# ANALYSIS OF THE RECOVERING PHASE AFTER THE CYCLING PRACTICE USING AUGMENTED VISUAL FEEDBACK

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The objective of this study was to use a system of augmented visual feedback to improve the pedaling technique in the recovery phase. Nineteen people from 14 to 16 years old with no experience in cycling divided in experimental (n=10) and control (n=9) group took part in this study. Two first evaluations were done to determine the maximal oxygen uptake and work load. Right after the second evaluation seven section pedaling practice was done and after the last one, a post test was conducted. After a week a retention test was done. The results showed that both groups increased their performance, but the experimental group showed better results in the retention moment and could be considered as a more appropriate tool for the teaching of cycling.

**KEY WORDS:** biomechanics, pedal forces, index of effectiveness, motor learning.

## INTRODUCTION:

The pedaling cycle is divided in two phases: (1) propulsion phase, from 0º to 180º and (2) recovery phase, from 180º to 360º. The recovery phase is considered as a critical sector of pedaling, because it's in this phase that the retarding forces show up to difficult the bicycle propulsion because there is torque to the opposite sense of the movement (Álvarez & Vinyolas, 1996). The pedaling technique depends on the good direction of the forces applied to the pedal in the propulsion phase as far as in the recovery phase. The forces applied to the pedal are measured in the terms of their components. These components are termed shear force component (Fx), that has its direction in the antero-posterior axis, and acts to the surface of the pedal and normal force component (Fy) that has its direction in the longitudinal axis, acting perpendicularly to the surface of the pedal (Gruben, Rogers & Schmidt, 2003; Sanderson & Black, 2003). The suitable direction of these two components of force along the pedaling cycle represents the efficient pedaling technique (Lafortune & Cavanagh, 1983). To improve the pedaling technique, studies related to the cycling teaching have been using the augmented visual feedback that consists of given information to the learner in order to improve their pedaling technique (Sanderson & Cavanagh, 1990; Broker, Gregor & Schmidt, 1993).The objective of this study was to use a system of augmented visual feedback to improve the direction of the force components applied to the pedal in the recovery phase and with this improve the pedaling technique.

## METHODS:

Nineteen people male from fourteen to sixteen took part in this study. They were divided in experimental (n=10) and control (n=9) group. The participants gave written informed consent. This study was approved by the commission of research from the Physical Education School of Federal University of Rio Grande do Sul – UFRGS. Three stages were realized: (1) pre-experiment period, to determine the maximal oxygen uptake ($VO_{2máx}$) and the work load corresponding to 60% of the $VO_{2máx}$; (2) Section of practice that consisted of seven days of practicing the pedaling technique for 30 minutes, cadence of 60rpm and load to 60% of $VO_{2máx}$; and (3) period of post-experiment that consisted of two tests, one right after the last practice session (post-test) and another interval of a week (retention). During the practice sessions the experimental group received augmented visual feedback (AVF) that consisted of verbal information to correct the pedaling technique with the graphic presentation of the effective force (EF) applied to the pedal overlapped to the curve of effective force reference produced by an athlete of elite category from the Gaúcha Federation of Cycling. The control group received augmented feedback (AF) that consisted of the same verbal information, but without the visualization of the effective force reference. From the first to the fifth day of practice sessions of the groups they received a minute of feedback to each minute of pedaling. From the sixth to the seventh day, they received a minute of feedback to each two minutes of pedaling (reduction of 73% in the time of feedback). In the final practice sessions, the individuals of both groups received a total of 95 minutes of feedbacks. The feedbacks were presented to the individuals, in the end of each acquisition of the dynamometry and eletrogoniometry signs, that is, in the interval between the pedaling series. In the post-experiment period, no group received feedback. The register of the dynamometry and eletrogoniometry signs was done in the three stages of the study and for its analysis an average of ten cycles of pedaling was used. From the decomposition of the normal and shear forces in relation to the crank it was possible to calculate the effective force (equation 1) that consists of the sum of the components of the normal (Fy) and shear (Fx) force perpendicular to the crank, using the angle of the pedal related to the crank (Broker & Gregor, 1990).

$$EF = Fy^{\perp} + Fx^{\perp} \quad \textbf{(1)}$$

After knowing the values of the EF it was possible to obtain the negative and positive values along the cycle. For this, all the negative and positive intervals of the EF curve were cut and integrated. Afterwards all the integrated negative and positive values were summed and then the total values of positive and negative EF were obtained. The resulting force (RF) applied to the pedal was calculated from the decomposition of the normal Fy and shear forces (equation 2). The instrumented used in this study doesn't allow the measurement of the component of side-medium force, so, this resulting force applied to the pedal represents the total force in the sagittal plan.

$$RF = \sqrt{Fy^2 + Fx^2} \quad \textbf{(2)}$$

Later the impulses of effective force (IEF) and resulting force (IRF) (equations 3 and 4 respectively) were calculated (Lafortune & Cavanagh, 1983).

$$IFE = \int_0^x dtFE \quad \textbf{(3)} \qquad\qquad IFR = \int_0^x dtFR \quad \textbf{(4)}$$

The padaling technique of the individual along the cycle was analyzed through the index of effectiveness (IE). This consists of the reason between the IEF and the IRF (equation 5). The IE indicates how much the RF was directioned as EF, that is, used for the bicycle propulsion (Lafortune & Cavanagh, 1983; Sanderson & Cavanagh, 1990).

$$IE = \int_0^x dtFE \Big/ \int_0^x dtFR \quad \textbf{(5)}$$

After this procedure the IE in the recovery phase (180º to 360º) was calculated. For the comparison intra-groups it was used the analysis of the variance to repeated measures and a test post-hoc of Bonferroni to check the differences between the moments. For the comparison inter-groups it was applied a test T of Student for the independent data. A software SPSS (version 12.0) was used and it was adopted $p \leq 0,05$ as significant level.

**RESULTS:**

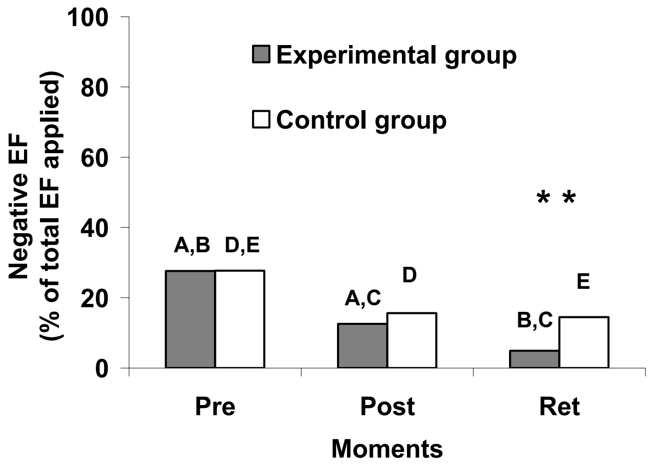
On table 1 are presented the resultas of the index of effectiveness in the recovery phase of the two sample groups.

**Table 1: Comparison of the average IE (%) in the recovery phase of the experimental (Exp) and control (Con) group on the three evaluated moments.**

| | Pre | Pos | Retention |
|---|---|---|---|
| **Exp** | -52±5* | -15±31*,+ | 13±27*,+ |
| **Con** | -53±4* | -26±20* | -32± 15* |

* indicates significant ≠ between the pre and post, and pre and retention moments.
\+ indicates significant ≠ between post and retention moments.

In the intra-group comparison the experimental group which received AVF presented significant increase in the average of IE in the recovery phase from the pre to the post moment, from the pre to the retention moment and from the post to the retention moment. The control group presented significant increases between the pre and post and pre and retention moments. In the inter-groups comparison there was no difference noticed in the pre and post moments, only in the retention moment.
Picture 5 shows the average the values of the negative EF along the pedaling cycle of both groups.




Picture 5 – Comparison of the average of negative EF of the experimental and control groups in the three evaluated moments. Equal letters indicates intra-group significant difference. ** indicates inter-group significant difference.

In the intra-groups comparison, the experimental group presented significant reduction in the average application of negative EF in the pre and post moments, pre and retention moments as well as post and retention moments. The control group presented significant reduction only between the pre and post moments, and pre and retention moments. In the inter-groups comparison it was noticed the significant difference in the average of application of negative EF only in the retention moment.

**DISCUSSION:**

The motor learning is characterized from the stable levels in the performing of determined task (Singer, 1975). This way, from the results obtained, it's possible to state that both groups learned the pedaling technique in the recovery phase. The reduction of the frequency of providing feedback seems to be responsible for the increasing in the average of the IE in the recovery phase and by the reduction of the negative EF along the cycle in both groups. Since the frequency of feedback is reduced, the individuals start to use the intrinsic feedback and this allows the detection and correction of errors resulting in less dependence of knowledge results (Tani et. al, 2004). The experimental group which received AVF presented a pedaling technique in the recovery phase even more consistent than the control group. This statement is justified by the fact that this group increased significantly its average of IE in the recovery phase and decreased significantly its average of negative EF along the cycle in the retention moment. This fact may be due to a better direction of the force components applied to the pedal specially in the recovery phase because according Lafortune & Cavanagh (1983) a better direction of the force components applied to the pedal results in a more efficient pedaling technique. The improvement in the application of force to the pedal may be related to the quality of information contained in the AVF. This allows the atribution of a relevant meaning to the visual information transmited, possibiliting their storing in the long-term memory (Klatzky, 1980) accomplishment of the task (Magill, 2000; Godinho, 2000). The control group although it has significantly increased the average of IE in the recovery phase and significantly decreased the average of application of negative IE after the practice sessions, didn't manage to keep the same performance in the retention moment. This fact may be related to the absence of visual information what made it difficult the atribution of a relevant meaning to the permanent storing of information (Klatzky, 1980).

**CONCLUSION:**

The results of this study showed that the AVF and the AF are appropriate tools to improve the performance of the pedaling technique in the recovery phase. However the AVF besides improving the directioning of the force components applied to the pedal, it was also efficient in the process of allowing that the experimental group, that used the AVF, increased even more the performing of the task in the retention moment, what makes this system an important resource to the cycling development.

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