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Title of the Article

COMPETITION LOAD DESCRIBED BY OBJECTIVE AND SUBJECTIVE METHODS DURING A SURFING CHAMPIONSHIP

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Abstract

The aims of this study were to describe the competition load of surfers during a single heat via objective and subjective methods and to analyze the relationship between objective and subjective methods with the judges' score. Ten competitive surfers were fitted with a global positioning system (GPS) during a competitive heat. The GPS was synchronized with a chronometer and a stationary video camera to identify the surfer's specific actions. After the end of each heat, participants were assessed for the rating of perceived respiratory and muscular exertion (RPEres, RPEmus) and also official scores from every participant were collected. A very large significant relationship between wave riding distance and respiratory perceived exertion heat load (RPEres HL, r =0.79; ± 0.26 CL p < 0 .01, 99.5/0.4/0.1, very likely) was found. Active time was also very large and significantly related to both RPEres HL (r = 0.75; ± 0.29 CL p < 0.05, 99.0/0.8/0.2, very likely) and muscular perceived exertion heat load (RPEmus HL, r = 0.83; ± 0.22 CL, p <0.01, 99.8/0.2/0.0, most likely). Very large significant correlation was obtained between the RPEres and score (r = 0.83; ± 0.22 CL, p < 0.01, 99.8/0.2/0.0, most likely). The subjective method seems to be a good instrument to assess the heat load of a surf competition. Wave characteristics seem to be an important factor in perceived exertion during competitive surfing.

Keywords: global positioning system, score, rating of perceived exertion, heat load

INTRODUCTION

Surfing has developed a multi-million dollar worldwide business (13) and it will be included in the 2020 Olympic Games. The World Surf League (WSL) holds 185 international competitions per year around the globe with more than 1000 professional athletes inscribed (3,4,13,15,18-20,26) and surfing competitions are organized in more than 98 countries (3,4,13,15,18-20,26). Previous research on surfing focused on the characteristics of surfing competition (3,4,15,18-20). On the one hand, a previous study to assess the physiological demands during a surfing heat, in the top 30 ranked surfers from the New Zealand surf association, has shown a mean heart rate (HRmean) of 139 ± 11 bpm (64% of their maximum HR [HRmax]) and a peak HR (HRpeak) of 190 ± 12 bpm (87% of their HRmax) (4). On the other hand, the physical demands (external load) have been carried out with global positioning system (GPS) units during both, training sessions and competitive heats (18,23). Specifically, it has been reported that during a two hours surfing training session, participants covered a total distance of 6293.2 ± 1826.1 m (Range = 4491 - 9527 m) with a consistent decline in HRpeak and HRmean (20). Nevertheless, during a 20 minutes surfing competitive heat the total distance covered was 1605 ± 313.5 m (18).

Even though objective methods have been used to quantify the physical and physiological demands during surfing (18,23), a HR monitor transmitter belt fastened around the sternum and a wrist GPS unit during surfing have a major drawback: surfers complain about their comfort during paddling with those devices. Besides, considering that during a surfing heat, total paddling time represents approximately the 51-58% of a surfing heat (4,19) and, secondly, that sprint paddling is a key action leading to wave riding (24), the use these devices could hamper the efficiency of the paddling action. The rating of perceived exertion (RPE), that was designed to be practical (20) is a subjective method that combines the external and internal load into a single score, and does not require HR and GPS units. Besides, this score is also affected by ventilation rate, psychological states, and environmental conditions (20), the latter having demonstrated its importance during surfing competitions (4,17,18,20,21,23). The RPE has been shown to be a valid and efficient method of measuring training load (17), even in sports

characterized for their multiple high intensity bouts (12), such as surfing. Therefore, considering the intensity profile of a surfing competition, where high intensity actions follow, repeatedly, lower intensity actions (18,19) the RPE could be an inexpensive and easy to use method to assess the surfers external and internal load. Furthermore, due to the nature of surfing, where surfers are continuously subjected to apneas of different duration, the assessment of differentiated RPE (dRPE), such as the respiratory RPE (RPEres) and muscle leg RPE (RPEmus), as used in other sports (14,16,25), could provide physical trainers and surfers themselves a deeper understanding of the characteristics of the training or competition load. Plus, this is the first study to tackle the association between dRPE and the objective methods.

Since the judges are responsible for scoring the performance of the surfers during wave riding, based on key elements such as the characteristics of the maneuvers (26), we hypothesized that the longer the wave riding distance and duration, the greater the chance of performing a combination of major maneuvers and, thus the better the score. Nevertheless, we are unaware of any study that assessed the relationship between the activity profile of surfers and the judges' score. Likewise, to understand the association between competitive quantification objective and subjective methods with score, as it may be relevant to acknowledge if the heat load could be an important factor for surfing performance.

The purposes of this study were threefold: 1) to describe the competition load of surfers during a surfing heat through objective (GPS) and subjective methods (dRPE), 2) to analyze the relationship between objective and subjective methods, and 3) to analyze the association of the objective and subjective methods with the judges' score.

METHODS

Experimental Approach to the Problem

We use an observational design to examine the relationship between objective and subjective competitive surfing load. Data were collected during a surfing competition at a national level open division competition. The study was conducted during the "Euskaltel Euskal Zirkuitua" championship in July 2015, hosted by the Basque Country Surfing Association, as part of the

open category three stops tour. Participants wore a GPS on the wrist during the heat. Upon completing the heat, participants were assessed for the RPEres and RPEmus.

Participants

Ten surfers participated in this study (28.50 ± 11.09 yr, 177.10 ± 5.54 cm, 70.20 ± 5.49 kg, 22.37 ± 1.25 $kg \cdot m^{-2}$) and reported a minimum of 7 years of experience (16.40 ± 9.55 yr). They currently were engaged in two to four surfing training sessions per week (3.20 ± 0.28 day/week). Participants were free of injuries at the time of the study. All participants received a clear explanation of the study, including the risks and benefits of participation and completed informed consent documents. Participants were then familiarized with the use of the 0-10 scale RPE assessment. The study and its procedures was approved by the institutional review board (CEID 2015-130) at the University of the Basque Country (UPV/EHU) and met the ethical standards in Sport and Exercise Science Research (10).

Procedures

Objective load: Objective loads were monitored with a GPS device (V800, Polar™, Kempele, Finland) attached to the wrist of the participants and outside the wetsuit. In every trial, the GPSs conditions were considered acceptable (wrist device connected to at least 8 satellites) and collected at a sample frequency of 2.4 Hz. The GPS was synchronized at least 5 minutes before each heat with a chronometer and a stationary video camera (Canon EOS 5D, Tokyo, Japan). The camera was set in the judges' area so that it could capture the entire range of wave riding and to identify the surfer's specific actions in each heat. The beginning of the heat was marked in the chronometer with a lap enabling the trimming of the video from the start to the end of the heat. Surfing activities during the heats were coded as time spent in wave riding (s), paddling time (s) and the stationary time (s). The GPS parameters included the total wave riding time (s) and paddling distance (m). Subsequently, wave riding time and paddling time parameters were determined via video recordings. The recordings were paused each time a change in the coded activity occurred, and the duration time for the activity was recorded. The active distance and active time were calculated as shown in *Formula 1* and *2*, respectively.

Formula 1: Active distance (m) = the overall wave riding distance (m) + the overall paddling distance (m)

Formula 2: Active time (s) = the overall wave riding time (s) + the overall paddling time (s). Besides, each wave riding distance, time, maximum and mean velocities were also obtained.

Perceived exertion (PE) subjective load: Ten minutes after the end of each heat, PE was obtained from each participant using the 0–10 point Foster scale (8,9). The surfers responded to 2 sequential questions 1) How intense was your session on your chest? and 2) How intense was your session on your legs? (1). A 10-minute delay was chosen so that particularly difficult or easy segments near the end of heats would not influence the participant's cumulative heat rating (9). The participants had to differentiate between 2 types of RPE: local (leg, muscular), which assess strain in the working muscles (RPEmus) and central (chest, respiratory), assesing strain on perceived tachycardia, tachypnea, and even dyspnea (RPEres) (1,2,22). An exercise score, referred to as heat load (HL), was calculated by multiplying the duration of the heat's active time (paddling time + wave-riding time - stationary time), by the RPEres or RPEmus, as previously described (1,7,8). The corresponding HL were named RPEres HL or RPEmus HL, and measured in arbitrary units (AU).

Surfing official scores: The official scores for each participant were obtained from the competition's internet broadcasting service. All of the judges involved in the competition were assigned by the Basque Country Surfing Association and utilized the score criteria of the WSL. Therefore, judges analyzed the following elements: commitment and degree of difficulty, innovative and progressive maneuvers, combination of major maneuvers, variety of maneuvers, and speed, power, and flow [8]. The judging scale was: 0.0 – 1.9 Poor, 2.0 – 3.9 Fair, 4.0 – 5.9 Average, 6.0 – 7.9 Good and 8.0 – 10.0 Excellent (26).

Statistical analysis

The results are presented as means ± standard deviation (SD). All variables were normal distributed and satisfied the equality of variances according to Kolmogorov-Smirnov test and Levene tests, respectively. Pearson product-moment correlation coefficient (r) with 90%

confidence limits (CL) were calculated to determine the relationships among the parameters obtained from the objective and subjective methods, as well as judge's scores. The magnitude of correlation between analyzed variables were assessed with the following thresholds: < 0.1, trivial; = 0.1–0.3, small; < 0.3–0.5, moderate; <0.5–0.7, large; <0.7–0.9, very large; and <0.9–1.0, almost perfect (11). Data analyses were performed using the Statistical Package for Social Sciences (version 23.0 for Windows, SPSS™ Inc, Chicago, IL, USA). Statistical significance was set at $p<0.05$.

RESULTS

The descriptive characteristics of all surfers during individual heats are presented in Table 1. The perceived exertion and perceived HL according to the muscular and respiratory systems are also presented in the same table.

****Please insert Table 1 about here *****

It was observed that a very large and significant correlation was found between wave riding distance and RPEres HL ($r = 0.79$; ± 0.26 CL, $p < 0.01$, 99.5/0.4/0.1, very likely) (Figure 1). Also, a very large and positive correlation was found between active time and both RPEres HL ($r = 0.75$; ± 0.29 CL, $p< 0.05$, 99.0/0.8/0.2, very likely) (Figure 2A) and RPEmus HL ($r = 0.83$; ± 0.22 CL, $p < 0.01$, 99.8/0.2/0.0, most likely) (Figure 2B). Lastly, RPEmus HL was significantly correlated to stationary time ($r = 0.79$; ± 0.26 CL, $p < 0.01$, 99.5/0.4/0.1, very likely). No other significant correlations were found between the remaining objective and subjective variables ($p > 0.05$).

****Please insert Figure 1 about here *****

****Please insert Figure 2 about here *****

Moderate and significant correlations were found between judge's the score and total wave riding distance (r = 0.37; ± 0.50 CL, p < 0.01, 77.7/12.5/9.8, likely) and large correlations were found between judge's score and wave riding duration (r = 0.68; ± 0.34 CL, p < 0.001, 97.6/1.8/0.6, very likely). No other objective variables (i.e. total distance, paddling distance, stationary, active time, wave riding peak velocity, wave riding mean velocity) were significantly correlated with judge's scores. Conversely, very large and significant correlations were found between the RPEres and judge's scores (r = 0.83; ± 0.22 CL, p < 0.01, 99.8/0.2/0.0, most likely) (Figure 3). Neither the RPEres HL or the muscular perceived exertion (i.e. RPEmus and RPEmus HL) significantly correlated with judges' scores.

****Please insert Figure 3 about here *****

DISCUSSION

The purpose of this study was to describe the physical demands of a surfing heat during a competitive event, as determined by both objective and subjective methods. We analyzed the association among these variables and determined how these measures correlated with the judges' scores. To our knowledge, this is the first study to assess dRPE (i.e. respiratory and muscular) workload in a surfing competition, and it is also the first to analyze the association between the objective and subjective methods to quantify the physical demands in surfing. This is important because it provides coaches and athletes a practical and inexpensive tool to quantify the physical activity during a surfing. The main finding of this study was that significant correlations exist between wave riding distance and respiratory workload and between active time spent surfing and to both respiratory (RPEres HL) and muscular exertions (RPEmus HL). Previously, the relationship between the maneuvers and the judge's scores in competitive surfing has been studied (15), however this is the first study to examine the association between quantified workloads in a surfing competition with the judges' score. Our results demonstrated judge's score were correlated with the total wave riding distance, wave riding duration, and RPEres.

Surfing performance has been characterized in previous studies by analyzing the paddling distance, wave riding distance, wave riding duration, stationary time and active time (4,20,23). However, one of the novelties of this study is that we analyzed the peak and mean wave riding velocities. These parameters are relevant to performance and are essential to understanding the intensity output while surfing. The results of our study demonstrated that the average wave riding peak velocity during a 20 minute heat in a national surfing contest was 0.61 ± 0.25 $m \cdot s^{-1}$ and the wave riding mean velocity was 0.50 ± 0.26 $m \cdot s^{-1}$.

Surfers in our study covered a total distance of 447.51 ± 126.31 m in a heat, which was a noticeably lower distance than the 1605 ± 313.5 m reported by Farley et al. (2012) during a competitive heat of the same duration. Since the ocean is not a static environment, the different surfing conditions might explain the differences between studies. Additionally, surfers in our study were active 40.1% of the time (i.e. paddling and wave riding), 59.9% of the time stationary (sitting or lying on their boards), and 3% riding on waves. The surfers in Farley's study spent 62% of the heat time as active and a 8% of that time riding waves (4). The reason for higher percentage of active time is due to paddling between the sets of waves, waiting or resting for waves, then having to paddle to reposition in the take-off area (4). A previous study analyzing the time motion analysis of professional surfers during a competitive heat revealed that their active time was 58.6%, while stationary time was the 41.4% (19). The wave riding time was similar to the results found in our study (3.8% vs. 3.1% of the total time), even though professional surfers spent 18.5% more of their heat time paddling, and consequently, less time as stationary as in our study.

Farley et al. (2012) additionally reported a paddled distance of 947.4 ± 185.6 m and a wave riding distance of 128.4 ± 25.x m for a 20 minutes heat. In our study, the distance paddled and the wave riding distance were 74% and 27% less, respectively. There are also considerable differences regarding the wave riding duration amongst studies; whilst in our study the total wave riding duration during a 20 minutes heat was 0.24 s, Mendez-Villanueva (19) reported 57 s and Farley et al. (2012) 1.6 minutes. Since competitive level may influence the surfers' activity pattern (19), the differences amongst studies in the time motion analysis might be

partially due to the differences in the expertise of the participants. Nevertheless, differences in the surf conditions (4) (i.e. swell size, wave length and wave frequency among many others) and beach breaks typology, have been reported to influence the activity performed by surfers (4,17,18,20,21,23). The physical demands during surfing are dependent upon many factors. These partially include wave and equipment selection (4,18,19), intrinsic motivation of the participants (4,17,19), and the season of the year (i.e. pre-season, competition season, off-season). Though the results of objective methods to measure the surfing performance have been previously reported (4-6,18,21,23,24,26), an understanding of the surfers' physical demands, as quantified by subjective methods in this study, may confer a deeper understanding of the mechanisms underpinning surfers' physical demands. To the best of our knowledge, no previous research has reported the dRPE of surfers after a competitive heat. In the present study, the RPEres and RPEmus of competitive surfers were 4.35 ± 1.54 and 3.25 ± 0.79, respectively, after a 20 minute heat. The RPEres HL was 36.60 ± 21.90, and RPEmus HL was 28.25 ± 15.23. Aerobic conditioning seems to be an important component of fitness for surf athletes, as is directly linked to the physical capacity to catch as many waves as possible during a heat and could be the difference between winning and losing (4). It has been observed that during a 20 minutes surfing heat, surfers performed at an intensity ranging from 55% to 90% of their HRmax, suggesting that not only the aerobic system is solicited, but also it is intercalated with bouts of high-intensity exercise (4). In our study, the relatively low RPEres and RPEres HL highlight the physiological demands imposed on each surfer. These are beholden to activity durations that are subject to the surf conditions, beach break typology, and surfer's tactical decisions (4,17,18,20,21,23). In addition to the aerobic demands, the intermittent nature of surfing activity requires different types of muscular work (i.e. upper- vs. lower-body, isometric vs. dynamic contractions) (18). Surfers are required to have highly developed upper-body and lower body strength and power(5,24). Upper-body strength related to paddling performance, where as with any start to a movement, the surfer must overcome a higher resistance initially to accelerate themselves on the surfboard to top speed (24), also maximal power force production for greater propulsion in water and, anaerobic endurance to withstand long durations of constant

paddling (4). Lower body strength and power, related to perform maneuvers and wave riding (5). However, in our study, RPEmus and RPEmus HL values were relatively low. The short duration of the time spent in wave riding and the long paddling time back to the break may have had a low impact on respiratory and muscular exertion. Nevertheless, we need to point out that the subjective parameters, as well as the objective parameters, are highly influenced by the surf conditions and other factors such as, strategic decisions, equipment (4,18,19), level of motivation of the surfers (4,17,19), judging criteria or season of the year, and therefore, different results would be expected in a same duration competitive heat but with different surfing conditions. We do consider therefore, that surfing conditions should be reported in any surfing study performed, in order to carefully compare the results. Since the present study is the first one to quantify dRPE in surf, further research is needed in order to obtain more accurate conclusions regarding surfing workloads in a variety of weather conditions.

One of the more used objective methods for quantifying load during training or competition sessions is HR monitoring (1). However, this method in real time surfing competition is limited due to technical problems as the HR monitors does not perform well in water conditions or under the athlete wetsuit, the expertise knowledge involved and the time consuming process of collecting the data from surfers in every session (1), and the uncomfortable feeling of wearing the device while paddling. In this regard, the assessment of the physiological RPEres HL could result in a better understanding of the required competition load needed to optimize the sport session process (1), especially for surfers or coaches that do not have the equipment to measure the HL variables trough objective methods. However, although in other sports the validity of the subjective methods has been verify to quantify the competition load (14,25), to the date we did not find any study that has analyzed the association between objective and subjective methods in surf. In the present study, a large and significant relationship between wave riding distance and RPEres HL was found (r =0.79; ± 0.26 CL) (Figure 1). On the other hand, the active time was also very/most likely largely related to both RPEres HL (r = 0.75; ± 0.29 CL) (Figure 2A) and RPEmus HL (r = 0.83; ± 0.22 CL) (Figure 2B). The subjective method seems to be a good

instrument, due to the positive relationships with objective method, to assess the heat load of a surf competition.

In competitive surfing, the athletes are judged on their ability to perform radical maneuvers in the most critical section whilst riding the wave (15). Previous research has provided descriptive data of the maneuvers executed and scores received (15), but to the date no research has been undertaken to explain the relation between wave riding performance and the received judges score. It seems crucial to gain some insights in the relation between the physical demands of a surfing heat and the obtained scores. Our results demonstrated judges scores were significantly and moderately correlated to the total wave riding distance ($r = 0.37$; ± 0.50 CL, $p < 0.01$), large and significant relationship with wave riding duration ($r = 0.68$; ± 0.34 CL, $p < 0.001$), and a very large significant correlation with RPEres ($r = 0.83$; ± 0.22 CL, $p < 0.01$, 99.8/0.2/0.0, most likely) (Figure 3). Judges analyze different elements when scoring waves, some of these elements are directly related to the wave characteristic, as speed, power, flow and commitment of the surfer (26). A longer wave will provide surfer more time and distance to perform more variety of innovative and progressive maneuvers, allowing a combination of major maneuvers, with a direct impact in the received score, as part of the judging criteria. Therefore, wave selections is an important factor in competitive surfing and should be note by the coaches, indicating that these must combine the information of the choice of maneuver, technique, power of execution (15) and wave selection in their feedback to the athlete.

PRACTICAL APPLICATIONS

The low cost and easy administration of the dRPE makes them readily accessible to surfers and coaches. Implementation of the dRPE in training routines allows surfers and coaches to quantify workloads during training sessions or competitions heats that are comparable to data derived from more expensive GPS devices. This may provide insight and knowledge in respect to modifying the conditioning and training regimes of the athletes. This is the first study to address the use of the dRPE for quantifying the surfers' workload; future researchers may use the findings of the current study to collect similar data in official competitions and heats. Future

research should include different cohorts of competition spots and locations to describe the variability of the surfers' workload between various competitions or surfing locations.

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LEGEND OF TABLES AND FIGURES

Table 1 Objective and subjective methods heat load (HL) variables measured during one heat of a surfing competition.

Figure 1 Correlation between wave riding distance (m) and respiratory perceived exertion heat load (RPEres HL), AU = arbitrary units.

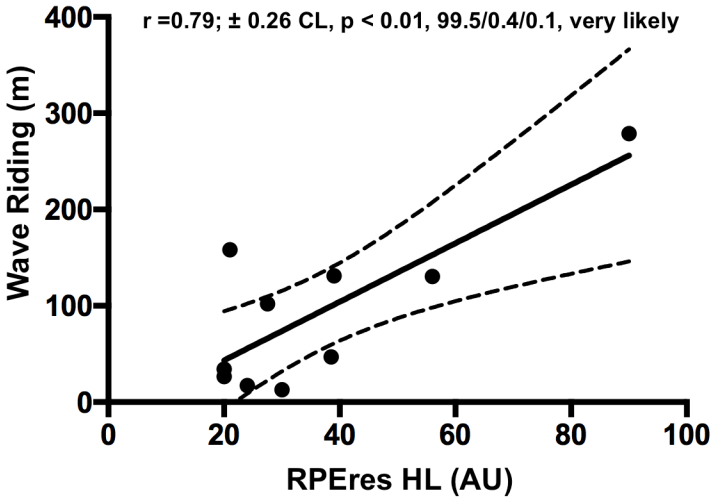
Figure 2 Correlation between active time (min) and respiratory perceived exertion heat load (RPEres HL) (2A) and muscular perceived exertion heat load (RPEmus HL) (2B), AU = arbitrary units.

Figure 3 Correlations between judge's scores and respiratory perceived exertion (RPEres).

Table 1. Objective and subjective methods heat load (HL) variables measured during one heat of a surfing competition.

	Mean	SD	Min.	Max.
Objective method HL				
Total distance (m)	447.51	126.31	243.90	609.70
Paddling distance (m)	353.66	149.28	111.40	550.10
WR distance (m)	93.85	84.26	12.90	278.90
WR duration (%)	3.13	2.35	0.95	8.24
Stationary time (%)	59.62	13.09	38.64	78.00
Active time (%)	40.17	13.37	20.20	61.32
WR Peak velocity ($m \cdot s^{-1}$)	0.61	0.25	0.25	1.38
WR Mean velocity ($m \cdot s^{-1}$)	0.50	0.26	0.16	1.31
Subjective method HL				
RPEres	4.35	1.54	2.50	7.00
RPEmus	3.25	0.79	3.00	5.50
RPEres HL (AU)	36.60	21.90	20.00	90.00
RPEmus HL (AU)	28.25	15.23	12.00	60.50

WR = wave riding, RPEres = respiratory perceived exertion, RPEmus = muscular perceived exertion, RPEres HL = respiratory perceived exertion heat load, RPEmus HL = muscular perceived exertion heat load, AU = arbitrary units.



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