ROTOR, GENERATOR OF HEALTH

ANALYSIS OF THE EFFECTS OF THE ROTOR PROPULSION SYSTEM UPON THE KNEE JOINT

STUDY CONDUCTED BY:

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Field experience with Normal Bicycle (NB) versus Rotor Bicycle (RB).

This document presents the rationale and preliminary results of a research study of the Rotor propulsion system.

1.1 Introduction

The knee is a joint possessing two degrees of freedom: flexion-extension in the sagittal plane and slight rotation in the transverse plane. It constitutes a high-instability joint compensated by a potent capsule-ligament apparatus and meniscal system.

However, these structures, i.e., capsule, ligaments and menisci, behave differently according to the degree of knee flexion during pedaling, which extends from 150°-155° to 70°-80°, thereby affording a total movement range of approximately 80°-90°.

The maximum knee flexion phase coincides with the upper movement arc which extends from the 11 o-clock to the 2 o-clock position, referred to as the Upper Neutral Point (UNP). According to different authors, in this phase (i.e., UNP) the body is only able to exert 6% of the total pedaling strength, involving a horizontal forward-guided force. In the UNP, the stability system of the knee is ensured by the stabilizing forces of the flexion-extension muscle pairs (ischiotibial: semimembranous, semitendinous and biceps of the thigh against the quadriceps femoris and gastrocnemius muscles), which in turn must also stabilize the minimum transverse torsion component.

At this point, and based on the normal order of appearance and the increasing severity of knee integrity, the following may occur:

1.- Muscle tension disadjustment due to differences in Tension / Length of the muscle pair.

2.- Stimulation of the joint mechanoreceptors which modify the work onset of the muscles.

3.- Stimulation of the pain receptors, with the appearance of pain and subsequent modification of muscle force.

4.- Dragging action of the intraarticular support point, with over-extension of the anterior cruciate ligament.

5.- Modification of the position of transverse joint torsion, with over-extension of the ligaments, particularly the internal lateral ligament and modification of the Lateral Control Active Chains (External LCAC: gluteus maximus, tensor muscle of the fascia lata; Internal LCAC: sartorius, internal rectus and semitendinous muscle).

This situation always arises in the UNP phase in the cyclist at the start of the season, or when the gear is not adjusted to the ground over which the cyclist is pedaling.

It should be mentioned that in the sports life of a cyclist these problems are repetitive and thus adversely affect the knee joint – often leading to the abandonment of cycling as a consequence of chronic knee pathology.

All this occurs in the context of a propulsion system afforded by a normal bicycle (NB), where both the so-called Upper Neutral Point (UNP) and Lower Neutral Point (LNP) exist – the latter involving similar conditions, though with a lesser incidence at knee level.

Our starting hypotheses have been tested in the present study based on a subjective experiment where a Rotor system bicycle (RB) has been used. In this Rotor propulsion system, decentering of the connecting rod aims to avoid neutral points such as UNP or LNP, thereby mitigating the effect of the associated pathologies and allowing improved knee health. The idea is to accelerate one connecting rod with respect to the other in certain phases of the pedaling cycle – upper and inferior part – in an attempt to avoid the neutral points generated by the traditional pedaling system.

1.2 Material and method

A study has been made comparing the behavior of the knee joint with two different propulsion systems: the Rotor propulsion system (RB) and the traditional or normal propulsion system (NB). The study was conducted in 11 cyclists, of which 6 pertained to the sub-23 category, three belonged to the juvenile category and two were cyclo-tourists. All had a minimum of two years of experience in competition, with 6.5 years of practice on average, and cycling a mean of 15,000 km a year. All were males, with an average age of 19.5 years, an average body weight of 64.8 kg, and an average height of 176.3 cm.

To the effects of the present study, we used a bicycle with the Rotor system, a pulsimeter (Polar, Model Xtrainer plus) for the recording of heart rate, speed and pedaling rhythm, and the corresponding software needed for data analysis and presentation. Metric tape was used for the subject and bicycle measurements. The corresponding questionnaire was developed by the Unit of Research in Physiotherapy of the University of Zaragoza (*UIFUZ*)(Spain). The questionnaire comprised subjective closed questions referring to muscle and joint sensations. The joint sensations were categorized as follows: pressure, friction, diffuse sensations and pain. The muscle sensations in turn comprised: tension, pain and fatigue. The results were assessed on a visual analog scale (VAS) with the following scores: 0 – None, 5 – Moderate, 10 – Extreme.

Open questions could also be considered. Each of the items was rated according to the above mentioned scale, moreover indicating on a drawing the pedaling position at which the sensations occurred.

1.2.1 Protocol

1.-) Prior to the tests and under laboratory conditions, measurements were obtained of the cyclist and of his bicycle used as NB control. Weight, height, distance from the seat to the center of the pedaling axis, vertical distance from the tip of the seat to the pedaling axis, and distance from the tip of the seat to the handlebar were measured. The measurements of the bicycle of the subject were then transferred to the Rotor bicycle. The connecting rods were also changed, fitting rods of similar length to those used on the NB. After completing adaptation of the Rotor bicycle (RB) to the morphology of the subject, the contents of the questionnaire were briefly explained.

2.-) Each study subjects underwent a series of four tests, involving four ascents measuring 500 m in length, with an average gradient of 6.0%, and including 50 m at the start and 50 m at the end of the distance which were practically level. The first and third ascents were made with the Rotor system RB, while the second and fourth were completed with the NB, for a total of four tests. In the first two ascents, 1st RB and 1st NB, the cyclist was allowed to pedal up the slope either seated or in the standing position on the bicycle. In the case of the 2nd RB and 2nd NB, only the sitting position was allowed. After each ascent, the cyclist answered the global series of questions, in the same order and with the same contents.

3.-) The following phase consisted of the field application. The cyclist first approached the ascending slope, performing a brief warm-up. At the start of the ascent the gear with which all the tests were to be carried out was selected. Once the cyclist selected the gear, he was not allowed to change gears during the rest of the ascents. Each ascent started from the stopping position, and the cyclist was instructed to complete each ascent with maximum intensity. The process was monitored by the pulsimeter. The data recorded by the latter, and the results of the questionnaire corresponding to each ascent were subsequently transferred to a personal computer for statistical processing.

1.3 Results

The three most significant study variables recorded are presented – the rest being postponed for a later analysis. These variables addressed the following aspects: 1.- Pedaling pattern, adaptation and ease; 2.- Strength sensation with NB versus RB; and 3.- Pressure in the knee. A brief account of the most significant conclusions is provided below.

1.3.1 Pedaling pattern, adaptation and ease

The pedaling pattern is understood to be the subjective sensation of pedaling mode.

Adaptation is defined as the perceived differences in sensation between RB and NB.

Pedaling ease can be defined as the sensations of difficulty and fluidness in the comparative pedaling phase during the test.

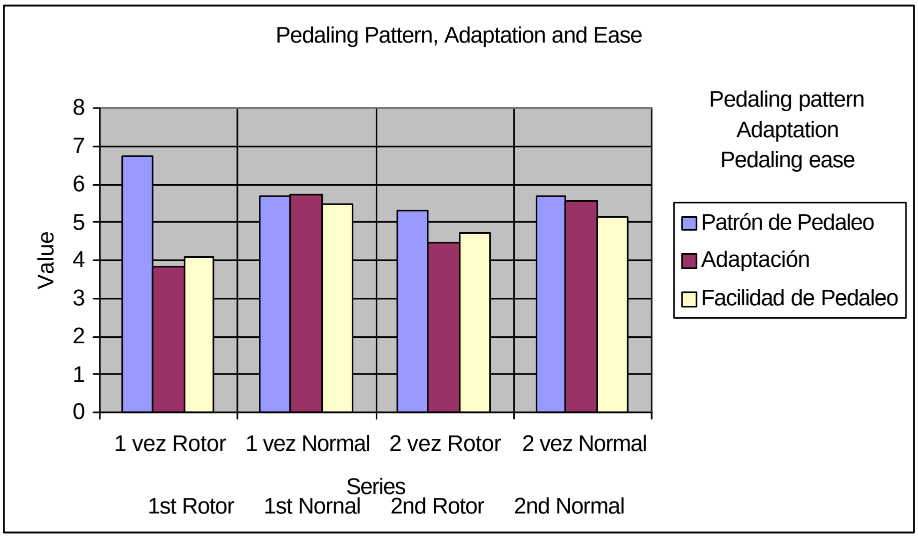
The first time the cyclists ascended the slope with the RB, they referred a considerable change in pedaling (6.8). Values: 0- None, 5- Moderate, 10-Extreme. The questionnaire was implementation based on the Visual Analog Scale (VAS).

On subsequently ascending on their own bicycle (NB), the subjects again referred a moderate change in pedaling – possibly because the RB pedaling sensation persists even long after having finished pedaling with this bicycle.

On ascending with the RB a second time, the perceived change in pedaling was less pronounced; indeed, this was the test in which the fewest differences in pedaling were reported. Curiously, the next pedaling test with the NB was described as the test in which the sensation of pedaling change was greatest. This could be corroborated to the fact that the pedaling pattern of the Rotor is more natural, with increased persistence of its associated sensations.

Adaptation to the RB was initially considered normal, and was logically better with the NB during the next test. On starting the second test with the RB, adaptation to the latter improved, though it logically remained below that referred for the NB in the fourth test. These values indicate that adaptation to the RB is similar to adaptation to the NB, and that no prior brief training period is required.

In the case of pedaling ease, the observations were similar to the pedaling adaptation findings. The recorded pedaling sensation proved normal, though comparatively better with the NB. However, in the following two tests the cyclists referred fewer differences between the two forms of pedaling.



Conclusions

- The RB pedaling pattern can seem more "Powerful / Dominant / Persistent" than the NB pattern (i.e., it offers increased perceptive adhesion). This implies that from the neurophysiological perspective, the Rotor system offers a more physiological profile in neuromotor terms.
- Although a first appraisal reflects a substantial change in pedaling pattern, adaptation to the RB is considered to be similar to that of the NB, in that apparently no prior technical adjustment was required before conducting the study.
- Pedaling ease with the RB is referred to as normal, and improves on training with this bicycle. This may be due to the more physiological position of the knee, thus ensuring improved adjustment.

1.3.2 Strength sensation NB versus Rotor

Subjective strength sensation is understood to be the amount of strength the cyclists feel they exert during the different pedaling movement ranges.

As can be seen in the figures, in relation to strength sensation with the first Rotor test and with the first NB test, a larger proportion of subjects refer increased strength in the 45-90º range, though more so with the Rotor (8.0). In the 0-45º range, increased strength is referred with the RB than with the classical bicycle (5.0), though the figure is comparatively less in the range of 90-135º. This indicates that a larger proportion of individuals refer increased strength with the Rotor system in the pedaling cycle range which all studies consider to involve greatest performance. However, in the 0-45º range with the RB, greater strength is exerted with the opposite leg which descends (range 135-180º and similar for both bicycles); maximum performance thus corresponds to the range 45-90º.

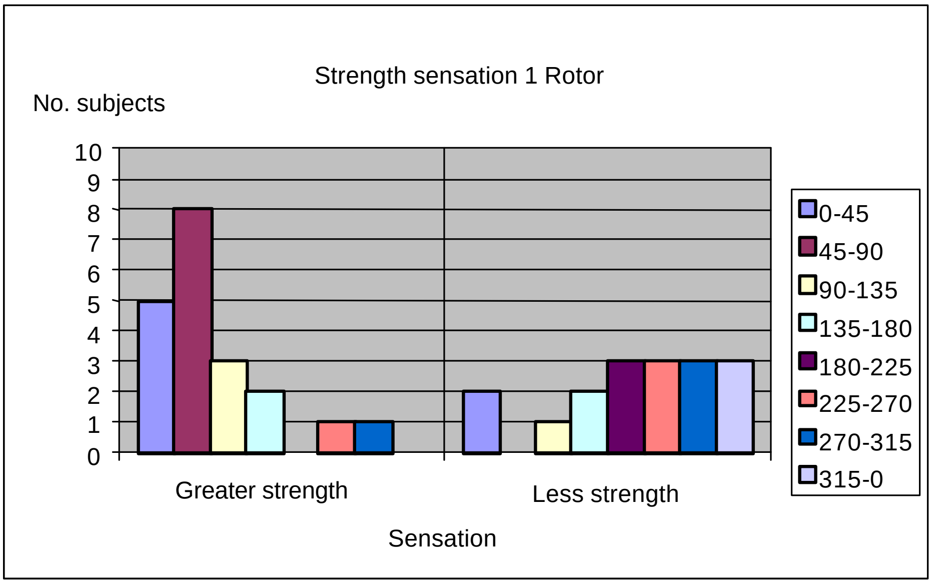
With both bicycles, increased force is also referred in the range 225-315º, possibly suggesting that the subject maintains rounded pedaling without conditioning to the Rotor system.

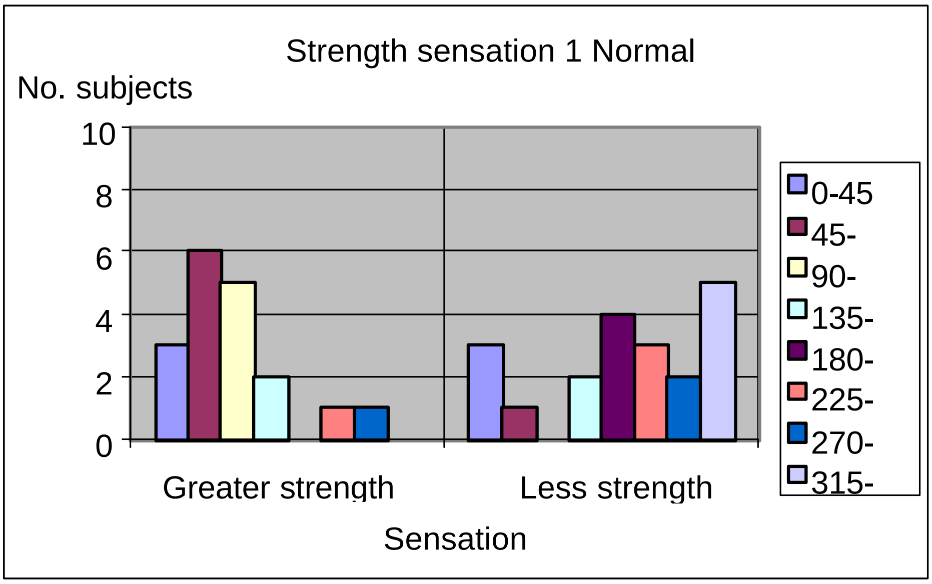
A number of subjects (n = 3) refer less force in the range 0-45º with the NB (3.0). An observation worth mentioning is that with the RB none of the study subjects referred less strength in the range 45-90º. Similar considerations apply to the NB, though in the range 90-135º. Beyond 180º, approximately the same number of subjects refer less strength up to 0º with both types of bicycle.

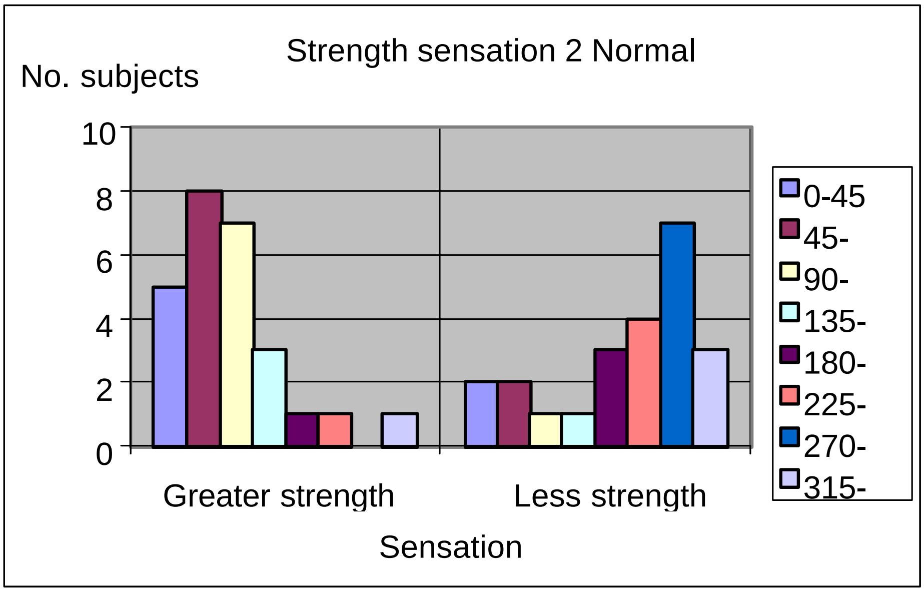
As can be seen in the figures corresponding to the strength sensations in the second Rotor and NB tests, the maximum force range referred for the RB is 45-90º (10.0), corresponding to the maximum strength which the subjects feel they are able to produce. The same applies to the NR, though the corresponding strength magnitude is a little less in this case (8.0). The second maximum-strength range is 90-135º for both bicycles, though the referred magnitude is greater for the NB in this case. This range again indicates that strength is generated in a segment of the pedaling cycle in which mechanical performance is less than in the range 45-90º.

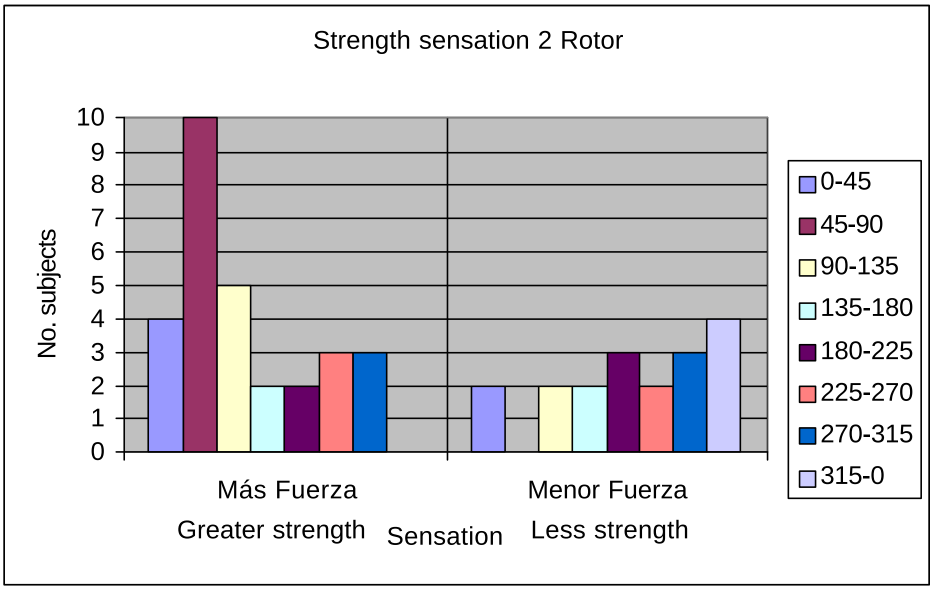
The ranges in which less force is generated with the RB are more uniform, being particularly manifest in the range 315-0º. A point deserving mention is that with the RB in the range 45-90º, none of the subjects referred less strength; indeed almost all referred the generation of increased strength.

With the NB there is a range from 270-315º in which an increased number of subjects refer less strength – a fact that could lead to reduced pedaling uniformity.


Strength sensation 1 Rotor
No. subjects
10
9
8
7
6
5
4
3
2
1
0
Greater strength
Less strength
Sensation
0-45
45-90
90-135
135-180
180-225
225-270
270-315
315-0


Strength sensation 1 Normal
No. subjects
10
8
6
4
2
0
Greater strength
Less strength
Sensation
0-45
45-
90-
135-
180-
225-
270-
315-





Conclusions

- All these observations suggest that the RB allows increased muscle work in the range of the joint and mechanical work at connecting rod level – a situation which probably benefits the knee by affording comparatively greater preservation of the joint physiology.
- The same situation applies to an even greater degree in the range 0-45° when using the RB, preserved by the other connecting rood which reflects elimination of the UNP.

1.3.3 Patellar pressure

Patellar pressure is defined as the pressure sensation in the patella during the different pedaling phases with the NB and Rotor system.

The pressure sensation upon the patella is very slight, since the study subjects were all asymptomatic individuals. The differences were therefore minimal, though important.

As can be seen in the figures corresponding to patellar pressure in the first tests with the RB and NB, the pressure sensation was described as practically uniform in the case of the Rotor bicycle, coinciding with the pedaling cycle ranges in which most subjects referred increased strength (0-135º) – the magnitude being greatest for 45-90º, and particularly in the inferior region of the patella, followed by the upper and lateral regions of the latter.

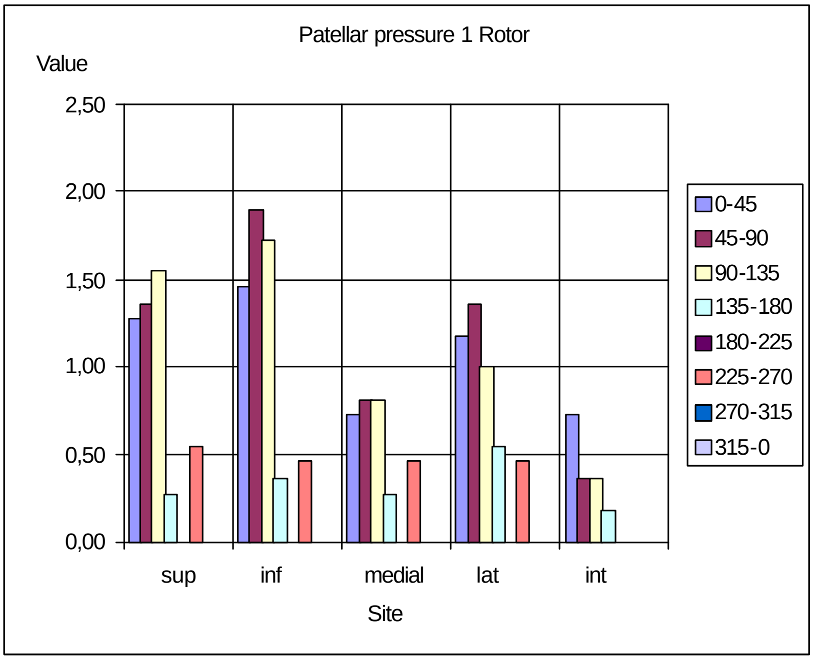
In the case of the NB this uniformity was not maintained throughout the pedaling cycle – the maximum referred pressure corresponding to the range 45-90º, particularly in the inferior region of the patella (a zone of frequent tendon disorders in cyclists), with a value greater than in the case of the RB.

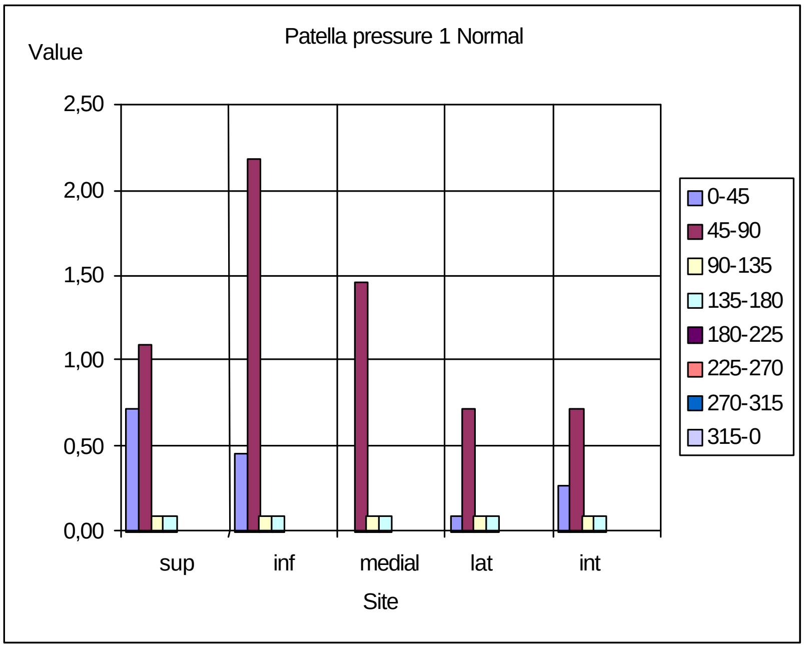
This situation could reflect a uniformity of sensations in the knee during pedaling with the RB, unlike in the case of the NB – the latter generating pressure peaks during the pedaling cycle. This situation possibly reflects improved joint mechanics during pedaling with the Rotor system.

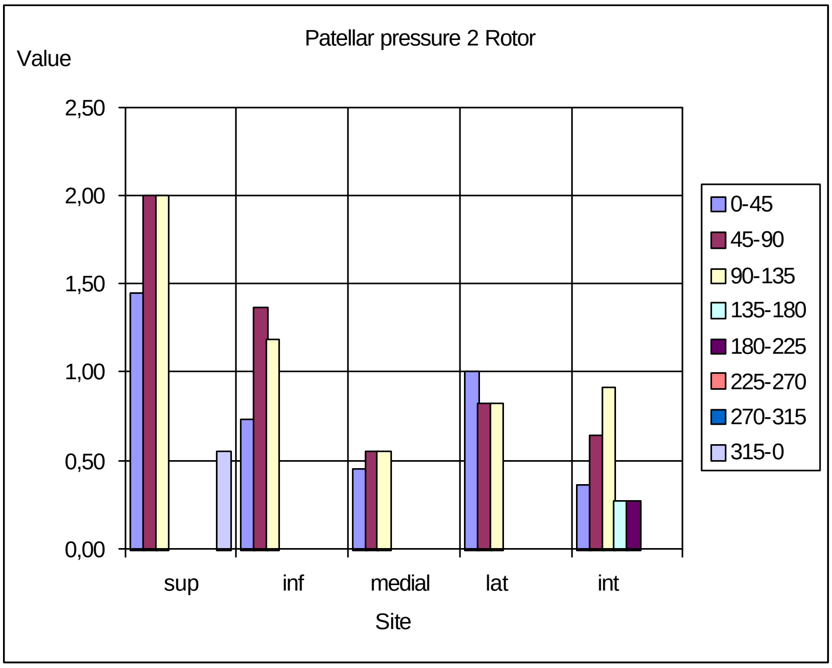
As can be seen in the figures corresponding to patellar pressure in the second tests with the RB and NB, in the sitting ascent series, the pressure sensation in the patella continues to be described as uniform in the pedaling range where most subjects feel to be generating most strength (i.e., 0-135º) – though in this case the pressure sensation centered on the upper region of the patella. This may correspond to an increase in muscle strength – in this case the pressure sensation being less in the inferior patellar region during sitting and standing pedaling. With the NB the pressure sensations were again described as non-uniform, with the generation of pressure peaks, particularly in the inferior region of the patella (as in the previous test).

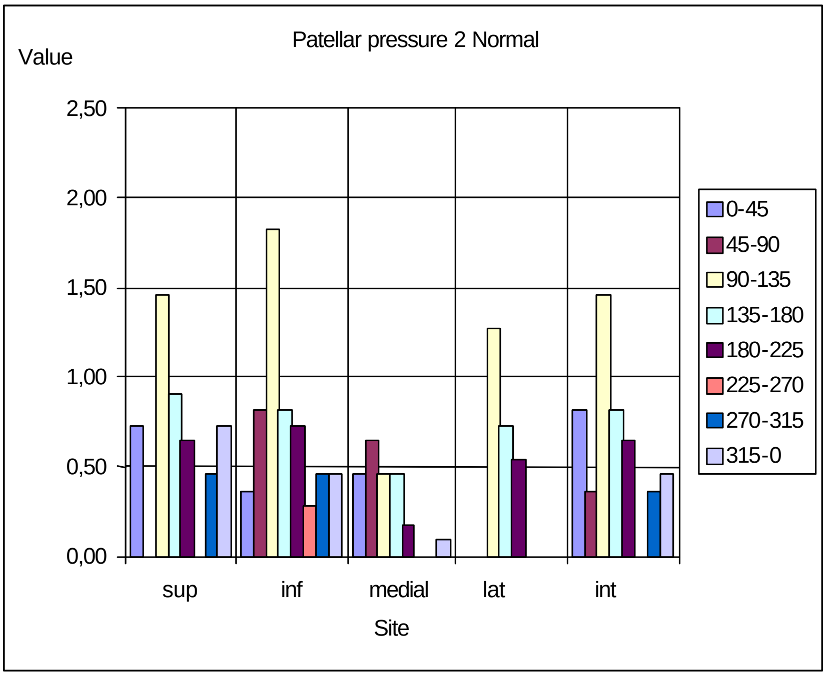
Conclusions

- The pressure sensation in the patella is clearly less pronounced with the RB, and the sensation of comfort is greater – even though the recorded values are within the normal range for the sample. It is thus considered that greater muscle strength can be generated with the Rotor bicycle in relation to knee discomfort.


Patellar pressure 1 Rotor
Value
2,50
2,00
1,50
1,00
0,50
0,00
sup
inf
medial
lat
int
Site
0-45
45-90
90-135
135-180
180-225
225-270
270-315
315-0


Patella pressure 1 Normal
Value
2,50
2,00
1,50
1,00
0,50
0,00
sup
inf
medial
lat
int
Site
0-45
45-90
90-135
135-180
180-225
225-270
270-315
315-0


Patellar pressure 2 Rotor
Value
2,50
2,00
1,50
1,00
0,50
0,00
sup
inf
medial
lat
int
Site
0-45
45-90
90-135
135-180
180-225
225-270
270-315
315-0


Patellar pressure 2 Normal
Value
2,50
2,00
1,50
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sup
inf
medial
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Site
0-45
45-90
90-135
135-180
180-225
225-270
270-315
315-0

1.3 Final conclusions

In synthesis, the following conclusions can be drawn:

- The RB system presents a pedaling pattern different to that observed with the NB. Rotor system pedaling appears to be more physiological, with rapid adaptation of neuromuscular function and easier pedaling performance.
- The referred strength sensation with the RB exceeds that of the NB. It may be concluded that greater strength can be generated with the RB, with preservation of knee integrity – the latter being the limiting factor in the use of long gear options.
- The patellar pressure sensation referred by the subjects when pedaling under great demand suggests that the RB affords more physiological knee activity, as reflected by the greater comfort reported despite the increased force applied with the Rotor system.

This last conclusion is in line with the results of biomechanical studies which consider the patella and its associated pressure sensations to be a determining factor in the performance of the knee.

The above considerations indicate that the Rotor propulsion system effectively preserves knee health.