INTEGRATED ANALYSIS OF BICYCLE POSTURE FOR THE OPTIMIZATION OF CYCLING EFFICIENCY

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INTRODUCTION
The problem of cycling efficiency is a well known research topic that was studied by several scientists since the last decades under either physiological, biomechanical or engineering point of view. Despite this great effort, mainly focused on the lower limb pacing and muscle recruitment, most professional and amateur cyclists demand for correct sizing and adjustment of their bicycle components, such as saddle, handlebar, frame and pedal cleats depending on their anthropometry and type of use.

Aim of the present study was to develop a method for analyzing the effect of different postures on the pedaling efficiency by integration of motion capture and load acquisition techniques, for subjects cycling at known different relative positions of the upper and lower limbs in order to find an optimized posture.

METHODS
Two groups of cyclists participated to this study: 5 professional riders and 5 amateur riders. Informed consent was obtained before the experiments. The subjects were asked to pedal on a specially designed motorized cyclo-ergometer equipped with a left dynamometric 4 channels pedal, a right SRM crank, a dynamometric handlebar and a dynamometric saddle pillar. The cyclo-ergometer geometry was adjustable by motorized actuators during the cycling action without stopping the test. Each subjects sustained three tests. Initially a Conconi test was performed to determine the anaerobic threshold. The second and third tests were performed at a workrate equal to the 80% of each subject anaerobic threshold and at 90rpm pedaling rate. In the second test, the relative position between handlebar and saddle was randomly changed while subjects were cycling; in the third test the lower limbs position relative to the trunk was randomly changed by moving the handlebar and the saddle together forward or backward with respect to the bottom bracket. Each test involved a 15 min warm up period at 90 RPM and five steady stages at five different postures. For each posture, body-bicycle interface loads were collected after 3 min steady-state period and posture of the body and the bicycle components was dynamically recorded by a motion capture system. The forces developed at the left pedal, the handlebar and the saddle were collected at 200Hz. The subjects were wearing an heart rate monitor and answered to a verbal questionnaire for the evaluation of the RPE. Body posture was defined by eighteen reflective markers placed on the skin of the cyclists. The acquisition frequency of the markers was 50Hz.

RESULTS AND DISCUSSION
The posture was related to the subject anthropometry and to the bicycle component adjustment as shown in Figure 1.

Forces at the handlebar and at the pedal during the revolution of the crank for each of the five position of the lower and the upper limbs were analyzed and correlated. Cycling efficiency was evaluated by an index of efficiency well established in literature.

Amateur cyclists showed more clearly than professional ones a particular posture where the Efficiency Index had a maximum as shown in Figure 2.

SUMMARY
A protocol for the analysis of the influence on pedaling efficiency of the rider posture was developed by means of a special cyclo-ergometer equipped with a dynamometric pedal and handlebar. The use of a simple index of efficiency allow to find an optimized posture. In addition, the analysis of handlebar loads revealed any asymmetry in the action of the cyclists.

REFERENCES
M.Bertoldini (2002), Padova University Degree Thesis