

Correlations Between Physiological Parameters and Competition Performance in Junior Windsurfers

Y.M. Tse, K.K. Lo, William C.W. Ko, Raymond C.H. So, Rene Appel
Hong Kong Sports Institute

Introduction Windsurfing is termed as a technical sport as it appears to demand more skills than physical fitness. However, since the sanction of sail pumping in all Olympic windsurfing competitions in 1993, windsurfing has become a physically demanding sport^[1,2]. In assessing the cardiorespiratory requirements of pumping in actual sailing conditions, De Vito *et al*^[3] found that oxygen uptake (VO_2) could rise up to 75% of VO_{2max} in male participants. Vogiatzis *et al*^[2] also concluded that windsurfing should be considered as physically demanding as most aerobic sports. Anaerobic power of arms, grip strength and lower back strength also demonstrated specific adaptation to the sport^[4-6]. These findings underlie the basic attributes that are required in windsurfing at a professional level. However, there is still limited information documenting such profiles of windsurfers especially at junior level. The purpose of the study was to determine the relationship between physical attributes and the sports performance.

Methods and Procedures

Subjects Twenty-three male windsurfers (age: 13.2 ± 0.7 years, training experience: 3.5 ± 1.0 years) volunteered for this study. They belong to the development squad under the supervision of Hong Kong Windsurfing Association. All participants spent 2 days a week and an average of 6 hours each day on training.

Study Design All subjects were required to participate in the assessment of anthropometry and physical fitness on 2 separate sessions. The assessments included the measurement of height, body mass, arm span, leg length, sit & reach, vertical jump, handgrip strength, 1-minute modified pull-ups, 1-minute sit-ups, torso pull, 1-minute push-ups, hanging and 20-m multi-stage shuttle run tests. None of the windsurfers had undergone any strenuous physical training 24 hours prior to the tests.

Windsurfing Race Performance Within a month after the assessment sessions the Hong Kong Youth Competition, which consisted of 4 races held in 2 consecutive days, were hosted by the Windsurfing Association of Hong Kong. The wind speed on the 2 days ranged from 8 to 18 km/hr. All competitors used raceboard Mini Minim in the competitions. The winner was given a race score of 1, the 1st runner-up of 2 and so forth. Race scores in the 4 races were summed up to generate an individual total race score for each participant. The total score was used as an indicator of windsurfing race performance. All race results were obtained from the Windsurfing Association of Hong Kong.

Statistical Analysis and Results Spearman-rank-order correlation analysis was conducted to evaluate any correlation between physical fitness attributes or anthropometric parameters and

windsurfing performance. Descriptive statistics of the anthropometric characteristics, physical fitness measurements, and correlation coefficients between variables and windsurfing performance are presented in Table 1. Number of training years had the highest correlation with windsurfing performance ($r = -0.71$). This was followed by estimated VO_{2max} ($r = -0.66$) and hanging ($r = -0.60$). Height and torso pull had the same strength of correlation with windsurfing performance ($r = -0.53$). Relatively weak correlations ($r = -0.45$ to -0.43) were found between windsurfing performance and arm span, leg length, handgrip strength and vertical jump.

Discussion The present study shows that aerobic capacity has moderate correlation with windsurfing race performance. It conforms to other studies that aerobic fitness is an important attribute of windsurfers^[2, 3, 6]. In terms of muscular endurance, hanging is the only endurance attribute among the test items that shows significant correlation with race performance. It indicates the sustained involvement of upper body muscles in windsurfing race^[7].

Our study found that explosive power of lower limbs, handgrip and lower back strength contributed moderately to success in windsurfing competition, which was consistent with other studies^[4, 8]. Windsurfing also favors those with good height, long arms and legs as they increase the outward leaning angle and facilitates the movement range of the sail for propulsion^[9]. The moderate strength of correlation between the above test items and race performance reflects that some other factors are also determinants of race performance. Technical skills and the ability to perform the correct judgment under various environmental conditions may be important factors. With increase in windsurfing experience, skills and the ability to make the right judgment will likely improve as well. This is in line with our study that those with longer training years tend to perform better in race. In this study, the 4 races selected for determining race performance were held under wind speeds ranged approximately from 8 to 18 km/hr. Hence, the results indicate the requirements of physical fitness and anthropometric measures for success in windsurfing competitions under light to moderate wind speeds. Wind speed directly affects physical exertion and race performance. Inclusion of more races under different wind conditions in future study will likely to reflect the necessary attributes for a successful windsurfer under various wind conditions. To conclude, the present study shows that aerobic capacity, upper body endurance, lower limb power, handgrip and lower back strength, height, arm and leg length are determinants of windsurfing race performance in junior windsurfers. These indices can be used in talent identification and serve as guidelines in targeted trainings, which will facilitate the development of training programmes for junior windsurfers in the near future.

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Table 1 Descriptive Statistics of anthropometric characteristics and physical fitness variables, and their correlations with windsurfing race score.

	Mean	±	SD	Correlation Coefficient (r)
No of subjects = 23				
Age (year)	13.22	±	0.74	-0.51*
Number of training years (year)	3.52	±	1.04	-0.71*
Height (cm)	163.07	±	9.10	-0.53*
Body Mass (kg)	50.53	±	9.95	-0.29
Body Mass index	18.82	±	2.22	-0.05
Arm Span (cm)	169.68	±	10.44	-0.45*
Arm Span / Height (%)	104.04	±	2.07	0.18
Leg Length (cm)	80.30	±	4.89	-0.43*
Leg Length / Height (%)	49.24	±	0.95	0.10
Sit & Reach (cm)	28.13	±	6.06	-0.19
Handgrip Strength (kg)	60.65	±	16.84	-0.44*
Vertical Jump (inch)	18.70	±	3.30	-0.45*
Torso Pull (kg)	92.78	±	24.56	-0.53*
Sit-Ups (times/min)	36.61	±	6.89	-0.19
Push-Ups (times/min)	24.61	±	9.61	-0.21
Modified Pull-Ups (times/min)	32.09	±	7.79	-0.37
Hanging (sec)	70.48	±	23.94	-0.60*
Estimated VO_{2max} (ml/kg/min)	45.16	±	6.75	-0.66*

* Significant correlation (p -value < 0.05) with windsurfing race score