# Effects of physical guidance on learning a dynamic balance motor skill


## Abstract

The aim of the present study was to investigate the effects of physical guidance on learning a motor skill of dynamic balance. Twenty-four university adults, of both sexes, were distributed in groups with and without the use of physical guidance in practices. The task involved riding the Pedalo, for seven meters in the shortest amount of time, with the pedalo's support bars being used as physical guidance devices to perform the motor task. The practice phase consisted of 20 trials, and the immediate transfer test consisted of 4 trials with the support bars and 4 trials without the support bars. After 24 hours, the same transfer tests were performed. The results showed better performance in the practice phase for the participants in the group that used physical guidance in all trials. However, opposite results were found in the immediate and delayed transfer tests when the task was performed without the use of physical guidance. We conclude that the frequent use of physical guidance devices can make learners dependent on extrinsic information and impair motor learning.



Keywords: Motor learning; Adults; Complex motor skills; Extrinsic information.


## 1. Introduction

Human movement professionals can often assist people in their early stages of learning, or relearning, by guiding them in the movement patterns to be achieved through the use of physical guidance (e.g., walkers and canes, floats used in swimming lessons, seat belts in Olympic gymnastics and training wheels on children's bicycles). These devices have the function of assisting the process of learning complex motor skills (Wulf & Toole, 1999), providing a clearer vision of the goal of the movement (Wulf, Shea, & Whitacre, 1998), increasing safety and reducing fear participants during the execution of a task (Domingo & Ferris, 2010).

Studies analyzing the effects of physical guidance on motor learning, in turn, have shown divergences about its use. In self-controlled conditions, it has been found that having autonomy to choose when to use physical guidance devices leads to gains in the acquisition of motor skills in different populations (Wulf & Toole, 1999; Chiviacowsky, Wulf, Lewthwaite, & Campos, 2011; Wulf, Clauss, Shea, & Whitacre, 2001). On the other hand, a controversy about the effects associated with possible dependence on its frequent use has been found in externally controlled conditions (Hagman, 1983; Wulf, Shea & Whitacre, 1998; Winstein, Pohl & Lewthwaite, 1994).

The use of physical guidance is a way to present continuous and simultaneous feedback through kinesthetic pathways. A number of studies have pointed out that frequent use of physical guidance does not benefit motor learning because high frequencies can lead the learner to dependence on extrinsic information (Armstrong 1970; Gillespie et al., 1998; Hagman, 1983; Tsutsui & Imanaka, 2003; Winstein et al., 1994). Based on the orientation hypothesis (Salmoni et al., 1984), the abundant use of physical guidance during acquisition encourages the learner to ignore important intrinsic information, since the use of physical guidance devices effectively guide them towards performing the appropriate movement pattern at this stage. However, the consequence of failing to process this intrinsic feedback is the failure to develop error detection and correction mechanisms. That is, the use of physical guidance devices could facilitate good performance during practice, but in a delayed learning test, performance could decrease significantly and not lead to gains in motor learning.

Some authors have contradicted this view and pointed out that the use of physical guidance would not lead to gains in learning simple motor tasks, but it would affect the acquisition of complex motor tasks (e.g., Wulf, Shea & Whitacre, 1998; Wulf & Shea, 2002). Specifically, the use of physical guidance can provide sensory information specific to the task at the beginning of the practice, with greater need for motor tasks involving a greater number of degrees of freedom, leading to a better performance in the learning tests (Proteau, 1992). For example, Wulf et al. (1998) found beneficial effects on motor learning for the group that used the poles during the acquisition of a task that simulates ski motor skills. The use of physical guidance was associated with the possibility for participants to experiment with different strategies in order to produce a more coordinated and effective movement pattern, which they would not be able to perform without the help of these devices.

In general, the effects of physical guidance on learning motor skills have not yet been clarified, mainly due to the small number of studies analyzing the learning of complex motor skills (Wulf et al., 1998). To date, most studies that have found no benefit from using physical guidance in motor learning have used motor tasks that involve low degrees of freedom (Armstrong 1970; Hagman, 1983; Winstein et al., 1994; Gillespie et al., 1998; Tsutsui & Imanaka 2003). However, studies have indicated that the learning principles derived from the study of simple or less complex skills are not necessarily generalizable for learning more complex skills (Wulf & Shea, 2002), which points to the need to directly examine the learning of this type of skill.

The aim of the present study, therefore, was to investigate the effects of physical guidance on learning a complex motor skill. We analyze to practice riding a pedalo over a distance of seven meters in the shortest time possible with a group using physical guidance and another group without using any assistance. Specifically, the Pedalo is a locomotor device that requires the learner to coordinate two connected platforms and propel forward with a movement similar to pedaling a bicycle, with the need to coordinate upper and lower limbs for its performance with a high demand for balance (Chen et al., 2005). When considering that a task involving a greater number of degrees of freedom for its accomplishment can benefit from the use of physical guidance, as it allows the learner to have an idea of the movement of the goal (with great amplitudes) and produce an effective coordination pattern that results in movements of great breadth, it is expected that participants who use physical guidance have better learning results than participants who do not use it during their practice.

## 2. Method

*Participants*

Twenty-four volunteer university students (14 men) with an average age of 21.5 years (SD = 2.25) participated in the study. The participants had no previous experience with the task, and all gave written informed consent. The study was approved by the Research Ethics Committee of the Federal University of Pelotas (protocol number 123/2012).

*Equipment and task*

The task, similar to that used by Abdollahipour, Land, Cereser & Chiviacowsky (2019), involved riding on a pedalo at a distance of seven meters demarcated by start and finish lines. The Pedalo is an instrument that moves when the upper platform is pushed back and forth and its use involves global body coordination and, mainly, maintaining balance. In addition, it offers the possibility of using support bars (Figure 1), providing physical guidance to perform the task. The support platforms measure 100 x 14 cm and the wheels 21.5 cm. All trials started with the learner's right foot on the upper platform and the data collection began as soon as the wheels of the pedalo touched the starting line. A timer was used to measure the movement time (TM): the time between the start and finish lines.

Insert Figure 1 here

*Figure 1.* Pedalo *(*made by Holz-Hoerz, Münsingen, Germany)

*Procedures*

Participants were randomly assigned and matched by sex to two experimental conditions: the group that used physical guidance (CAF) and the group without physical guidance (SAF). The experiment consisted of six phases: pre-test, practice phase, immediate transfer test with support, immediate transfer test without support, transfer test 24h with support and transfer test 24h without support. Before the practice started, all participants were informed that they would have to make several trials in Pedalo and was provided regarding the task's goal, the total number of trials and the phases of the study.

Before the start of the practice phase, the participants perform a pre-test trial using physical guidance. Subsequently, the CAF group was informed that all trials would be made with physical guidance, while participants in the SAF group were instructed that all trials would be made without physical guidance. In the practice phase, participants made 20 trials, with an interval of 30 seconds between each trial, and providing knowledge of result in relation to the movement time after each trial. Immediately after the practice phase, two transfer tests with four trials each (with and without physical guidance) were carried out. After 24h, two transfer tests were performed with and without physical guidance, similarly to the immediate tests. Before all tests, participants were informed that they should carry out the stipulated route at the highest possible speed. In addition, no knowledge of results was provided regarding the MT after the trials.

*Data analysis*

The MT, in seconds, were calculated using block averages of four trials. Analysis of Variance (ANOVA) two-way (2 groups x 5 blocks), with repeated measures in the last factor, was used to analyze the practice data. One-way ANOVAs were performed separately to check for possible differences in the pre-test and in the immediate and delayed transfer tests. The calculation of the effect size used was the Partial Eta Squared ($\eta p^2$). Statistical Package for Social Sciences (SPSS 20.0) was used to perform the statistical procedures and an alpha level of significance of 5% was adopted.

## 3. Results

The pre-test analysis revealed that the groups had similar performance before the beginning of the practice, $F (1, 22) = 0.21$, $p < 0.65$, $\eta p^2 = 0.10$.

*Practice*

The results of the MT over the practice blocks are shown in Figure 3. ANOVA revealed a decrease in the MT in both groups from the first to the last block of trials, with effect on the Trials factor, $F (1.58, 34.78) = 152.87$, $p < 0.0001$, $\eta p^2 = 0.87$. The first block showing a longer time than the other blocks ($p < 0.0001$). In addition, there was a difference in the Groups factor, $F (1, 22) = 44.18$, $p < 0.0001$, $\eta p^2 = 0.671$, with superiority of CAF compared to SAF. Still, interaction between Groups and Trials was verified, $F (1.58, 34.78) = 91.72$, $p < 0.0001$, $\eta p^2 = 0.80$. The Post-Hoc revealed that CAF was higher in all blocks of the acquisition, compared to SAF (Blocks 1 and 2, $p < 0.0001$; Blocks 3 and 4, $p = 0.001$; Block 5, $p = 0.007$).

Insert Figure 2 here

*Immediate and delayed transfer*

In the immediate transfer test with support (Figure 2) there was no difference between the groups, $F(1, 22) = 1.24$, $p = 0.277$, $\eta p^2 = 0.053$. In turn, in the Immediate Transfer Test without support, the SAF revealed a shorter average MT compared to CAF, $F(1, 22) = 14.34$, $p = 0.013$, $\eta p^2 = 0.248$.

In tests performed after 24h, no difference between groups was found in the Transfer Test with support, $F(1, 22) = 0.43$, $p = 0.71$, $\eta p^2 = 0.006$. On the other hand, SAF was superior in comparison to CAF in the Transfer Test with support, $F(1, 22) = 5.42$, $p = 0.029$, $\eta p^2 = 0.198$.

## 4. Discussion

The aim of the present study was to verify the effects of physical guidance on learning a motor skill of dynamic balance. The current panorama of studies analyzing the use of physical guidance in motor learning has pointed out divergences about its effects (e.g., Domingos & Ferris, 2010; Wulf et al., 1998; Wistein et al., 1994). Despite the limited number of studies, gains in motor learning were expected from the frequent use of physical guidance based on evidence pointing to positive effects on the acquisition of complex motor skills (Wulf et al., 1998). The results, in turn, did not confirm the initial hypothesis of the study.

Specifically, the results revealed better performance in the practice phase for participants in the group who practiced with physical guidance. In turn, opposite results were found in the immediate and delayed transfer tests, when the task was performed without the use of physical guidance. This result goes in the direction of studies that have not shown gains in motor learning from the use of physical guidance (Armstrong, 1970; Tsutsui & Imanaka, 2003).

The main explanation for this result is associated with dependence caused by the frequent use of physical guidance. These devices can act in a similar way to extrinsic feedback that informs the result of the movement performed in relation to the task goal (knowledge of result). Evidence from research on outcome knowledge suggests that practice arrangements with provision of relative frequencies less than 100% are beneficial for learning, although they appear to produce adverse effects during performance (Schmidt et al., 1989; Wulf & Schmidt, 1989; Winstein & Schmidt, 1990). Such results support the orientation hypothesis (Salmoni et al., 1984), which suggests that the frequent use of knowledge of result can cause dependence, impairing the learning of motor tasks. The same seems to be the case with the use of physical guidance devices.

In the same direction, the gains in the group's learning tests without physical guidance are consistent with the theoretical premises proposed by Guadagnoli and Lee (2004). These authors propose that learning is improved when the learner faces an optimal level of challenge during the process. Conversely, learning is compromised if the challenge imposed is too high or too low.

Motor learning, therefore, is related to the available and interpretable information, which depends on the difficulty of the task, which can be nominal (regardless of who performs it and in which contexts it is performed - for example, high or low perceptual and motor demands) or functional (depending on the challenge it causes in the performer - for example, level of skill beginner, intermediate, skilled or expert and the conditions of practice in which they are being performed) (Guadagnoli & Lee, 2004). Based on this proposition, the participants who used physical guidance experienced a relatively easy task, and the difficulty of the task has not changed. In turn, the participants of the group without physical guidance, adjusted the functional difficulty of the task to an ideal level, which possibly resulted in an optimal cognitive effort that benefited the acquisition of motor skill.

This reasoning helps to explain the differences in results found in the present study and in the study by Wulf et al. (1998). Although the tasks of both studies involve more degrees of freedom than previous studies (Armstrong, 1970; Tsutsui & Imanaka, 2003; Wistein et al., 1994), Wulf et al. (1998) used a more complex full-body task (learning to use a ski simulator), in which participants performed the skiing skill better when practiced with ski poles to stabilize the movement pattern than without them. Specifically, the ski poles allowed the participants to select the magnitude and timing of the auxiliary forces, keeping the focus on the dynamic task, which possibly may have generated a greater functional difficulty. Even with the use of physical guidance, it may have resulted in an optimal cognitive effort that benefited the acquisition of motor skills (Guadagnoli & Lee, 2004). However, future studies analyzing different levels of complexity of motor tasks are necessary to understand their relationship with the effects of physical guidance.

Another possible explanation may be associated with the socio-affective demands imposed by the motor task. It is possible to speculate that the complexity of the task with regard to the degrees of freedom involved in coordinating movements and keeping it balanced for its execution increased the challenge for its accomplishment with motivational consequences, which may have led to gains in motor learning for the group that did not use physical guidance.

Studies analyzing the engagement of individuals in different contexts have found that the motivation and performance of goal-driven activities are affected by relatively easy or difficult “optimal” challenges (Delle Fave, Bassi, & Massimini, 2003; Ellis, Voekl, & Morris , 1994; Jones, Hollenhorst, & Perna, 2003; Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). Specifically, the challenge can affect motivational constructs, even in more intrinsically motivated activities, since the challenge promotes greater pleasure and interest in performing tasks (Abuhamdeh & Csikszentmihalyi, 2012). Thus, it is possible that the challenge generated by the motor task throughout the practice trials led to an increase in motivation when practicing without physical guidance, leading to benefits in motor learning. However, future studies measuring possible motivational consequences are necessary to deepen this explanatory hypothesis.

## 5. Conclusions

We concluded that the practice without the use of physical guidance device benefits the learning of a dynamic balance task in relation to the use of 100% physical guidance. The realization of new studies with different populations, motor tasks and frequencies of physical guidance can help to better understand the effects of this important variable on motor learning.