81 - MECHANICAL EFFICIENCY ANALYSIS OF HIKING IN HOBIE CAT 16 ATHLETES.

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INTRODUCTION

When sailing, specially in upwind with medium and strong winds, a pair of forces appear, one in the mainsheet and another one in the dagger board that generating a moment that makes the boat to heel [1,2]. To prevent that the boat heels excessively, the sailor creates a moment in the inverse direction to the cited one using its weight to a certain distance of the boat gravity center. This sailors action is called "hiking", and can occur with the assist of a rope connected to the mast and next the sailor's waist, defined trapeze (FIGURE 1 - left). In the Hobie Cat 16 (Figure 1 right), the trapeze makes possible the sailor, when necessary, to keep all the body outside the boat, supported by its feet in the lateral of the hull, making possible a bigger Hiking Moment. Deshors [3] cites the necessity of a most extended possible position the in the boat's prolongation to it progress more quickly.

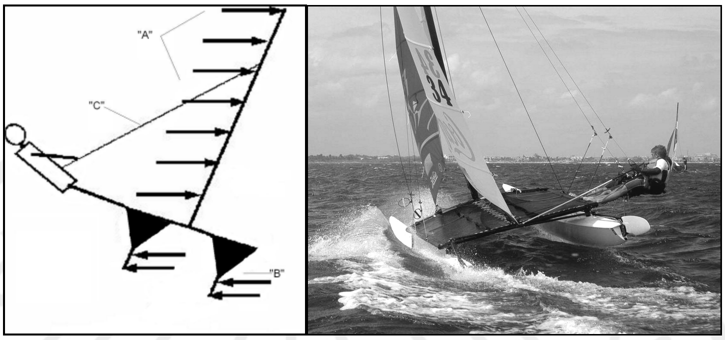

Figure 1 - Left: Illustration of the hiking strap, being "A" the representation of the force in the mainsheet; "B" the force in the dagger board; "C" identifying the hiking rope. Right: Sailors in the hiking position in a Hobie Cat 16.

To evaluate in the sport Sailing, Mackie [4] cites key points as indicators of performance and a hierarchy amongst these, being distinguished the factors related to the sailor characteristics, presented orderly of importance: 1) the Hiking Moment; 2) the corporal mass and the distance of the sailor center of mass to the middle of the boat; 3) the sailor's height and the hiking positions; 4) and finally, the knee and hip angles, from the distance of the foot to the middle of the boat, reference the hiking strap, not used in the Hobie Cat 16.

The moment generated for the sailor is defined as "Hiking Moment" ("HM"), being this the product of the "Hiking Distance" ("HD") and the athlete's weight force, being "HD" the distance between the sailor center of gravity (CG) to the middle of the boat [5,6,7]. The capacity to keep certain hiking position can be determinative performance factor [7], therefore contributes to maintain the boat speed during the race and still, a great factor to be gotten in training is to increase the tolerance to the hiking positions [8,9].

Biomechanics studies can contribute to give technical answer to sailor's doubts, referring to the motor gestures during sailing, making possible to the technician and athlete to choose comfortable and efficient positions to reach greater income. Already biomechanics methods in studies had been used describing and analyzing the used sailors positions in laboratories situations, being that these inquiries had occurred mainly in monohull boats type, as of the Laser class [10, 11, 12, 13, 14]. Few studies [5,15] if had worried in analyzing the positions adopted for sailors in the Hobie Cat 16. Marchetti, Figura and Ricci [15] cite that the physiological requirement of the positions with trapeze support in Hobie Cat 16 as a very light exercise in comparison with hiking in the Laser class, being able to be this explanation for the lower concern of the gestures in this class. However, Roesler, Haupenthal and Faquin [5] cite the necessity of mechanical efficiency and comfort knowledge of each position gather to the athletes to determine which the best choice for the competition situations. The trapeze use and the efficiency of this were verified by Dumortier and Iachkine [16], being executed the analysis, in laboratorial situation, a 470 class boat, where it is possible to one of the two sailors to use hiking strap.

When using the hiking strap, independently of the class, the sailor can assume diverse positions, some more comfortable than others, and each one depending on the corporal position and the athlete anthropometrics characteristics generates a different "HM".

From that, this work objectified to technically answer the Hobie Cat 16 sailor's doubts on the mechanical efficiency of hiking positions usually adopted.

METHOD

Participated in this research a pair composed for one subject of masculine gender and one of feminine gender. Athlete 1 had 30 years, 76,0kg of mass, 1,86m of stature and athlete 2 had 37 years, 60,7 kg of mass, 1,72m of stature.

Instruments and analysis

A SVHS camcorder was used, with frequency acquisition of 30Hz, being the analysis executed in the Peak Motus software system [17]. For the athlete CG determination the Clauser[18] model was used, for the definition of the masses and the geometric and inertial properties definition for each segment.

An anatomical model was used with the determination of the following (control) points in the athlete: temporomandibular joint, acromion, humeral lateral epycondile, ulna lateral styloid process, lateral iliac crest, femur lateral epycondile, fibula lateral malleolus, distal fifth metatarsal. The use of the hiking belt connected to the "shorts" for the Hobie Cat 16 boat athlete only made possible the marking of the lateral iliac crest as control point.

In the situations proposals the bidimensional analysis (2D) was made, with the respective calibrators for each coordinates axle. The SVHS camcorder position was perpendicular to the longitudinal plan of the boat in front of its CG. The boat's CG on plane positions can be referenced by the middle of the boat [4].

Development/Procedures:

After positioning the camcorder perpendicular to the boat CG, had been acquired about 10 seconds for each position. The sailor had been analyzed separately, with the analysis of a frame for each position and totalizing seven positions for each athlete.

Three positions can be visualized in Figure 3 and had been called HC1, HC2 and HC3.

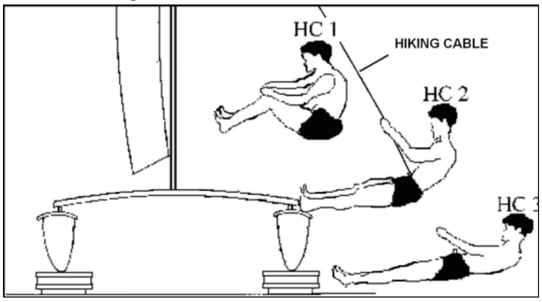

Figure 3 - Figure of the sailor carrying through the hiking positions.

In position HC1 the feet were separated by the shoulders line, ankle in dorsiflexion, knee in flexion and hip in flexion. In the HC2, feet more separated that the shoulders line, ankle in dorsiflexion, extended knee and extended hip joint. In HC3, joined feet, ankle in plantar flexion, extended knee and extended hip joint.

There is the possibility of differentiate the trapeze rope length being defined the situations, "High hiking strap" with trapeze rope in the minimum length (5,83±0,05m) and "Low hiking strap" with cable in the maximum length (6,03±0,05m). In Low trapeze the sailors had also executed position HC3 with the arms extended above of the head resulting in position HC4.

For the mechanical efficiency analysis the most studied angles and considered of bigger influence on the moments generated for the different positions are the knee and hip internal angles [4,7,12,13,14,15,16], determined for the angle formed for the half-straight lines that bind to the anatomical points lateral iliac crest, femur lateral epycondile and fibula lateral malleolus for knee internal angle (âK) determination; e for the anatomical points acromion, lateral iliac crest and femur lateral epycondile for hip internal angle (âH) determination.

RESULTS AND DISCUSSION

In Table 1 the internal knee and hip angles referring values are presented, being these described for each adopted position. **TABLE 1 - Values of knee and hip angles in the different positions [º].**

	Athlete 1		Athlete 2	
	Knee [º]	**Hip [º]**	**Knee [º]**	**Hip [º]**
High hiking strap				
HC1	166	87	136	139
HC2	177	143	179	159
HC3	178	170	181	172
Low hiking strap				
HC1	167	82	132	136
HC2	180	136	182	155
HC3	178	169	180	175
HC4	180	182	180	193

The athletes had presented similar knee and hip angles in the two situations proposals. It still can be observed that in position HC4 the use of the arms promotes the maximum extension of the segments and a hyperextension given for the hip angle, more detached in athlete 2.

After determined the athlete's CG, it was calculated the distance of this to the boat's CG thus determining "HD". Multiplying "HD" to the athlete's weight the “HM” generated in each position was calculated, being the values presented in Table 2. **TABLE 2 - Hiking Distance and Hiking Moment values for the positions.**

	“HD” (Hiking Distance) [m]		“HM” (Hiking Moment) [N.m]	
	Athlete 1	**Athlete 2**	**Athlete 1**	**Athlete 2**
High hiking strap				
HC1	2,02	1,84	1506	1096
HC2	2,29	2,01	1707	1197
HC3	2,48	2,06	1849	1227
Low hiking strap				
HC1	2,15	1,91	1603	1137
HC2	2,36	2,16	1760	1286
HC3	2,53	2,30	1886	1370
HC4	2,64	2,45	1968	1459

As waited, a gradual “HM” increase is perceived. In the measure where it has the segments extension, generating a bigger feet separation in the longitudinal direction in relation to the middle of the boat, generates a bigger “HM” and increases thus its efficiency.

To determine the mechanical efficiency increase of the executed positions it was opted to compare: the increase in the mechanical efficiency during the position change, taking for base position HC1 (told as the most comfortable for the athlete) until position HC3 in High trapeze and HC4 in Low trapeze; b) and the difference in the hiking rope length, comparing HC1, HC2 and HC3 in the two lengths.

In Table 3 it is presented, in percentage, the mechanical efficiency increase of the positions in comparison the HC1. Together is presented the knee and hip internal angles increase, also referred by position HC1.

TABLE 3 - Increase of the mechanical efficiency with the increase of the internal angles.

	Athlete 1			*Athlete 2*		
	Efficiency	*Knee*	*Hip*	*Efficiency*	*Knee*	*Hip*
High hiking strap						
HC1 x HC2	*(+)13%*	*(+)11°*	*(+)56°*	*(+)09%*	*(+)43°*	*(+)20°*
HC1 x HC3	*(+)23%*	*(+)12°*	*(+)83°*	*(+)12%*	*(+)45°*	*(+)33°*
Low hiking strap						
HC1 x HC2	*(+)10%*	*(+)13°*	*(+)54°*	*(+)13%*	*(+)50°*	*(+)19°*
HC1 x HC3	*(+)18%*	*(+)11°*	*(+)87°*	*(+)20%*	*(+)48°*	*(+)39°*
HC1 x HC4	*(+)23%*	*(+)13°*	*(+)100°*	*(+)28%*	*(+)48°*	*(+)57°*

From the most comfortable position (HC1) to position HC2 it was observed that the increase in the gesture mechanical's efficiency was given by the knee and hip angles increase, being that for the positions HC3 and HC4 only one variation in the hip angle is observed. This only variation use of the hip angle approximately resulted in increase of 7% in the gesture efficiency, having athlete 1 make look like a better use of the trunk, represented for the increases in the efficiency and in the hip angle, in the trapeze execution.

To evaluate the arms use it was compared positions HC3 and HC4 in Low hiking strap, being found an increase of 5% for athlete 1 and 8% for athlete 2. Athlete 2 presented a bigger increase, however the arms use generated an exaggerated increase in the hip angle, what it results in the lumbar region hyperextension and great discomfort, as told for the athlete. Athlete 1 also presented an increase in the efficiency, however with little increase of the hip angle, being able to be explained by a possible greater musculature preparation of the body's anterior region and with this, being able to support the position, even with the arms raised.

To verify the possible hiking rope length influence in the mechanical efficiency of the positions, it was compared the similar positions in the two presented rope lengths. The data are presented in Table 4.

TABLE 4 - Increase of the mechanical efficiency with the increase of the hiking rope.

	Athlete 1	Athlete 2
Length hiking cable Increase		
HC1 x HC1	06%	04%
HC2 x HC2	03%	07%
HC3 x HC3	02%	12%

Athlete 2 presented one better use of this tool, making possible bigger "HMs" and increasing the mechanical efficiency in the gesture.

The efficiency between the position that generated the lower "HM" (HC1 in High hiking strap) to the position executed with greater "HM" (HC4 in Low hiking strap), it was verified an increase in the efficiency of 31% for athlete 1 and 33% for athlete 2.

CONCLUSIONS

The position of bigger efficiency at the Hiking Moment was for the position of low trapeze with the extended united legs, even so this position being very uncomfortable. The decision of which position to adopt will depend on the strategy of the race, the climatic conditions and the direction in relation to the wind. Also to small differences or adjustments between the athletes in the analyzed positions had been identified. These differences or strategies used for the athletes must better be analyzed and be argued between technician and athlete to make possible one better agreement of the trapeze execution and then search the best athletes performance. A combination of these presented details can bring one better performance in this movement execution.

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MECHANICAL EFFICIENCY ANALYSIS OF HIKING IN HOBIE CAT 16 ATHLETES.

ABSTRACT

It was objectified to answer Hobie Cat 16 sailors technical doubts like mechanical efficiency of the hiking positions generally adopted. It participated a pair of subjects composed with one of the masculine gender and one of the feminine gender. A SVHS camcorder was used (30Hz); with about 10 seconds acquisition for each position and the two-dimensional analysis was performed in the Peak Motus system software. Seven positions for each athlete had been analyzed (called HC1, HC2 and HC3 in two rope lengths and HC4 for the arms extension above the head). The athletes had presented similar knee and hip angles in the proposal situations. A gradual Hiking Moment increase was noticed when occurred the segments extension. From the most comfortable position (HC1) to HC2 position the mechanical efficiency increase was observed when increase in the angles of knee and hip happened, and for the positions HC3 and HC4 only one variation in the hip angle was observed, that resulted approximately an increase of 7% in the gesture efficiency. In the use of the arms were compared positions HC3 and HC4, being found an increase of 5% and 8% for athlete 1 and 2, respectively. However athlete 2 presented an exaggerated increase in the hip angle, that resulted in hyperextension of the lumbar region and great discomfort, as told for the athlete. Athlete 1 also presented an increase in the efficiency, however without the hyperextension of the lumbar region, being explained for a possible greater musculature preparation of the anterior region of the body. Small differences or possible adjustments between the sailors in the analyzed positions had been identified. These differences or strategies used for the athletes identified and argued with the technician can make possible one better understanding about the trapeze use and search the best performance.
Word-key: Biomechanics; Sail; hiking strap.

ANALYSE MÉCANIQUE D'EFFICACITÉ D´ALLER RAPPEL DANS DES ATHLÈTES DE CAT 16 DE HOBIE.

RÉSUMÉ

Il a été objectivé pour répondre, les doutes techniques de Hobie Cat 16 barreurs techniques comme efficacité mécanique des positions de rapell, généralement sont adopté. Il a participé une paire de sujets qui sont composée avec un genre masculin et un genre féminin. Une caméra vidéo SVHS a été utilisée (30Hz) avec l'acquisition d'environ 10 secondes pour chaque position et l'analyse bidimensionnelle a été exécutée dans le logiciel système Peak Motus. Sept positions pour chaque athlète avaient été analysées (appelé HC1, HC2 et HC3 dans deux longueurs de câble et HC4 pour la prolongation des bras au-dessus de la tête). Les athlètes avaient présenté des angles semblables de genou dans les situations de la proposition. Une augmentation graduelle du moment de la Randonnée a été notée quand s'est produit la prolongation des segments. De la position la plus confortable (HC1) à la position HC2 on a observé l'augmentation mécanique d'efficacité quand l'augmentation des angles du genou et de la hanche s'est produite, et pour les positions HC3 et HC4 on a observé seulement une variation dans l'angle de hanche qui a résulté approximativement une augmentation de 7% de l'efficacité du geste. Dans l'utilisation des bras les positions HC3 et HC4 étaient comparées, on a trouvé une augmentation de 5% et de 8% pour l'athlète 1 et 2, respectivement. Cependant l'athlète 2 a présenté une augmentation exagérée de l'angle de hanche, cela a eu comme conséquence l'hyperextension de la région lombaire et du grande incommodité, comme dit pour l'athlète. L'athlète 1 a également présenté une augmentation de l'efficacité, de quelque manière que sans hyperextension de la région lombaire, étant expliqué pour une plus grande préparation possible de la musculature de la région antérieure du corps. De petites différences ou ajustements possibles entre les barreurs em positions analysées avaient été identifiés. Ces différences ou stratégies qui sont utilisées pour les athlètes, sont identifiés et discutés avec le technicien. Ils peuvent faire possible un meilleur arrangement au sujet de l'utilisation du trapeze et rechercher la meilleure exécution.

Mots-clés : Biomécanique; Voile; trapèze.

ANÁLISIS DE LA EFICIENCIA MECÁNICA DEL COLGARSE EN ATLETAS DE HOBIE CAT 16.

RESUMEN

Fue objetivado dar respuesta a las dudas de atletas de Hobie Cat 16 cuanto a la eficiencia mecánica de las posturas de colgarse . Participó del estudio una dupla, compuesta por un sujeto de género masculino y un de sexo femenino. Una SVHS videocámara (30Hz) fue usada con aproximadamente 10 segundos adquiridos para cada postura y el análisis bidimensional fue llevada a cabo en el software del sistema Peak Motus. Siete posturas para cada atleta fueron analizados (denominadas HC1, HC2 y HC3 en dos medidas de cable y HC4 para obtener la extensión de los brazos encima de la cabeza). Los atletas habían presentado similares ángulos de rodilla y cadera en las situaciones propuestas. Se percibió un gradual aumento del Momento del colgarse a la medida que ocurria la extensión de los segmentos. De la postura más confortable (HC1) a la postura de HC2 se observo que el aumento en la eficiencia mecánica fue dado por el aumento en los ángulos de la rodilla y cuadril, siendo que para las posturas HC3 y HC4 se observó apenas una variación en el ángulo del cuadril, lo que resultó en aumento de aproximadamente 7% en la eficiencia del gesto. Para la utilización de los brazos se comparó las posturas HC3 y HC4, siendo encontrado un aumento de 5% y 8% para los atletas 1 y 2, respectivamente. Entretanto el atleta 2 presentó un aumento exagerado en el ángulo del cuadril lo que resultó en una hiperextensión de la región lumbar y de grande incómodo, como relatado por el atleta. El atleta 1 también presentó un aumento en la eficiencia, entretando sin la hiperextensión de la región lumbar, pudiendo ser explicado por una posible mejor condición de la musculatura de la región anterior del cuerpo. Fueron identificadas pequeñas diferencias o posibles ajustes entre los atletas en las posturas analisadas. Estas diferencias o estrategias utilizadas por los atletas identificadas y discutidas con los técnicos pueden posibilitar un mejor entendimiento sobre la utilización del trapecio y buscar la mejor performance.

Palabras-clave: Biomecánica; Vela; Trapecio.

ANÁLISE DA EFICIÊNCIA MECÂNICA DA ESCORA EM ATLETAS DE HOBIE CAT 16.

RESUMO

Objetivou-se responder tecnicamente as dúvidas de velejadores de Hobie Cat 16 quanto à eficiência mecânica das posturas de escora comumente adotadas. Participou uma dupla composta por um sujeito do gênero masculino e um do gênero feminino. Utilizou-se uma filmadora VHS (30Hz), sendo adquiridos cerca de 10 segundos para cada postura e a análise bidimensional realizada no software do sistema *Peak Motus.* Foram analisadas sete posturas para cada atleta (denominadas HC1, HC2 e HC3 em dois comprimentos de cabo e HC4 para a extensão dos braços acima da cabeça). Os atletas apresentaram ângulos de joelho e quadril semelhantes nas situações propostas. Percebeu-se um gradativo aumento do Momento de escora à medida que ocorria a extensão dos segmentos. Da postura mais confortável (HC1) à postura HC2 observou-se que o aumento na eficiência mecânica deu-se pelo aumento nos ângulos de joelho e quadril, sendo que para a para as posturas HC3 e HC4 observou-se apenas uma variação no ângulo de quadril, o que resultou em aumento de aproximadamente 7% na eficiência do gesto. Para a utilização dos braços comparou-se as posturas HC3 e HC4, sendo encontrado um aumento de 5% e 8% para os atletas 1 e 2, respectivamente. Entretanto o atleta 2 apresentou um aumento exagerado no ângulo de quadril, o que resultou na hiperextensão da região lombar e de grande desconforto, como relatado pelo atleta. O atleta 1 também apresentou um aumento na eficiência, entretanto sem a hiperextensão da região lombar, podendo ser explicado por um possível maior preparo da musculatura da região anterior do corpo. Foram identificadas pequenas diferenças ou possíveis ajustes entre os atletas nas posturas analisadas. Estas diferenças ou estratégias utilizadas pelos velejadores identificadas e discutidas com os técnicos podem possibilitar um melhor entendimento sobre a utilização do trapézio e buscar a melhor performance.

Palavras-chave: Biomecânica; Iatismo; trapézio.