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The use of augmented visual feedback on the learning of the recovering phase of pedaling

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The use of augmented visual feedback on the learning of the recovering phase of pedaling

Abstract: The objective of this study was to investigate if the use of augmented visual feedback would improve the learning of 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) groups took part in this study. Initially, two evaluations were performed to determine the maximal oxygen uptake and work load. Right after the second evaluation seven pedaling practice sections were performed and after the last one a post test was conducted. After a week a retention test was performed. The results showed that both groups increased their performance, but the experimental group showed better results in the retention test. It was concluded that the augmented visual feedback could be considered a more appropriate tool for teaching of cycling.

Key Words: Cycling, recovery phase, augmented visual feedback, motor learning, biomechanics.

Introdução

A Pedaling a bicycle seems to be easy to learn since most of the children end up riding a bike. However, learning the right technique is not as trivial as it seems to be. The pedaling technique depends on the good direction of the forces applied to the pedal in the propulsion phase as much as in the recovery phase (Figure 1) (Henke, 1998; Holderbaum et al., 2005; Holderbaum et al., 2006a; Holderbaum et al., 2006b; Holderbaum et al., 2006c).

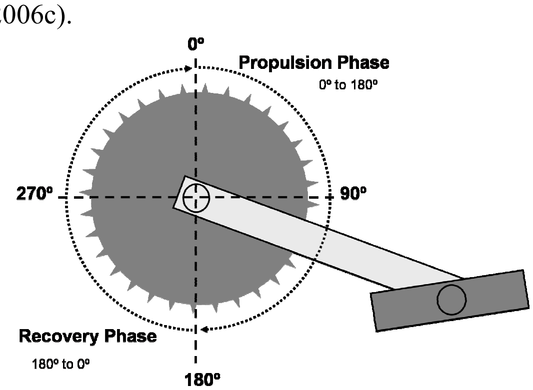

FIGURE 1: Pedaling cycle (from 0º to 360º) divided in two phases. Propulsion phase (from 0º to 180º) and recovery phase (from 180º to 0º) along the pedaling cycle.

The forces applied to the pedal are measured in terms of their components. These components are termed shear force component (Fx), that has its direction in the anterior-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 (Figure 2) (Lafortune & Cavanagh, 1983; Ericson & Nissel, 1988; Neptune & Herzog, 1999; Neptune & Herzog, 2000; Gruben et al., 2003a; Gruben et al., 2003b; Sanderson & Black, 2003).

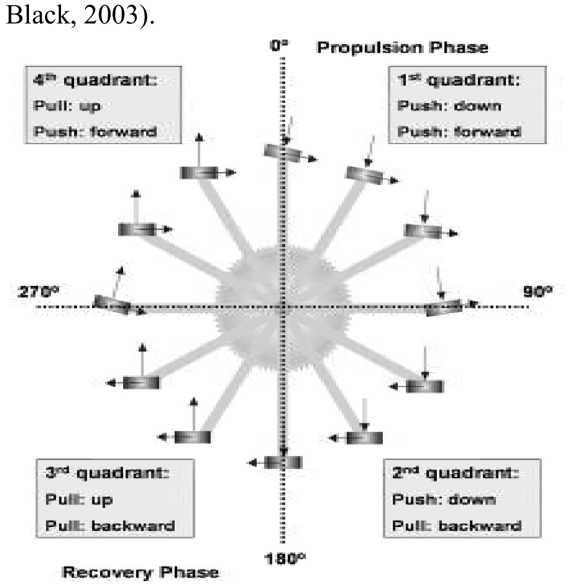

FIGURE 2: Ideal directions of the forces applied to the pedal in the propulsion phase and in the recovery phase along the pedaling cycle.

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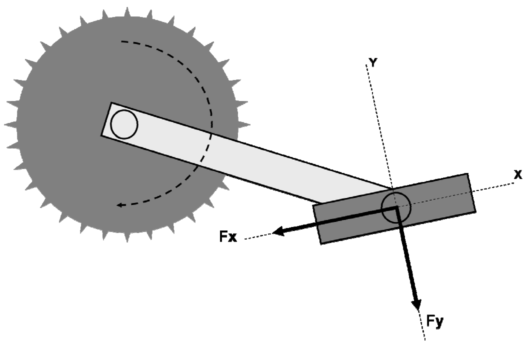

FIGURE 3: Shear force component (Fx) and normal force component (Fy) applied to the surface pedal.

The suitable direction of these two components of force along the pedaling cycle represents the efficient pedaling technique (Lafortune & Cavanagh, 1983; Burke, 1996; Gregor, 2000). To improve the pedaling technique, studies related to the cycling teaching have been using the augmented visual feedback (AVF) that consists of given information to the learner in order to improve their pedaling technique (Sanderson & Cavanagh, 1990; Broker et al., 1993; Henke, 1998). Besides AVF on line, studies still use pedaling cadence between 60 and 80 rpm and fixed work load between 112 and 200w.

Unlike the published studies about teaching of cycling, that used resultant force (RF), shear force (Fx) and index of effectiveness (IE) as reference of the visual augmented feedback (Sanderson & Cavanagh, 1990; Broker et al., 1993; Henke, 1998), this study used the effective force (EF) (Figure 4). This, in turn, is the force that is used in the propulsion of the bike and depends on the magnitude and direction of forces applied to the pedal, so is presented as a key component for the movement of the pedaling technique.

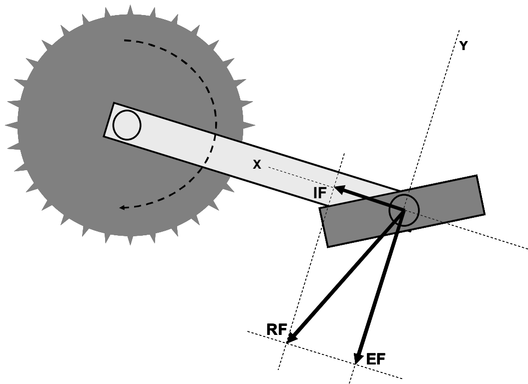

FIGURE 4: Effective force applied perpendicularly to the crank. This force is used in the propulsion of the bike and depends on the magnitude and direction of forces applied to the surface pedal.

The present study, besides using summary feedback (unlike the on line feedback that provides information in real time, the summary feedback consists of information about the task that has just been completed), cadence of 60 rpm (due to the relation between speed and accuracy) still has a physiological normalization of the work load in order to keep all individuals in the same intensity of exercise. Therefore, the purpose of this study was to investigate if the use of augmented visual feedback would improve the learning of the pedaling technique in the recovery phase.

Methods

Participants

Nineteen male from fourteen to sixteen years of age took part in this study. They were divided into experimental (n=10) and control (n=9) groups. The participants signed written informed consent. This study was approved by the Research Commission of the Physical Education School of the Federal University of Rio Grande do Sul – UFRGS.

Procedures

The experiment was divided in three parts: (1) pre-experiment period, to determine the maximal oxygen uptake ($VO_{2máx}$) and the work load corresponding to 60% of the $VO_{2máx}$ in order to establish criteria of physiological normalization of the work load for all the individuals; (2) seven days of practicing the pedaling technique for 30 minutes, cadence of 60rpm and load of 60% of the $VO_{2máx}$; and (3) period of post-experiment that consisted of two tests, one right after the last practice session (post-test) and another after a week (retention test).

During the practice sessions, both groups received verbal augmented feedback (AF), however only the experimental group received augmented visual feedback (AVF) that consisted of a graphic presentation of the curve of effective force (EF) applied to the pedal overlapped to the curve of effective force reference produced by an elite athlete from the Gaúcha Federation of Cycling. These curves were presented to individuals on a computer screen. Thus, it was possible to show to the individual how far or near his technique was from the technique of an elite cyclist.

The period of practice sessions took seven days and it was divided into two phases: phase 1 (1^{st} to 5^{th} day) and phase 2 (6^{th} to 7^{th} day). Each practice session lasted 35 minutes. The first five minutes were without feedback, because they were only for warming up and individual familiarization with the bike. In both phases the pedaling rate was 60rpm.

In the 30 minutes left, both the individuals of the experimental and the control groups received AVF and AF, respectively, in an alternated way, in order of not delaying the learning. Feedback (AVF and AF), in any of the practice sessions, was provided with participants not pedaling.

From the 1^{st} to the 5^{th} day of practice, the experimental and control groups received AVF and AF during one minute, respectively, for each series of one-minute pedaling, so they pedaled one minute and received the corresponding feedback of that minute. With this strategy both groups received a total of 75 minutes of feedback for 75 minutes of pedaling in the first phase of the practice sessions (5 sessions of 15-minutes pedaling and 15 minutes of feedback).

From the 6^{th} to 7^{th} day of the practice sessions, the experimental and control groups received AVF and AF during one minute, respectively, for each 2-minutes series of the practice sessions, so they pedaled for 2 minutes and received the feedback corresponding to those 2 minutes, a total of 20 minutes of feedback to 40 minutes of pedaling in the second phase of the practice sessions (2 sessions of 20 minutes of pedaling and 10 minutes of feedback).

The feedback was presented to the individuals at the end of each acquisition of the dynamometry and eletrogoniometry signs, that is, in the interval between the pedaling series when the individuals were not pedaling, but just receiving the feedback about their pedaling technique. The verbal information given to both groups were related to the direction of the applied forces on the pedal (Figure 2).

By the end of the practice sessions the experimental and control groups received, respectively, 75 minutes of AVF and AF from the 1^{st} to 5^{th} day (phase 1) and 20 minutes from 6^{th} to 7^{th} day (phase 2), totalizing 95 minutes feedback for both groups during seven days of practice sessions. Therefore, feedback reduction from phase 1 to phase 2 was about 73% and was used to avoid dependence on feedback (Sanderson & Cavanagh, 1990).

In the post-experiment period, the groups did not receive feedback. It was also divided into two days of evaluation, with the first one immediately after the last learning session, the post-test, and the second one occurring one week after the post-test, the retention test.

The register of the dynamometry and eletrogoniometry signs were captured 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 (EF) (equation 1) that consists of the sum of the components of the normal (Fy) and shear (Fx) forces 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 instrument used in this study did not allow measurement of the component of side-medium force, so, this resulting force applied to the pedal represents the total force in the sagital 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).

$$IEF = \int_0^x dtEF \quad \textbf{(3)}$$

$$IRF = \int_0^x dtRF \quad \textbf{(4)}$$

The padaling technique of the individual along the cycle was analyzed through the index of effectiveness (IE). This consists of the ratio 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).

$$IE = \int_0^x dtEF / \int_0^x dtRF \quad \textbf{(5)}$$

After this procedure, the IE in the recovery phase (180º to 360º) was calculated.

Statistical Analysis

A descriptive analysis of data was performed calculating the mean and the standard deviation. Once verified normality, homogeinity, and esfericity (Shapiro - Wilk, Levene and Mauchly, respectively), an ANOVA with repeated measures and post-hoc tests of Bonferroni were employed to verify possible differences among the moments. For the comparison inter-groups, it was applied a T Test of Student for the independent data. A software SPSS (version 12.0) was used and it was adopted p ≤ 0,05 as significant level.

Results

Table 1 presents the results of the index of effectiveness (this indicates how much the total force applied to the pedal was used for the bicycle propulsion) in the recovery phase of the two sample groups.

TABLE 1: Average of index of effectiveness (%) 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)* +
Com	-53 (±4)*	-26 (±20)* +	-32 (±27)*

* indicates significant difference between pre and post and pre and retention moments (p≤0.05).
\+ indicates significant difference post and retention moments (p≤0.05).

In the intra-group comparison of the IE, the experimental group 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 increase between the pre- and the post- and pre- and retention moments. In the inter-groups comparison there were no differences noticed in the pre- and post- moments, only in the retention moment. Figure 5 shows the average the values of the negative EF along the pedaling cycle for both groups. The negative EF is considered as retarding forces that show up to difficult the bicycle propulsion in the recovery phase since there is torque to the opposite sense of the movement (Sanderson & Black, 2003).

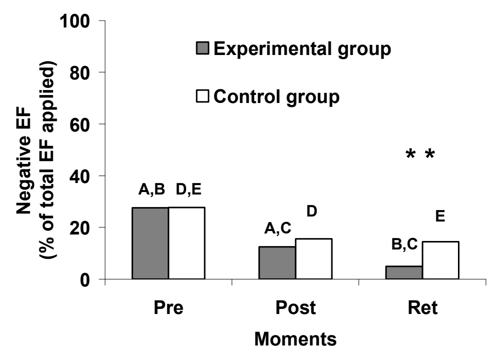

FIGURE 5: Comparison of the average negative EF of the experimental and control groups in the three evaluated moments. Note: Equal letters indicates intra-group significant difference. ** indicates inter-group significant difference.

In the intra-group comparison of the EF, 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

Motor learning is characterized by stable levels in the performing of a given task (Singer, 1975; Magill, 2000; Schmidt & Wrisberg, 2001; Wishart et al., 2002; WULF et al., 2002). From the results obtained in this study, it is possible to suggest that both groups learned the pedaling technique of the recovery phase. The feedback providing to the individuals 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 was reduced from phase one to phase two, the individuals start to use the intrinsic feedback which allowed them the detection and correction of errors, resulting in less dependence of the feedback (Tani et. al, 2004).

The experimental group which received AVF presented a pedaling technique in the recovery phase more consistent than the control group. It 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 test. This fact may be due to a better direction of the force components applied to the pedal specifically in the recovery phase because according to Lafortune and Cavanagh (1983), Sanderson and Cavanagh (1990) and Broker et al. (1993) a better direction of the force components applied to the pedal results in a more efficient pedaling technique.

The average IE in the experimental group, in the recovery phase, agrees with the results of Henke (1998) with regard to a better use of forces in pedaling. HENKE (1998) evaluated the IE in the recovery phase, dividing its analysis by quadrant, which also represents an interesting way to examine the presence of retarding forces. This author used AVF, and found significant results in 3rd and 4th quadrants, with increases in performance in the order of 15% and 62% respectively.

SANDERSON and CAVANAGH (1990) found significant results when analyzed the reduction of retarding forces in the recovery phase, it reduced the presence of RF at this phase by almost half. Although in this study RF in the recovery phase was not evaluated, it is possible to say that the results the present study agree with the results of SANDERSON and CAVANAGH (1990), because there was a reduction in negative EF of approximately 27% at the pre moment for approximately 5% at the retention moment. It is interesting to note that the value of negative EF of 5% reached in of the experimental group is about five times lower than the value obtained by the same group at the pre moment, which represents a large reduction in negative EF over pedaling cycle.

The results of the control group also agree with the study of SANDERSON & CAVANAGH (1990), because that group showed a reduction of approximately 27% at the pre moment to 14% at the retention moment, which represents almost half of the value obtained in the pre moment. However, these results from the control group did not corroborate with the results found by Henke (1998), in which the control group failed to decrease the amount of negative EF in the fourth quadrant. Although the negative EF in this study was not examined for each quadrant, it is possible to say that as there was a decrease throughout the pedaling cycle it is very likely that individuals from the control group have managed to pull the pedal in the recovery phase, thus decreasing the amount of negative EF applied to the pedal in the 3rd and 4th quadrants, which contradicts the findings of Henke (1998).

The improvement in the force application to the pedal by the experimental group may be related to the quality of information contained in the AVF. This allows the attribution of a relevant meaning to the visual information transmitted, allowing its storing in the long-term memory (Klatzky, 1980; Holderbaum et al., 2005; Holderbaum et al., 2006a; Holderbaum et al., 2006b; Holderbaum et al., 2006c) accomplishment of the task (Magill, 2000; Godinho, 2000).

Although the control group significantly increased the average of IE in the recovery phase and significantly decreased the average of application of negative IE after the practice sessions, it did not manage to keep the same performance in the retention test. This fact may be related to the absence of visual information that made it difficult the attribution of a relevant meaning to the permanent storing of information (Klatzky, 1980; Holderbaum et al., 2005; Holderbaum et al., 2006a; Holderbaum et al., 2006b; Holderbaum et al., 2006c).

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 direction of the force components applied to the pedal, it is more efficient in the learning process.

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