# EXPERIMENTAL DEVICE FOR THE ANALYSIS OF THE CYCLER'S MOVEMENT

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## INTRODUCTION

Overuse knee joint injuries are the primary injuries to cyclists (Ruby, 1992) so that's the shoelpedal interface received special attention in the bicycle component design industry. Still today, there are numerous shoe/ pedal interface systems with various adjustable degrees of float. The aim of this study is the perspective of quantitative evaluation of the shoelpedal interface with performance and injury prevention aspects. In particular, this article presents the instrumentation of the cycle to characterize the differences between the clipless fixed and the clipless float pedals in its kinematic and dynamic aspects. This paper described the experimental setup to create experimental devices. Moreover, one male subject's first results are presented to characterize differences between clipless fixed and clipless float pedals.

## METHOD

Experimental data were collected from the right and the left leg of one male subject. Data were collected on the Look pedal in combination with "black" (represented clipless fixed condition) or "red" (represented clipless float condition) cleat secured to the bottom of the subject's cycling shoes (Figure 1). Prior to data collection, subjects cycled at least 15 min at a preferred cadence (85 CPM) and at a power of about 120 W to familiarize themselves with each pedal's design. Experimental data were collected during seated cycling at 90 rpm (preferred cadence) and 200 w (imposed) at a sampling rate of 50 Hz for 30 s. During these experiments the kinematic of the lower limb and the stress imposed by the shoes on the pedals were recorded. The acquisition of these two types of signals were synchronized to a frequency of 50 Hz.

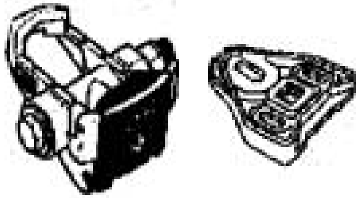


Figure 1.
LOOK pedal with cleat secured

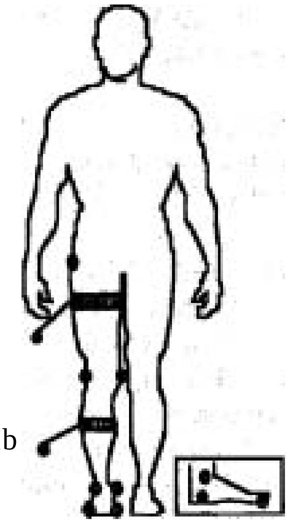

Figure 2.
Reflective markers on the lower limb

**THE INSTRUMENTATION ADOPTED**

A bicycle used in cycling sport competition and a home trainer constituted the experimental devices. The bicycle is fixed by its front fork and this device allows to simulate the seated position of a cyclist on the road. Subject had reflective markers attached on anatomical landmarks (Figure 2). The SAGA3 system equiped with four 50Hz cameras allowed the acquisition of kinematic variables. Simultaneously, force plate data were recorded, with the same frequency.

The SAGA3 system (Cloup, 1989) allows the acquisition of kinematic variables. This system was equipped with four CCD 50 Hz cameras. The subject was equipped with markers : prominence of the greater trochanter external surface, most medial ridge of the medial tibial plateau, most lateral ridge of the lateral tibial plateau, medial and lateral malleolus (Cappozzo & Benedetti, 1991).

Cameras were placed according to the frontal and sagittal plane. The two cameras placed in the frontal plane allow the identification of known positions of markers on the lateral and medial femoral epicondyle and the lateral and medial malleolus. These two cameras contributed to increase the accuracy of the determination of articulate centers (Figure 4). The accuracy for this study was of 1.9% for distances and 1.8° for angles.

In addition, a goniometer was used to determine the position of the crank arm at each moment (Figure 5). The theoretical imprecision was less than 1°.

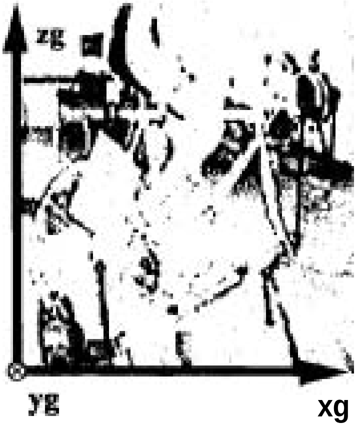



Figure 5. The goniometer

**Figure 3.**
The saggital plan

**Figure 4.**
The frontal plan

LOGABEX mini platform was used to acquire the stress that the foot exerted on the pedal. The bicycle was equipped with two force plates whose dimensions were 114 mm diameter, 45 mm total height and 0.335 kg mass. Its measurement range was 200 daN for Fz, 50 daN for Fx and Fy, 6 daN.m for Mz and 5 daN.m for Mx and My. The theoretical imprecision was less, than 1% of the measurement range for the different components.

To locate this force plate in the global reference system a device was conceived and fixed under the pedal (Fig 7). In fact, to compute the effective transmission of force from the shoe to the pedal, it was necessary to locate the force plate in the global reference system. So, a processing associated with the force plates was required.

## THE PROCESSING ASSOCIATED WITH EXPERIMENTAL DEVICE

On the one hand, a processing associated with the force plate was developed. The force plate under the pedal was mobile and moved with the cycler's movement, Processing was based on the principle of the calculation of a passage matrix used to locate this force plate on the global reference sytem (Nikravesh, 1988).

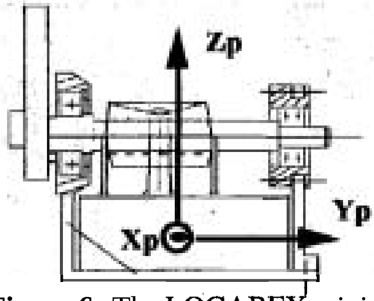


**Figure 6.** The LOGABEX mini platforms under the pedal

**Figure 7.** The mini force plate

Two stages were required (Pudlo, 1996). The first stage changed the coordinates for the force plate referential to those for the device to locate the force plate. The resultant matrix was constant. Deduced from the construction, the referential was called the intermediate referential. The second stage transformed the intermediate referential into the global referential. The resultant matrix was calculated for each acquisition.

So, data measured by the mobile force plate could be expressed in the global reference system and permitted the computation of effective transmission from the shoe to the pedal (Figure 8).

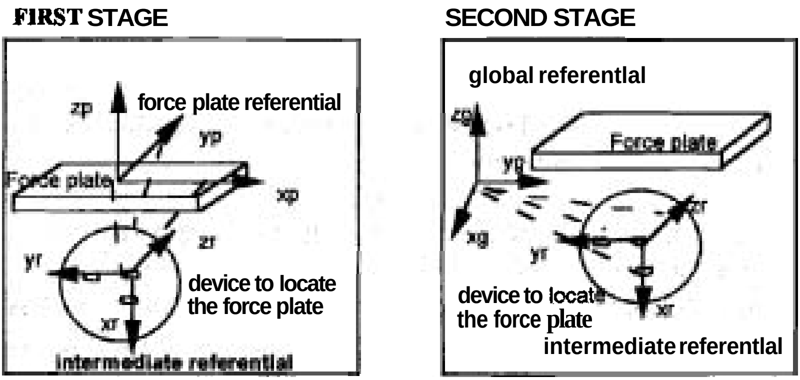


**Figure 7.** The processing associated with the forces plates

On the other hand, force and moment patterns and link segment kinematic patterns were normalized to one complete revolution. Data were averaged over 40 complete revolutions. A processing based on interpolation splines were used to cut up and normalize data to one complete revolution.

In addition, prior to link segment kinematic analyses, the **3D** coordinates were smoothed using quintic splines and force plate data were digitally filtered using a 2nd order, zero lag low-pass Butterworth filter with a cut-off at 15 Hz.

## FIRST RESULTS

The experimental device was tested with one male subject (22 years old, 179 cm, 62 kg). From a qualitative point of view, it is often said that in cycling the lateral movement of the clipless float pedals reduces the effective transmission of force from the shoe to the pedal. This torque was a function of the crank angle, of the forces Fx, and Fz as stated in the Rg (xg,yg,zg) global referential.

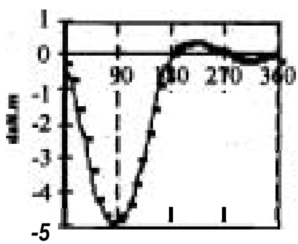

**Figure 8.** The effective transmission from the shoe to the pedal

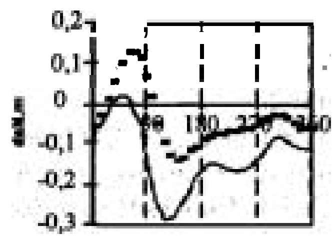

**Figure 9.** The applied moment Mz from the shoe to the pedal

The two curves were quite similar (Figure 8), which meant that, for this subject, there was no effective loss of mechanical torque transmission from the shoe to the pedal when the floating pedal systems were used. This fact emphasized Wheller 1995's results. Moreover, the applied moment patterns Mz from the shoe to the pedal changed with the pedal design system. In fact, the applied - Mz moment, corresponded to the rotation of the heel inward, was weaker when clipless float pedals were used. This result was the axial moment realized at the knee (Wheeler, 1995) and has been computed in (Maronneaud, 1997).

## CONCLUSION

This article describes the experimental setup to create the experimental device. The adopted instrumentation was an opto-electronic **SAGA3** system and two force platforms. This experimental device permitted acquisition of kinematic data and pedal loads. Overmore, this paper has defined processing associated with the force plates (to determinate as a first result the effective transmission from the shoe to the pedal) and processing associated with data collection (to cut and normalize to one complete revolution). The experimental device was tested with one male subject. With this subject, clipless float pedals reduce the applied moment - Mz at the pedal without compromising power transmitted to the bike.

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