



## PADDLING PERFORMANCE AND RANKING POSITION IN JUNIOR SURFERS COMPETING AT THE ASSOCIATION OF SURFING PROFESSIONALS: A PILOT STUDY

*Capacidad de remada y posición en el ranking de surfistas junior de la Asociación de  
Surfistas Profesionales: un estudio piloto*

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Recibido: 30/05/2011  
Aceptado: 13/07/2011

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### Resumen

Los objetivos de este estudio piloto son por un lado, determinar las características aeróbicas de surfistas junior que compiten en la rama Europea de la Asociación de Surfistas Profesionales (ASP) y por otro, analizar la relación de estas características con la posición en el ranking. Diez surfistas tomaron parte en el estudio. Se realizó un test máximo incremental en un ergómetro. Se determinaron el consumo máximo de oxígeno ( $VO_{2MAX}$ ), la potencia máxima ( $W_{MAX}$ ), la frecuencia cardiaca máxima ( $HR_{MAX}$ ), la máxima producción de lactato en sangre ( $[La]_{MAX}$ ) y la potencia en el umbral de lactato ( $W_{LT}$ ) y en el inicio de la acumulación de lactato en sangre ( $W_{OBLA}$ ). No se observó una relación significativa entre la posición en el ranking y los parámetros a intensidad máxima ( $VO_{2MAX}$ ,  $W_{MAX}$ ,  $HR_{MAX}$  y  $[La]_{MAX}$ ). La  $W_{LT}$  ( $W \cdot kg^{-1}$ ) y la  $W_{OBLA}$  ( $W \cdot kg^{-1}$ ) mostraron una relación significativa con la posición en el ranking ( $r = -0.69$ ,  $p = 0.02$ ;  $r = -0.72$ ,  $p = 0.01$ , respectivamente).

**Palabras clave:** Umbral de lactato, intensidades submáximas, diseño del entrenamiento.

## Abstract

The aims of this pilot study are on one hand, to evaluate the upper body aerobic characteristics of junior surfers competing at the European branch of the Association of Surfing Professionals (ASP) and on the other, to assess the relationship between the junior surfers' upper body aerobic characteristics and their ranking position. Ten surfers competing at the European junior branch of the ASP took part in the study. The maximal oxygen uptake ( $VO_{2MAX}$ ), the maximum power output ( $W_{MAX}$ ), the maximum lactate concentration  $[La]_{MAX}$ , the maximum heart rate ( $HR_{MAX}$ ) and the power output at the intensity where the lactate threshold and the onset of blood lactate accumulation are produced ( $W_{LT}$  and  $W_{OBLA}$ ) were determined during an incremental maximal test in a swim bench ergometer. It was observed a lack of a significant relationship between the ranking position and the parameters at maximal intensity ( $VO_{2PEAK}$ ,  $W_{MAX}$ ,  $HR_{MAX}$  y  $[La]_{MAX}$ ). The  $W_{LT}$  ( $W \cdot kg^{-1}$ ) and the  $W_{OBLA}$  ( $W \cdot kg^{-1}$ ) were significantly related to ranking position ( $r = -0.69$ ,  $p = 0.02$ ;  $r = -0.72$ ,  $p = 0.01$ , respectively).

*Key words:* Lactate threshold, submaximal intensities, training design.

## Introduction

Surfing is a sport enjoyed both at the recreational and competitive levels on the beaches of five continents (Mendez-Villanueva, Bishop, & Hamer, 2006). It is mainly characterized by three different phases, such as the paddling out phase to reach the take-off area, the waiting period in which the surfers wait for an appropriate wave to come and the wave riding along the unbroken section of a wave (Carrasco, 2008; Lowdon, 1983). This process is repeated continuously during one surfing session (Carrasco, 2008). At surfing contests the priority to catch a wave among different surfers will be determined by the so-called interference rules (Association of Surfing Professionals, 2011a). The priority at the heats where two surfers compete will be given to the surfer reaching first to the take-off area (Association of Surfing Professionals, 2011a). Therefore, the paddling out phase will be considered critical to reach the take-off area as soon as possible. This phase has been characterized as a high intensity activity (Lowdon, Bedi, & Horvath, 1989) accounting for the 51% of a 25-minute heat at a contest of the Association of Surfing Professionals (ASP) (Mendez-Villanueva, et al., 2006). During the waiting period, which usually ranges at surfing contests from 1 to 90 s (Mendez-Villanueva, et al., 2006), there is a rapid decline of the heart rate (HR) and of the oxygen uptake ( $VO_2$ ) (Tomlin & Wenger, 2001).

Since surfing has been characterized as a predominantly aerobic activity (Mendez-Villanueva & Bishop, 2005), various authors have pointed out the relevance of the upper body aerobic fitness not only at a professional level, but also at a recreational level (Carrasco, 2008; Lowdon & Peteman, 1980; Meir, Lowdon, & Davie, 1991; Mendez-Villanueva, et al., 2005). A previous study reported the amateur surfers' physiological characteristics (Mendez-Villanueva, et al., 2005). Nevertheless, since participating in competitive sport at young age has been associated with specific physiological characteristics compared with participants that have finished their process of growth (Claessens, et al., 1991; Hansen & Klausen, 2004; Rutenfranz, et al., 1982), junior surfers might show different physiological characteristics compared to amateur surfers. Furthermore, the relationship obtained in amateur surfers between the upper body aerobic characteristics and their ranking position (Mendez-Villanueva, et al., 2005) might not be applicable to junior surfers.

This is a pilot study that will determine the upper body aerobic characteristics of junior surfers competing at the European branch of the ASP. We also aimed to assess the relationship between the junior surfers' upper body aerobic characteristics and their ranking position.

## Method

Ten surfers (mean: 17.6; SD:  $\pm$  2.1 years) competing at the European junior branch of the ASP league volunteered to take part in the study. All of them were free of injuries at the time of the study. The participants were instructed to refrain from intense physical activities during the 48 hours before testing. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the University of the Basque Country (UPV/EHU). The tutors of the participants gave their written informed consent before inclusion in the study.

An incremental maximal test in a swim bench ergometer (Ergo Vasa Swim, USA) was performed at the end of the competitive season. A surfboard was attached to the bench of the ergometer to allow the participants a posture resembling their paddling position in the water. The paddling consisted of pulling alternately on the hand paddles. All the participants were asked to perform before the maximal test a 5-minute duration warm-up at self-selected intensity and cadence followed by a 2-minute rest period. The test started with an initial workload of 30 W with further increments of 15 W every 3 minutes interspersed with 1-minute recovery intervals. The paddling cadence was maintained at the participants' preferred rate. The test continued until volitional exhaustion or until the participants were not able to maintain the 95% of the power output at each workload step.

The gas exchange data were continuously collected using a breath-by-breath system (Jaeger Oxycom Delta, Germany). The O<sub>2</sub> and CO<sub>2</sub> analysers and the flowmeter were calibrated with reference gases (Praxair, Spain) and with a 1 L syringe, respectively. For blood lactate determination, capillary blood samples were withdrawn from the ear lobe during the 1-minute recovery interval of each successive workload step (Lactate Pro, Japan). The blood lactate threshold (LT) was identified at the point where the [La] increased 1 mmol·L<sup>-1</sup> above baseline (Coyle, et al., 1991). The exercise intensity corresponding to the onset of blood lactate accumulation (OBLA) was determined on the blood lactate concentration-power output curve as the exercise intensity eliciting a blood lactate concentration of 4 mmol·L<sup>-1</sup> (Sjodin & Jacobs, 1981). The HR was monitored throughout the test (Polar R S400, Finland). The maximal oxygen uptake (VO<sub>2MAX</sub>) was determined as the highest VO<sub>2</sub> during 30 s (Mendez-Villanueva & Bishop, 2005). The maximum power output (W<sub>MAX</sub>) was determined as the highest workload surfers could maintain for a complete 3-min period. The surfing performance was assessed according to the participants' ranking position at the European junior branch of the ASP at the end of the competitive season.

### *Statistical analysis*

Descriptive statistics were performed for all variables. The Shapiro-Wilk test was used to test the null hypothesis that the sample came from a normally distributed population. The inferential statistics Levene's test was conducted to assess the equality of variances. Spearman's rank order correlation test and linear regression analysis were used to find out the relationship between the physiological parameters and the ranking position. Statistical significant level was accepted for  $p < 0.05$ . The statistical analysis was conducted using SPSS 15.0 (SPSS Inc., USA).

## Results

The anthropometric and physiological characteristics of surfers competing at the European junior branch of the ASP are presented (Table 1). The ranking position (Table 2) significantly correlated with  $W_{LT}$  and with  $W_{OBLA}$  relative to body mass ( $W \cdot kg^{-1}$ ) ( $r = -0.69$ ,  $p = 0.02$  and  $r = -0.72$ ,  $p = 0.01$ , respectively) (Figure 1 and 2). Nevertheless, no significant correlation was found between the ranking position and the  $W_{LT}$  ( $W$ ) ( $r = -0.49$ ,  $p = 0.14$ ), the  $W_{OBLA}$  ( $W$ ) ( $r = -0.45$ ,  $p = 0.18$ ), the  $W_{MAX}$  ( $W$ ) ( $r = -0.53$ ,  $p = 0.11$ ) and the  $W_{MAX}$  relative to body mass ( $W \cdot kg^{-1}$ ) ( $r = -0.49$ ,  $p = 0.14$ ). Neither was found a correlation between the ranking position and the  $VO_{2MAX}$  ( $L \cdot min^{-1}$ ) ( $r = -0.46$ ,  $p = 0.17$ ), the  $VO_{2MAX}$  relative to body mass ( $mL \cdot kg^{-1} \cdot min^{-1}$ ) ( $r = -0.12$ ,  $p = 0.72$ ), the  $[La]_{MAX}$  ( $mmol \cdot L^{-1}$ ) ( $r = 0.09$ ,  $p = 0.80$ ) and the  $HR_{MAX}$  ( $bpm \cdot min^{-1}$ ) ( $r = 0.06$ ,  $p = 0.86$ ).

Table 1. Anthropometric and physiological characteristics of junior surfers competing at the European branch of the Association of Surfing Professionals.

Parameter	Mean $\pm$ SD	Range
Mass (kg)	66.7 $\pm$ 5.9	58.8-75.6
Height (cm)	174.3 $\pm$ 0.6	166-184
$\Sigma$ 6 skinfolds (mm)*	57.3 $\pm$ 12.2	34.8-74.2
$W_{LT}$ (W)	54.9 $\pm$ 6.9	45-63
$W_{OBLA}$ (W)	60.6 $\pm$ 10.3	47-72
$W_{MAX}$ (W)	96.2 $\pm$ 16.1	75-120
$W_{LT}$ ( $W \cdot kg^{-1}$ )	0.8 $\pm$ 0.1	0.7-0.9
$W_{OBLA}$ ( $W \cdot kg^{-1}$ )	0.9 $\pm$ 0.1	0.7-1
$W_{MAX}$ ( $W \cdot kg^{-1}$ )	1.4 $\pm$ 0.1	1.2-1.6
$VO_{2PEAK}$ ( $L \cdot min^{-1}$ )	3.1 $\pm$ 0.5	2.3-4.2
$VO_{2PEAK}$ ( $mL \cdot kg^{-1} \cdot min^{-1}$ )	46.5 $\pm$ 8.7	36.5-68.4
$[La]_{MAX}$ ( $mmol \cdot L^{-1}$ )	12.0 $\pm$ 2.7	7.8-17
$HR_{MAX}$ ( $bpm \cdot min^{-1}$ )	182.4 $\pm$ 6.6	175-193

\* Sum of subscapular, triceps brachii, supraspinale, abdominal, anterior thigh and medial calf.

Table 2. Ranking position of the subjects participating in the study.

Subject	Ranking position
S1	105
S2	105
S3	4
S4	64
S5	33
S6	13
S7	32
S8	17
S9	5
S10	33

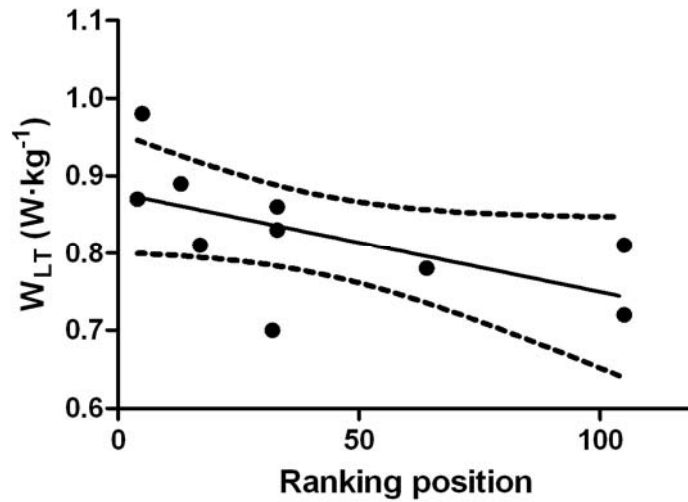


Figure 1. Data illustrating the relationship between the power output at exercise intensity where the lactate threshold is produced ( $W_{LT}$ ) and the ranking position.

Linear regression is represented by a solid black line,  $\pm$  95 confidence intervals by dashed lines. There is a negative correlation between the two variables ( $\beta = -0.69$ ,  $p < 0.05$ ). The formula describing the relationship is  $y = -0.001x + 0.877$ ;  $R^2 = 0.351$ .

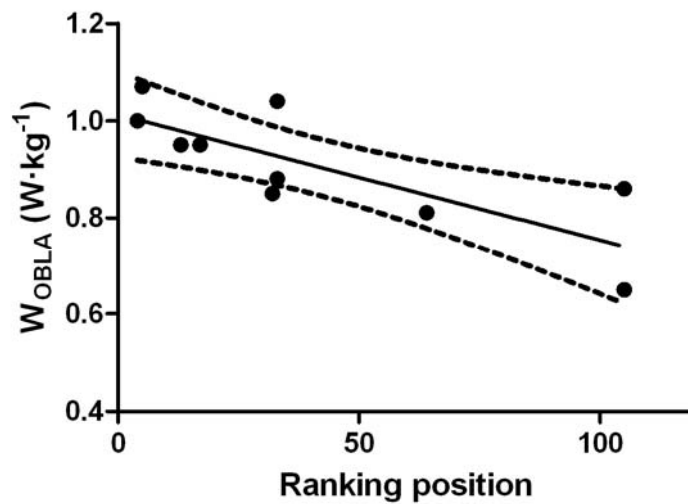


Figure 2. Data illustrating the relationship between the power output at the exercise intensity where the onset of blood lactate accumulation is produced ( $W_{OBLA}$ ) and the ranking position.

Linear regression is represented by a solid black line,  $\pm$  95 confidence intervals by dashed lines. There is a negative correlation between the two variables ( $\beta = -0.72$ ,  $p < 0.05$ ). The formula describing the relationship is  $y = -0.002x + 1.012$ ;  $R^2 = 0.629$ .

## Discussion

Despite the growing number of surfing practitioners in the last years (Mendez-Villanueva & Bishop, 2005) and the inclusion of the junior circuit in the ASP in 1998 (Association of Surfing Professionals, 2011b), there is a sparsity of studies analysing the upper body aerobic characteristics of junior surfers and their relationship with their ranking position. A previous study reported the physiological characteristics of amateur surfers competing at the ASP and their relationship with the ranking position (Mendez-Villanueva, et al., 2005). Nevertheless, the influence of the maturation process on the surfers' physiological characteristics (Armstrong & Welsman, 2007; Krahenbuhl, Skinner, & Kohrt, 1985; Van Praagh & Dore, 2002) suggests that the relationship between the upper body aerobic characteristics of junior surfers and the ranking position might differ from the results obtained from amateur surfers.

The  $VO_{2MAX}$  values obtained in the present study are higher to the previously observed values in recreational and competitive junior surfers (Loveless & Minaham, 2010) ( $46.5 \pm 8.7$  vs.  $37.8 \pm 4.5$  and  $39.5 \pm 3.1$  mL·kg<sup>-1</sup>·min<sup>-1</sup>, respectively). Lowdon et al. (Lowdon, et al., 1989) also observed lower values in older surfers ( $40.4 \pm 2.9$  mL·kg<sup>-1</sup>·min<sup>-1</sup>). These results are not comparable to ours since in Lowdon's study (Lowdon, et al., 1989) the tests were performed in a water tank and in the Loveless's study (Loveless & Minaham, 2010) the workload increment was determined by a previous performed maximal anaerobic test. Other authors reported higher  $VO_{2MAX}$  values in both recreational (Meir, et al., 1991) and competitive amateur surfers (Mendez-Villanueva, et al., 2005) competing at the ASP ( $54.2 \pm 10.2$  and  $50 \pm 4.6$  mL·kg<sup>-1</sup>·min<sup>-1</sup>, respectively). Since the surfing level has shown not to reflect the surfers'  $VO_{2MAX}$  (Loveless & Minaham, 2010; Mendez-Villanueva, et al., 2005) and the age has been related to the fitness of physically active subjects (Rutenfranz, et al., 1982), the lower  $VO_{2MAX}$  values in our study in comparison to both recreational (Meir, et al., 1991) and competitive amateur surfers (Mendez-Villanueva, et al., 2005) might be explained by their lower age ( $17.6 \pm 2.1$  vs.  $21.2 \pm 2.7$  and  $25.6 \pm 3.4$  yr, respectively). These results come in accordance with Armstrong and Welsman (Armstrong & Welsman, 1994; Armstrong, Welsman, & Kirby, 1998) who showed a progressive linear increase of the  $VO_{2MAX}$  in relation to chronological age independent of the subjects' body mass.

The power output is also related to chronological age (Armstrong, Welsman, & Chia, 2001; Lefevre, Beunen, Steens, Claessens, & Renson, 1990) and hence the lower  $W_{MAX}$  obtained in our study in comparison to the values observed in competitive amateur surfers ( $154.7 \pm 36.8$  W) (Mendez-Villanueva, et al., 2005) might be due to the older age of the latter ones. Nevertheless, the differences in the testing protocol might have had also an influence on the differences between studies. The initial power output of both studies was 30 W with further increments of 15 W every 3 min. However, in Mendez-Villanueva's study (Mendez-Villanueva, et al., 2005), after the fourth workload the surfers were asked to perform a maximal intensity bout for at least 2-minute period to attain the  $W_{MAX}$ . In our study, on the contrary, the increments were maintained constant at 15 W and the  $W_{MAX}$  was determined as the highest workload surfers could maintain for a complete 3-min period. Even though the body mass has been related to the  $W_{MAX}$  (Davies & Sandstrom, 1989), the similar body mass of the surfers in both studies suggests that the lower  $W_{MAX}$  in our study has not been affected by this parameter.

Since surfers are given scores based on the variety, speed, power, flow and degree of difficulty of the manoeuvres during wave riding (ASP, 2010), a good surfing technique is essential to excel in this sport. Competitive surfing sessions have been characterized as bouts of high-intermittent exercise interspersed with periods of moderate and low intensity activity demanding aerobic metabolism (Mendez-Villanueva, et al., 2005). Therefore, in addition to the surfing technique, the surfers' upper body aerobic characteristics might also be an important contributing factor to the success in this sport. In the present study it was observed that the  $VO_{2MAX}$ , both in absolute values ( $L \cdot \text{min}^{-1}$ ) and relative to body mass ( $\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ ), was not related to the surfers' ranking position. These data are consistent with a previous research where no significant relationship between these two parameters was observed in amateur surfers ( $r = -0.14$ ,  $p = 0.64$  ( $L \cdot \text{min}^{-1}$ ) and  $r = -0.23$ ,  $p = 0.43$  ( $\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ )) (Mendez-Villanueva, et al., 2005). These results suggest that the chronological age, from junior to amateur, might not have an influence on the relationship between the  $VO_{2MAX}$  and the ranking position. The significant relationship between performance and the  $VO_{2MAX}$  in other "upper-body" sports, such as swimming (Alves, Gomes-Pereira, & Pereira, 1996; Costill, et al., 1985), suggests that the  $VO_{2MAX}$  might be related to paddling performance. Nevertheless, this parameter can not be used to predict surfers' ranking position.

The muscular power has been found to be a determinant of athletic performance (Noakes, 1988), both in "lower-body" (Hawley, Williams, Vickovic, & Handcock, 1992; Noakes, Myburgh, & Schall, 1990) and in "upper-body" sports (Hawley, et al., 1992; Sharp, Troup, & Costill, 1982). In the present study neither the  $W_{MAX}$  in absolute values (W) nor relative to body mass ( $W \cdot \text{kg}^{-1}$ ) were related to ranking position. Furthermore, other physiological parameters at maximal intensity, such as the  $HR_{MAX}$  and the  $[La]_{MAX}$  were neither related to ranking position. On the contrary, it was observed a positive relationship between the ranking position and both the  $W_{LT}$  ( $W \cdot \text{kg}^{-1}$ ) (Figure 1) and the  $W_{OBLA}$  ( $W \cdot \text{kg}^{-1}$ ) (Figure 2). These results suggest that the upper body power output at submaximal intensities seems to be better predictor of ranking position than  $HR_{MAX}$ ,  $[La]_{MAX}$ ,  $W_{MAX}$  and  $VO_{2PEAK}$ . Mendez et al. (Mendez-Villanueva, et al., 2005) also found that surfers ranking better tended to have a higher  $W_{OBLA}$  value. Considering that in predominantly aerobic sports, as it is surfing (Mendez-Villanueva & Bishop, 2005), the exercise intensity is majorly determined by the intensity where the LT and the OBLA are produced (Padilla, Mujika, Orbananos, & Angulo, 2000; Padilla, et al., 2001), surfers with a higher  $W_{LT}$  and  $W_{OBLA}$  will have a greater capacity to paddle out faster reaching sooner to the take-off area and enhancing the probability of catching appropriate waves to maximally perform during wave riding. From a practical standpoint, the results of this study suggest that junior surfers competing at the ASP may benefit from training inducing improvements in submaximal upper body power. Therefore, it could be important for surfers to perform incremental maximal tests in a swim bench ergometer in order to assess their upper body physiological characteristics, which could be considered for the design of the training session.

## Conclusions

This research has shown that surfers with a higher power output relative to body mass at the intensities where the lactate threshold ( $W_{LT}$ ) and the onset of blood lactate accumulation ( $W_{OBLA}$ ) are produced, present a higher ranking position at the European junior branch of the Association of Surfing Professionals. Therefore, training inducing gains in upper body aerobic power at submaximal intensities might be beneficial for junior competitive surfers. These parameters have also been observed to be smaller than the previously reported in amateur surfers. The lower values in junior surfers might be explained by their differences in the biological maturity status. Given that this is a pilot study, more extensive studies are needed to better determine the upper body aerobic characteristics of junior surfers competing at the Association of Surfing Professionals and their relationship with the ranking position.

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Referencia del artículo:



Cámara, J., Maldonado-Martín, S., Fernández, J.R., y González, M. (2011). Paddling performance and ranking position in junior surfers competing at the Association of Surfing Professionals: a pilot study. *E-balonmano.com: Revista de Ciencias del Deporte* 7(3), 147-156. <http://www.e-balonmano.com/ojs/index.php/revista/index>