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The influence of wave size on the performance of surfers in the World Surf League (WSL wave size)

A influência do tamanho da onda no desempenho dos surfistas da World Surf League (tamanho da onda WSL)

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Abstract – This study aimed to verify the influence of wave size on the performance of surfers in the main division of the World Surf League (WSL) Tour. The study included 31 surfers from the top division of the 2019 tour of the WSL. The two best waves of each surfer per heat were evaluated, separated, and combined, from round one to the final, totaling 1749 waves and 847 combinations. The study variables were related or associated with the number of victories and ranking. Spearman's correlation coefficient was used in all correlations in the study and Binary Logistic Regression to verify possible associations and estimate the odds ratio (OR) between the variable wave size and the result. Through the evidence, it was concluded that: 1) those surfers who during the season caught the biggest waves of the heats more often were more likely to win their heats and achieve better rankings in the season; 2) all surfers had to catch a portion of just no bigger waves and the best classifieds took advantage of them better; 3) the biggest waves had the greatest influence on the tubes, then on the turning maneuvers and lastly on the aerials; 4) the three groups of maneuvers were decisive for the good performance in the season, being the tubes the most decisive.

Key words: Athletic performance; Sports; Water esports.

Resumo – *O objetivo deste estudo foi verificar a influência do tamanho da onda no desempenho dos surfistas da divisão principal do Tour da World Surf League (WSL). Participaram do estudo 31 surfistas da divisão principal do Tour de 2019 da WSL. Foram avaliadas as duas melhores ondas de cada surfista por bateria, separadas e combinadas, da rodada um a final, totalizando 1749 ondas e 847 combinações. As variáveis do estudo foram relacionadas ou associadas ao número de vitórias e ao ranking. Foi empregado o coeficiente de correlação de Spearman, em todas as correlações do estudo e a Regressão Logística Binária para verificar possíveis associações e estimar a razão de chances (OR), entre a variável tamanho da onda e a resultado. Através das evidências concluiu-se que: 1) aqueles surfistas que durante a temporada pegaram mais vezes as maiores ondas das baterias tiveram mais chances de vencer suas baterias e conseguiram melhores classificações na temporada; 2) todos os surfistas tiveram que pegar uma parcela de apenas ondas não maiores e os melhores classificados as aproveitaram melhor; 3) as maiores ondas apresentaram maior influência nos tubos, depois nas manobras de virada e por último nos aéreos; 3) os três grupos de manobras foram determinantes para o bom desempenho na temporada, sendo o dos tubos o mais determinante.*

Palavras-chave: *Desempenho atlético; Esportes; Esporte aquático.*

INTRODUCTION

Performance in competitive surfing is subject to two sets of factors: those that are within reach and depend directly on the surfers, such as physical and psychological capabilities, technical and tactical skills; and external factors, which can benefit or harm surfers' scores, such as equipment, wave conditions, refereeing, and opponents[1]. This multiplicity of factors causes great variability in surfers' performance, making competitive results almost unpredictable[2].

Waves are essential for surfing, they have different sections and shapes[3], the waves on the same beach can change during the day, they are influenced by tide changes, winds, and swells that reach the beach[4]. The more varied the wave sections, the more skills surfers must have to take advantage of them[3,5].

The World Surf League (WSL) annually tests surfers' skills at different events, beaches and waves[6]. Each wave surfed receives a score from a panel of judges. Depending on the beach where the event is held, the waves favor the execution of certain types of maneuvers[3,7,8].

Performance in competitive surfing has been studied through physical and physiological indicators[1,9,10], through interventions[11], testing protocols[12], psycho-behavioral[13,] and technical-tactical indicators[8,14].

Recently, many studies have been carried out based on information from top-division surfers available on the official WSL page. Some studies compared scores and verified the number of successful maneuvers[7,15], compared scores of the best and worst in the ranking[16], compared waves with and without aerials[17], compared types of aerials[18,19], analyzed aerial landings[20], injuries resulting from aerial[21], related the aerial with the ranking[22], verified the influence of the surfers' appealing expressions on the scores[23] and studied the essential skills for performance[24].

However, no study has quantified the influence of wave size on the performance of WSL surfers. The objective of this study was to verify the influence of wave size on the performance of surfers in the main division of the World Surf League (WSL) Tour.

METHOD

Participants

Thirty-one surfers from the main division of the 2019 World Surf League (WSL) Tour participated in the study. As an inclusion criterion, surfers had to have participated in at least 9 events during the season.

Procedures

Data from the 2019 season was collected through the official WSL page, where 10 of the 11 stages were analyzed (excluding Fresh Water Pro, USA / wave machine). The two best waves of each surfer per heat were evaluated, separately and combined (together), from round one to the final, totaling 1749 separate waves and 847 combinations.

To verify the influence of wave size on the performance of WSL surfers, the study variables were related or associated with the number of victories and the ranking. The verification was carried out directly through wave sizes and indirectly through types and combinations of maneuvers.

The wave size variable categories were collected following the following procedures: at the moment the surfer was preparing to perform the first maneuver, the surfer who caught the wave chosen as the highest was the one who caught the biggest wave in the heat, and the rest took the non-larger ones.

The type of maneuver as in the study by Lundgren et al.[7] was divided into three groups, turning maneuvers, aerials, and tubes. The collections of these groups followed the following procedures: waves that contained at least one aerial or tube were classified as aerial or tubes, the others as turning maneuvers; when the aerial and the barrel were performed on the same wave, the one performed in the most powerful region of the wave was chosen between them.

The variable combination of maneuvers classified the maneuvers of each surfer's two best waves and was composed of six categories: (1) turn maneuver-turn maneuver; (2) aerial-turn maneuver; (3) aerial-aerial; (4) tube-turn maneuver; (5) tube-tube; (6) tube-aerial.

In the number of maneuvers variable, maneuvers performed in the critical part of the wave were counted, being analyzed wave by wave and categorized into: one maneuver, two maneuvers, and three maneuvers or more.

The performance reference variables were collected as follows: in the result variable, the first place was considered the surfer who won the heat, and the others entering the category did not win the heat; The ranking of the stages and the season was obtained from the official WSL page.

Statistical analysis

The statistical packages IBM SPSS Statistic, version 20.0, Past 318, and BioEstat 5.3 were used, with a significance level of 95% ($p<0.05$).

The normality of the data was initially assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Spearman's correlation coefficient was used in all correlations in the study. As indicated by Cohen[25], the effect size of the correlations followed the following references: (0.10-0.29) small effect, (0.30-0.49) medium effect, (≥0.50) large it is made.

Binary Logistic Regression was used to check possible associations and estimate the odds ratio (OR) between the wave size variable and the outcome.

For association tests, the variables were analyzed in their binary formats. For correlation tests, new variables were obtained through the number of times each surfer performed each category of each variable.

RESULTS

In Table 1, the absolute and relative frequencies of the study variables were presented. During the 2019 season, those surfers who won their heats represented 46% and those who caught the biggest wave 45% of the total. The most frequent maneuver group was turning maneuvers (62%), followed by tubes (28%) and aerials (10%). The most frequent maneuver combinations of the two best waves were turn maneuver-turn maneuver (52%) and tube-tube (21%).

Table 1. Absolute and relative frequencies of the variables observed in the study.

Variables	n	%
Type of maneuver/wave		
Turning maneuvers	1082	62.0
Aerials	180	10.0
Tubes	482	28.0
Total	1749	100.0
Result		
Won the heat	387	45.7
Didn't win the heat	460	54.3
Wave size		
Big wave	381	45.0
No bigger waves	466	55.0
Combination of maneuvers (two best waves)		
Turning Maneuver-Turning Maneuver	444	52.4
Aerial -Turning Maneuver	82	9.7
Aerial-Aerial	34	4.0
Tube-Turn Maneuver	80	9.4
Tube-Tube	181	21.4
Tube-Aerial	26	3.1
Total	847	100.0
Event ranking	36	100.0
Season ranking	31	100.0

In the season observed. the wave size variable was associated with the result variable. surfers who caught the biggest wave in the heat were four times more likely to win their heats than those who didn't (95%CI: 3.02 – 5.36. p<0.001. n=847). The odds ratios of winning the heat by catching the biggest wave. according to the maneuver combinations of each surfer's two best waves. were presented in Figure 1. The lowest value was found in the aerial-aerial combination (2.8) and the highest in the tube-tube combination (6.6).

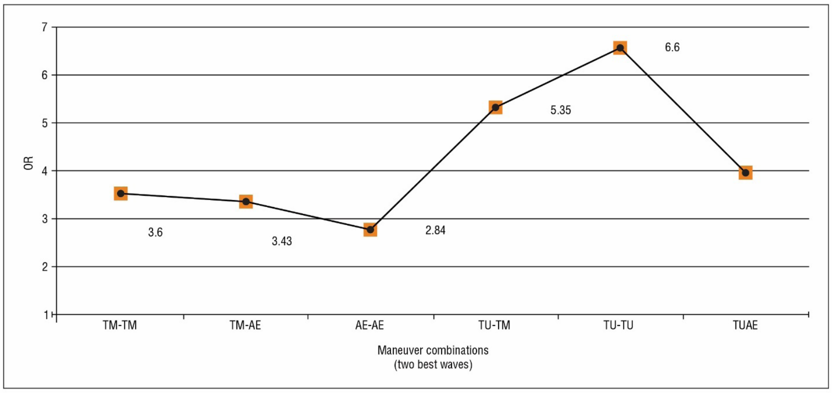

Figure 1. Odds ratio (OR) of winning the heat by catching the biggest wave according to the maneuver combinations of each surfer's two best waves (847). Note. TM-TM: turning maneuver and turning maneuver; TM-AE: turning and aerial maneuver; AE-AE: aerial and aerial; TU-TM: turning and tube maneuver; TU-TU: tube and tube; TU-AE: tube and aerial.

The correlations of the variables observed in the study with the number of victories and the season ranking (n=31) were presented. The biggest wave in the battery was the study variable that showed the greatest correlation with the number of victories and the ranking (rs=0.79 vs. -0.77). The non-largest waves presented lower correlations than the largest wave. relating more to the ranking (rs=0.51 vs. -0.55) (Table 2).

Regarding the types of maneuvers, the group of turning maneuvers showed a lower correlation with the number of victories than with the ranking (rs=0.48 vs. -0.56). The group of aerial maneuvers showed a higher correlation with the number of victories than with the ranking (rs=0.63 vs. -0.52) and the tubes showed the highest correlations with approximate values in both situations (rs=0.67 vs.-0.68) (Table 2).

Table 2. Correlations of the variables observed in the study with the number of victories and the season ranking (n=31).

Variables	Number of Wins		Ranking	
	rs	p-value	rs	p- value
Wave size				
Big wave	0.79	<0.001	-0.77	<0.001
No bigger waves	0.51	0.003	-0.55	0.001
Type of maneuver/wave				
Manobras de Virada	0.48	0.007	-0.56	0.001
Air	0.63	<0.001	-0.52	0.003
Tubes	0.67	<0.001	-0.68	<0.001
Combination of maneuvers (two best waves)				
Turning maneuver-Maneuver turnaround	0.28	0.120	-0.38	0.033
Aerial turning maneuver	0.48	0.007	-0.38	0.032
Aerial-Aerial	0.44	0.012	-0.33	0.068
Tube-Turn Maneuver	0.46	0.009	-0.45	0.012
Tube-Tube	0.45	0.012	-0.49	0.005
Tube-Aerial	0.41	0.022	-0.33	0.072

Note. rs: Spearman correlation.

For surfers of the season (n=31). turning maneuvers showed a correlation of great effect with three maneuvers or more per wave (rs=0.84. p<0.001) and a medium effect with two (rs=0.34. p=0.060). the aerials showed a correlation of great effect with one maneuver (rs=0.61. p=0.001) and a medium effect with two (rs=0.37. p=0.038). the tubes showed a correlation of great effect with one maneuver (rs=0.84. p<0.001) and medium effect with two (rs=0.32. p=0.075).

DISCUSSION

In the study by Méndez-Villanueva and Bishop[1] it was stated that wave conditions were among the external factors that could influence competitive performance. Méndez-Villanueva et al.[2] emphasized the almost unpredictable nature of performance in competitive surfing.

In the present study. regardless of how the maneuvers were performed. the simple fact of catching the biggest wave in the heat quadrupled the number of surfers' chances of winning their clashes. Although it is not included in the WSL[6] rule book. it was the variable that showed the greatest correlation with the ranking. consequently, the variable studied that had the greatest impact on the season's performance. In events where the waves varied more in size. those surfers who caught the biggest waves increased their chances of winning. In this way. in line with what was stated by Slater and Borte[26:14]. the size of the wave is also a factor that can influence the judgment.

The same maneuvers when performed in the biggest waves of the battery were more valued than when performed only in the non-biggest ones. This could explain the intriguing correlation (r=0.76) between the duration of each wave and the grades received in the study by Peirão and Santos[8]. This study analyzed the WSL judging criteria and found a large effect correlation of a variable that was not and is not included among the judging criteria[6]. Everything indicates that the bigger waves provided surfers with a greater area covered and more vigorous maneuvers.

Demonstrated by a correlation with a large effect. although smaller than that of the largest waves. non-larger waves played an important secondary role in the season. It was less frequent to achieve victory with just these waves and all surfers had to catch a portion of them during the season. Their greater correlation with the ranking demonstrated that the best classifieds made better use of them. which according to Garcia and Romero[13] may be related to the high competitiveness of these surfers.

Smaller waves were used during events. particularly in some phases. for example: in the Jeffreys Bay (RSA) event. they provided more critical walls for better use of turning maneuvers. in Portugal (POR) and Gold C (AUS) were widely used in the final heats through the execution of aerials and in Theahupo'o (PYF) they allowed deeper tubes.

Lundgren et al.[7] highlighted that professional athletes. to maximize their performance. should be able to choose the waves that score the most. In the present study (n=36). catching the biggest wave in the heat was significantly correlated with the ranking of all stages of the season and catching the non-biggest ones only in Jeffreys Bay (rs=-0.33. p=0.043). France (rs=-0.40. p=0.015) and Portugal (rs=-0.35. p=0.034). Even so. the effects of being able to catch the biggest waves in the ranking of these stages were greater rs=-0.55. p<0.001. rs=-0.51. p=0.001 and rs=-0.48. p=0.002 respectively.

The present study analyzed the maneuvers through separate waves like previous studies and together. a model closer to the reality of heat. where the two best waves of each surfer are considered by the judges[6]. The combined maneuvers of the two waves together presented lower correlations than those analyzed separately. cleaner correlations. with less interference in the value of one maneuver over the other.

The turning maneuvers were the most performed maneuvers of the season. they were usually performed through two maneuvers or more and proved to be important for achieving better classifications. Wins were common when they were associated with the biggest wave in the heat. as the biggest waves increased your chances of winning by more than three times. In non-larger waves. they were used in smaller. more hollow waves that allowed the use of more powerful maneuvers.

Confirming the findings by Lundgren et al.[7] and Forsyth et al.[15] turning maneuvers did not prove to be a group of high-scoring maneuvers. However. the present study proved that when the surfer's other wave had an aerial or tube. their results were enhanced.

Most of the aerials' victories were achieved through waves, not the biggest. when they were performed along the biggest waves. few surfers lost their heat. Isolated aerials showed a correlation of great effect and. across the two best waves. of medium effect with the number of victories. Corroborating the studies Lundgren et al.[7,17], Ferrier et al.[18,19] and Forsyth et al.[15] which confirmed that waves with aerials scored higher than waves without aerials. On the other hand. the weakening of their correlations with the season's ranking demonstrated that the best classified diversified their maneuvers through the use of turning maneuvers and tubes instead of aerials.

The correlation of the number of aerials with the 2019 season ranking (rs=-0.52) had a greater effect than that found by Tietzmann et al.[22] in the 2016 season (rs=-0.39. p=0.030). Evidencing that to achieve better rankings. greater amounts of aerials were required in 2019 than in 2016. The turn-aerial maneuver combination was the only aerial combination to correlate with the season's ranking. but the aerial-aerial and tube-aerial combinations ratified its importance by correlating with the ranking (n=36) with a large and medium effect in the Gold C. (AUS) (rs= -0.60. p<0.001) and Rio de J. (BRA) (rs= -0.46. p<0.011).

The tube group was the second most performed group of maneuvers in the season. like aerials. tubes were widely used in waves of one to two maneuvers. but larger. The tubes demonstrated great interference from the biggest wave in the battery. which could increase your chances of victory more than four times. In non-larger waves. they were used mainly through deeper tubes and as high-value maneuvers. to join with another wave that contained turning maneuvers and in some situations aerial.

As was also seen in the study by Lundgren et al.[7] tube waves exhibited a reduced number of turning and aerial maneuvers. corroborating that the ability to catch tubes was proven almost independently of other maneuvers. Among the maneuvers. the pipes were the ones that showed the highest correlations with the number of victories (rs=0.67) and with the ranking (rs=-0.68). still the greatest effects of the maneuver combinations of the two best waves with the ranking (rs=-0.49 and -0.45). Evidence that they were vital for surfers to win many heats and the most decisive maneuver group to achieve better classifications and avoid disqualification.

CONCLUSION

Through the evidence, it was concluded that: 1) those surfers who during the season caught the biggest waves in the heats more often had more chances of winning their heats and achieving better rankings in the season; 2) all surfers had to catch a portion of only no larger waves and the best classified made the most of them; 3) the biggest waves had a greater influence on the tubes. then on the turning maneuvers and finally on the aerials; 4) the three groups of maneuvers were decisive for the good performance in the season. with the tubes being the most.

This study may help surfers understand that bigger waves are generally more valued than non-larger waves and in some cases, non-larger waves are the only and best option. Because the three types of maneuver were related to the ranking. it is recommended that they train the three types. with the tubes proving vital for the classification. New studies could be carried out replicating this in a longitudinal directionand could also study the tactics involved in catching the waves.

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COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

This research is following the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: LET, SMP; Analyzed the data: LET, SMP; Contributed reagents/materials/analysis tools: HR; Wrote the paper: LET, SMP.

REFERENCES

1. Méndez-Villanueva A, Bishop D. Physiological aspects of surfboards riding performance. Sports Med. 2005;35(1):55-70. http://doi.org/10.2165/00007256-200535010-00005. PMid:15651913.
2. Méndez-Villanueva A, Mujika I, Bishop D. Variability of competitive performance assessment of elite surfboard riders. J Strength Cond Res. 2010;24(1):135-9. http://doi.org/10.1519/JSC.0b013e3181a61a3a. PMid:19644407.
3. Scarfe BE, Elwany MHS, Mead ST, Black KP. The Science of surfing waves and surfing breaks. In: 3rd International Surfing Reef Symposium; 2003; Raglan, New Zealand. Proceedings. Hamilton: ASR Limited; 2003. p. 37-59.
4. Black KP. Natural and artificial reefs for surfing and coastal prediction. J Coast Res. 2001;29:51-65.
5. Moreira MAAG. Matriz de análise das tarefas desportivas: sistema de classificação estrutural- modelo taxinômico do surf [tese]. Lisboa: Faculdade de Motricidade Humana, Universidade Técnica de Lisboa; 2007.
6. WSL: Word Surf League. WSL rule book 2019 [Internet]. Santa Mônica; 2019 [cited 2019 Dec 06]. Available from: https://www.worldsurfleague.com
7. Lundgren L, Newton RU, Tran TT, Dunn M, Nimphius S, Sheppard J. Anylisis of manouvres and scoring in competitive surfing. Int J Sports Sci Coaching. 2014;9(4):663-9. http://doi.org/10.1260/1747-9541.9.4.663.
8. Peirão R, Santos SG. Critérios de julgamento em campeonatos internacionais de surfe profissional. Rev Bras Cineantropom Desempenho Hum. 2012;14(4):439-49. http://doi.org/10.5007/1980-0037.2012v14n4p439.
9. Méndez-Villanueva A, Perez-Landaluce J, Bishop D, Fernandez-García B, Ortolano R, Leibar X, et al. Upper body aerobic fitness comparison between two groups of competitive

surfboards riders. J Sci Med Sport. 2005;8(1):43-51. http://doi.org/10.1016/S1440-2440(05)80023-4. PMid:15887900.

10. Farley ORL, Harris NK, Kilding AE. Physiological demands of competitive surfing. J Strength Cond Res. 2012;26(7):1887-96. http://doi.org/10.1519/JSC.0b013e3182392c4b. PMid:21986691.

11. Coyne JOC, Tran TT, Secomb JL, Lundgren LE, Farley OR, Newton RU, et al. Maximal strength training improves surfboard sprint and endurance paddling performance in competitive and recreational surfers. J Strength Cond Res. 2017;31(1):244-53. http://doi.org/10.1519/JSC.0000000000001483. PMid:27253832.

12. Tran TT, Lundgren L, Secomb J, Farley ORL, Haff GG, Seitz LB, et al. Comparison of physical capacities between nonselected and selected elite male competitive surfers for the National Junior Team. Int J Sports Physiol Perform. 2015;10(2):178-82. http://doi.org/10.1123/ijspp.2014-0222. PMid:25010163.

13. Garcia FG, Romero DN. Autoestima y competitividade em uma selección juvenil peruana de surf. Rev Ibero Psico Ejerc Desp. 2009;4(2):253-69.

14. Souza PC, Rocha MA, Nascimento JV. Correlação da técnica bottom turn com as notas atribuídas no surf de alto rendimento. Rev Bras Cineantropom Desempenho Hum. 2012;14(5):554-60. http://doi.org/10.5007/1980-0037.2012v14n5p554.

15. Forsyth JR, de la Harpe R, Riddiford-Harland DL. Analysis of scoring of maneuvrs performed in elite men's professional surfing competitions. Int J Sports Physiol Perform. 2017;12(9):1243-8. http://doi.org/10.1123/ijspp.2016-0561. PMid:28253028.

16. Farley ORL, Raymond E, Secomb JL, Ferrier B, Lundgren L, Tran TT, et al. Scoring analysis of the men' s 2013 world championship tour of surfing. Int J Aquat Res Educ. 2015;9(1):38-48. http://doi.org/10.1123/ijare.2014-0072.

17. Lundgren L, Dunn M, Nimphius S, Sheppard J. The importance of aerial manouvers in elite competitive surfing performance. J Aust Strength Cond. 2013;21(1):70-2.

18. Ferrier B, Sheppard J, Newton RU, Nimphius S. The importance of aerial manouvre variations on competitive surfing performance. J Aust Strength Cond. 2014;22(5):135-8.

19. Ferrier B, Sheppard J, Farley O, Secomb JL, Parsonage J, Newton RU, et al. Scoring analysis of the men's 2014, 2015 and 2016 world championship tour of surfing: the importance of aerial manoeuvres in competitive surfing. J Sports Sci. 2018;36(19):2189-95. http://doi.org/10.1080/02640414.2018.1443747. PMid:29469611.

20. Forsyth J, Riddioford HDL, Steele JR. Characterising successful aerial manouvres in professional surfing competitions. In: XXXIV International Conference on Biomecanichs in Sports; 2016; Tsukuba, Japan. Proceedings. London: International Society of Biomechanics in Sports; 2016. p. 601-4.

21. Lundgren L, Butel M, Brown T, Nimphius S, Sheppard J. High ankle sprain: The new elite surfing injury? Int SportMed J. 2014;4(2):321-7.

22. Tietzmann LE, Pacheco EA, Roesler H, Pereira SM. Aerials and their influence on Woarld Surf League surfer performance (WSL flights). Rev Bras Cineantropom Desempenho Hum. 2020;22:e67473. http://doi.org/10.1590/1980-0037.2020v22e67473.

23. Furley P, Thrien F, Klinge J, Dörr J. Claims in surfing: the influence of emotional postperformance expressions on performance evaluations. J Sport Exerc Psychol. 2020;42(1):26-33. http://doi.org/10.1123/jsep.2019-0122. PMid:31883502.

24. Forsyth JR, Riddiford-Harland DL, Whitting JW, Sheppard JM, Steele JR. Essential skills for superior wave-riding performance: a systematic review. J Strength Cond Res. 2020;34(10):3003-11. http://doi.org/10.1519/JSC.0000000000003402. PMid:31714460.

25. Cohen J. Statistical power analises for the behavioral sciences. New York: Lawrence Erlbaum Associates; 1988.

26. Slater K, Borte J. A biografia de Kelly Slater: pipe dreams. São Paulo: Gaia; 2004.