), and V5 (HL:  $1.26 \pm 0.06$  vs. LL:  $1.19 \pm 0.03$  m·s<sup>-1</sup>,  $p < 0.05$ ), while no differences were observed in V10 (HL:  $1.41 \pm 0.09$  vs. LL:  $1.33 \pm 0.05$  m·s<sup>-1</sup>,  $p = 0.06$ ) and V10-V5 (HL:  $0.15 \pm 0.05$  vs. LL:  $0.14 \pm 0.06$  m·s<sup>-1</sup>,  $p > 0.05$ ).

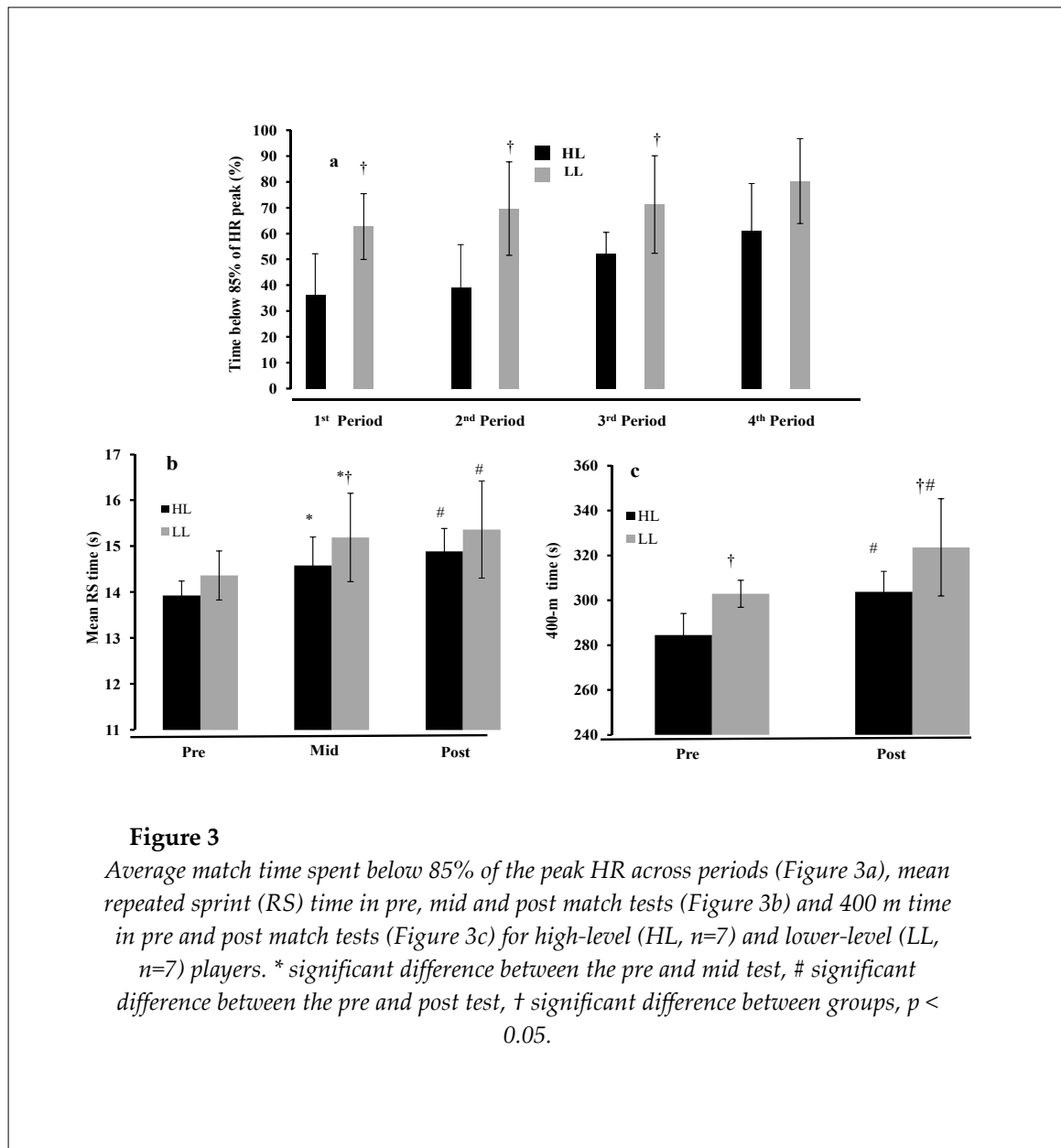
Regardless of the group, the mean HR was decreasing as match time was progressing (first period:  $153 \pm 9$ , second period:  $151 \pm 8$ , third period:  $146 \pm 7$ , fourth period:  $143 \pm 9$  beats·min<sup>-1</sup>,  $p < 0.05$ ). No HR differences were observed between groups in the first, third and fourth period ( $p > 0.05$ ). In the second period, HL athletes demonstrated higher mean values compared to LL athletes (HL:  $155 \pm 8$  beats·min<sup>-1</sup> vs. LL:  $147 \pm 7$  beats·min<sup>-1</sup>,  $p < 0.05$ ). Additionally, HL athletes played shorter amount of time with the HR below or equal to 85% of the HR<sub>peak</sub> in the first, second and third period ( $p < 0.05$ ), while no differences were detected among groups in the fourth period of the match ( $p = 0.06$ ; Figure 3a). However, when V4 was used as a covariate, no differences were detected between groups both in the mean HR at the second period ( $p = 0.38$ ) as well as in the percentage of playing time spent at intensity corresponding to <85% of the HR<sub>peak</sub> ( $p > 0.05$ ). In addition, significant correlations were detected between V4 and the percentage of playing time spent at <85% of the HR<sub>peak</sub> in all periods of the match ( $r = -0.71-0.78$ ,  $p < 0.01$ ).

There was no difference between groups in RS ability (main effect of groups,  $p = 0.18$ ), but performance was decreased at post match by 7 ± 3% (main effect of time,  $p < 0.01$ ). A group x time interaction was detected indicating that although both groups showed similar mean RS time at Pre and Post-match tests (Pre, HL:  $13.9 \pm 0.3$  vs. LL:  $14.3 \pm 0.5$  s,  $p > 0.05$ ; Post, HL:  $14.9 \pm 0.5$  vs. LL:  $15.4 \pm 1.1$  s,  $p = 0.06$ , Figure 3b), a between group difference was detected in the Mid match test (HL:  $14.6 \pm 0.6$  vs. LL:  $15.2 \pm 1.0$  s,  $p < 0.05$ , Figure 3b). Both groups exhibited similar  $S_{\text{dec}}$  in all RS tests (Pre, HL:  $16.0 \pm 3.8\%$  vs. LL:  $16.1 \pm 3.2\%$ ; Mid, HL:  $10.6 \pm 2.1\%$  vs. LL:  $11.9 \pm 4.4\%$ ; Post, HL:  $10.87 \pm 3.9\%$  vs. LL:  $9.7 \pm 4.4\%$ ,  $p > 0.05$ ). Moreover, Post-compared to Pre-match 400 m performance was

decreased by  $7 \pm 4\%$  (main effect of time,  $p < 0.01$ ). HL athletes showed a better performance both at Pre and Post-match tests ( $p < 0.05$ , Figure 3c). Along this line, 400 m performance time at Pre and Post-match tests was related with mean RS

time in all trials ( $r = 0.56-0.76$ ,  $p < 0.05$ ). Mean RS time was also related with initial sprint time at Pre-, Mid- and Post-match tests ( $0.63-0.85$ ,  $p < 0.05$ ).





**Figure 3**

Average match time spent below 85% of the peak HR across periods (Figure 3a), mean repeated sprint (RS) time in pre, mid and post match tests (Figure 3b) and 400 m time in pre and post match tests (Figure 3c) for high-level (HL,  $n=7$ ) and lower-level (LL,  $n=7$ ) players. \* significant difference between the pre and mid test, # significant difference between the pre and post test, † significant difference between groups,  $p < 0.05$ .

## Discussion

The present study examined the influence of the competitive level on water-polo match-performance changes and playing intensity. The main findings of the study were that HL compared to LL players: a) exhibited a higher physical fitness level (V4 and V5), b) presented an attenuated drop in playing intensity and spent a shorter amount of time with the HR less than 85% of the  $HR_{peak}$  across match periods, c) demonstrated greater mean RS performance in the Mid match tests and swam the 400 m test faster both at Pre and Post match.

The overall water-polo match mean HR

corresponds to lactate threshold intensity (Platanou and Geladas, 2006). Consistent with previous findings suggesting that the mean HR decreases towards the end of the match (Pinnington et al., 1988; Platanou and Geladas, 2006; Galy et al., 2014), we found a lower mean HR in the last stages of the match. Regarding the level of competitiveness, HL players demonstrated a higher mean HR than LL players in the second period of the match and played a shorter amount of time with the HR less than 85% of the  $HR_{peak}$ . The latter finding is in line with previous observations suggesting that players with higher aerobic capacity demonstrate a lower

drop in match intensity (Galy et al., 2014). However, in the study of Galy et al. (2014),  $\text{VO}_{2\text{max}}$  was assessed through an incremental treadmill test that possibly did not reflect the specific  $\text{VO}_{2\text{max}}$  values of water-polo players. Applying a specific in-water test in the present study, we observed that V4 was related with the percentage of playing time spent with  $<85\%$  of the  $\text{HR}_{\text{peak}}$  suggesting that the higher the swimming velocity at  $4.0 \text{ mmol}\cdot\text{l}^{-1}$ , the greater the playing intensity.

Regardless of the group, mean RS performance showed a decline both in the Mid and Post match tests ( $7 \pm 3\%$ ) denoting that match-induced fatigue limited RS ability. Although it was expected that HL players would exhibit a higher mean RS across the match, no differences were observed between groups. However, the superior mean RS performance observed in the Mid test suggests that HL players exhibited greater resistance to fatigue and this could offer a possible advantage in winning a match, compared to the LL players. In fact, a greater performance decrement has been observed in the middle of the match (Botonis et al., 2016) highlighting the importance of performance maintenance at this match point.

Although the RS testing protocol was highly anaerobic (a pilot study showed lactate values of  $8\text{-}12 \text{ mmol}\cdot\text{l}^{-1}$ ), the high relationships detected between 400 m performance time at Pre and Post match tests with RS mean time in all match tests suggest that aerobic power is important for maintaining a high speed during repeated sprints (Tomlin and Wenger, 2001). However, it appears that apart from aerobic capacity differences, the anaerobic capacity may also play a role in discriminating performance between players. This is supported by the higher mean RS performance in Mid match tests of the HL group concurrent with similar  $S_{\text{dec}}$  between groups. Although, the fatigue index was similar between HL and LL groups of players, the high correlations between initial sprint time at the Mid and Post match test with the respective mean RS time ( $r = 0.79\text{-}0.85$ ,  $p < 0.01$ ) imply that players with higher anaerobic potential may exhibit better repeated sprint ability (Bishop et al., 2003; Meckel et al., 2013). To our knowledge, this is the first study that showed meaningful differences considering the competition level within game RS performance. Data from other ball-sports indicate that players

of different competitiveness demonstrate greater repeated sprint ability before a match (Rampinini et al., 2009). In contrast to previous findings, we found no differences between groups at the Pre match test.

Regarding the 400 m performance, players of both groups exhibited a 7% reduction at Post compared to Pre match tests. It has been suggested that muscle glycogen might be the most crucial factor that determines performance in such trials (Welsh et al., 2002) and that low muscle glycogen is related with match-induced fatigue (Krustrup et al., 2006). In the present study, the HL players exhibited higher performance both at pre and post match tests. This might be related to the higher aerobic fitness (i.e. swimming economy) that allowed them to use muscle glycogen more economically.

We acknowledge the absence of match analysis as a main limitation associated with our work. In this case, the application of match analysis would provide some valuable information regarding the players' activities during match periods. Indeed, unpredictable situations such as the power-play and the number of counterattacks and transitions which occur during a match-play may affect the physiological responses of the players as well as fatigue development (Botonis et al., 2015, 2016; Lupo et al., 2010, 2012). Future studies should combine time motion analysis together with physical performance tests in order to improve our understanding concerning both the physiological demands and fatigue related patterns of water-polo.

## Conclusion

In conclusion, the present findings indicate that aerobic fitness is a determinant factor that distinguishes higher and lower level water-polo teams. Indeed, V4 may explain the differences observed between groups of a different competitive level in playing intensity and exercise performance. High-level players demonstrate an attenuated drop in playing intensity and greater resistance to fatigue, compared to lower-level players. This practically means that the development of players' aerobic capacity should be of high priority in water-polo training.

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