This presentation regards Olympic class only, offshore competitions not being considered herein. Our concern is the distribution of effort during the race or during the day if more than one regatta is scheduled for the day. The regatta rules have recently been changed and the duration of the competition is now greatly reduced in comparison with the past. The windward tack especially has been reduced to 15-20 minutes depending on boat and wind speed. It is clear that in this time the sailor must produce the \textit{minimum} effort he can \textit{maintain} until the end of the tack. In order to accomplish this we need to define and measure the effort as well as measure the capability of the sailor to endure the effort.

Sailing is a very different activity in comparison with other sports. In mild wind and sea the athletic fitness is quite useless in respect to other qualities such as dexterity in rudder and sail trimming, knowledge about meteorology and regatta rules and tactic competence. When wind speed increases the particular sailor fitness becomes more and more relevant and this special quality is the endurance in hiking. To counteract the wind's capsizing effect the sailor projects himself out the boat (hiking) and this taxes, by an isometric effort, mainly the abdominal, ilep-psoas and quadriceps muscles (1). Actually, the sailor's posture is not really static, him having to adapt to waves and wind variation. Thus on a background of isometric contraction jerks are superimposed (2) which approximate the Maximum Voluntary Contraction (MVC). In the laboratory the biomechanics of such postural activities have been extensively studied (1,2,3,4) and the greatest torques were measured at the knee, hip and lumbosacral joints. To carry out these measures, a number of boat simulators were designed, all very alike, but we must remember that the real sea conditions cannot really be simulated in the laboratory. On the other hand, meteorological conditions are so unpredictable, that a laboratory environment is preferred if all variables have to be controlled. The general effect of static effort has been extensively studied and it is well established that when the force is greater than 20\% of the MVC the resistances to blood flow in the muscular vascular bed increase. When the muscular contraction is above 50\% of MVC the muscle becomes completely ischemic and its metabolism is deeply affected. Many chemicals accumulate in the interstitial fluid and stimulate sensors which send signals to the central nervous system. The first effect is pain which becomes greater and greater with time. At the same time the stimulation of pontine and medullar cardiovascular control centers elicits a sympathetic volley on the heart that increases the heart rate (HR). This in turn enhances the cardiac output and the paramount effect is the arterial blood pressure greatly increasing. This is a result of vascular peripheral resistances not having changed respect to the basal condition. It has also been demonstrated that a similar effect is produced in the same way in the sailor during hiking, albeit using the simulator both with sphygmomanometry (4) and directly by aortic catheterisation (5). We have no records of blood pressure during actual sailing. The HR values registered during sailing were greater than the values we would expect in accordance with the \( V\text{O}_2 \) values measured in the same session (6,7,8). This suggests a typical isometric contraction effect. In the laboratory the fatigue induced by hiking simulation has been studied, looking at \(\text{VO}_2, \text{VCO}_2,\) Blood Lactate, HR and Electromyographic analysis. A relatively low energy cost of sailing was measured during actual sailing even in strong wind: about 25 ml kg\(^{-1}\) m\(\text{m}^2\)\(^{-1}\). At the end of a sea session (regatta simulation) blood lactate was in the range of 4 mmol L\(^{-1}\): laboratory tests confirmed these results. Nowadays a Laser regatta lasts 50-60 min.: in this time range we can estimate a 50 g glycogen breakdown. Not a
very great amount in comparison with other sports, but we must consider that a) this loss is mainly at the expense of quadriceps which sustain the greatest torque (1,2) and b) glycogen is the principal fuel in an anaerobic - or quasi-anaerobic - condition. The loss of muscular glycogen storage can have a substantial effect if another regatta follows the first with a very brief restoration time of some 15 mins. In this time it is improbable that lactate could be completely removed from the blood and the glycogen muscular storage refilled. When a third regatta is scheduled in the day, the situation can be very dramatic and the athlete must consider the best way to distribute his metabolic reserve throughly the day. Local muscular fatigue has been studied with a lab simulator when the athlete performs bouts of hiking contractions with a very brief rest interval (4) or a single contraction maintained until exhaustion. In this latter case we obtained an inverse relationship between hiking torque (HT) (i.e., the effective ami-capsizing torque) and exhaustion time (ET) (i.e., the length of time the sailor can maintain this torque until exhaustion). When the data are plotted on a graph, a typical rectangular hyperbolic relationship (ET HT= constant) is obtained (5). The assessment of the individual curve can be useful in order to a) follow the effectiveness of training and b) know how long a particular tack can be maintained. As a determinant of muscular pain K+ is the principal candidate (4). After a regatta the blood concentration of this ion is deeply diminished and this effect is quantitatively related to the difficulty of the performance and the fatigue felt by the sailors (9). The electromyographic responses obtained during hiking are consistent with those reported by other fatigue studies (4,5): a left shift of the EMG power spectrum during the effort which is syntetically described as a decrease in the median value of the spectrum. In a series of hiking bouts an increase in integrated EMG was noted (4) and its relationship with muscular fatigue was discussed. Being objective signs of fatigue both these EMG findings are of great interest in studies aimed at investigating the determinants of the exhaustion in hiking.

REFERENCES

5 - Marchetti M., Rodio A., Madaffari A.: The hiking fatigue. (in press)