



Article

Effective Modeling on Learning Ballet Online

Jeongwon Kim ^{1,2} , Iseul Jo ^{1,2} , Younha Ma ^{1,2}, Hyewon Yoon ^{1,2} and Dongwon Yook ^{2,3,*}

- ¹ Department of Physical Education, Graduate School of Yonsei University, Seoul 03772, Republic of Korea; jw31244@yonsei.ac.kr (J.K.); whdltmf53@yonsei.ac.kr (I.J.); younha48@yonsei.ac.kr (Y.M.); hyenn0828@yonsei.ac.kr (H.Y.)
- ² Frontier Research Institute of Convergence Sports Science, College of Educational Sciences, Yonsei University, Seoul 03772, Republic of Korea
- ³ Department of Physical Education, College of Educational Science, Yonsei University, Seoul 03772, Republic of Korea
- * Correspondence: dyook@yonsei.ac.kr

Abstract: After COVID-19, face-to-face learning was changed to online learning. However, very few effective online learning methods were available regarding physical education. Therefore, this study aimed to examine the modeling effects on learning ballet movement in the online system. We aimed to find effective modeling presentations based on objective information, expert assessments, and a kinematic approach. The study included 36 individuals who were divided into an expert modeling group, a self-modeling group, and controls. Participants performed 60 trials of Pas de basque in the acquisition phase and 10 trials without a demonstration video after 24 h. 10 min later, the reversed Pas de basque was conducted for the retention test. All groups showed improved performance after the acquisition phase, which indicated that the modeling presentation was effective despite adopting an online learning system. However, higher expert scores and more accurate joint movements were shown in the expert modeling group compared to the other groups. Therefore, expert modeling seems to be the most effective method for learning high-difficulty tasks with jumps and turns.

Keywords: social-cognitive theory; motor learning; modeling; joint kinematic



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1. Introduction

As a result of the COVID-19 pandemic, the online learning system, which provides a teaching and learning environment beyond physical time and space, has quickly become a new educational paradigm [1]. Universities offered physical education courses using YouTube videos, real-time streaming, and professor-led practical classes, with 20.9% of the classes using Zoom [2]. However, online classes limited immediate observation and feedback on students' performance compared to face-to-face classes. Therefore, creating an effective learning environment for online classes is imperative [3].

Recently, there has been an increase in demand for effective dance instruction, both for professional dance training and as a leisure activity [4]. Dancing requires students to express themselves through creative movement [5,6], and in order to increase their efficacy, it is essential to have a specific teaching-learning strategy. However, dance training has typically been provided based on the expertise of the instructors, which limits the ability to provide clear information [7]. Therefore, scientifically effective learning techniques must be approached and analyzed [7–10].

According to previous studies, modeling and observational learning occur when a learner watches a model being used before engaging in physical activity to produce the motor learning effect [11,12]. As a result, modeling is considered more effective when learning continuous skills than non-continuous ones, making it essential for learning dance [4]. Quinn et al. (2020) suggested the advantages of video modeling for female dance students, ages 9–13 years, with ballet class experience [13]. In addition, there was no difference in the speed of the video demonstration, but it was found to be helpful in ballet

skill learning when expert modeling and self-modeling were provided [14]. In particular, modeling will play a particularly significant role in determining the effectiveness of online learning due to the constraints of visual information and the physical environment [3].

Expert modeling [15–17], self-modeling [18–21], and peer modeling have been proposed as the modeling techniques. Expert modeling—which imitates the expert model—tends to increase positive motivation by drawing and maintaining the learner’s attention [9,22–26]. The expert model allows observers to form a “perceptual blueprint” of the task to be learned as it demonstrates how to correctly perform the task or appropriate movement strategy [27]. This blueprint serves as a standard against which participants can compare their performance [11]. Therefore, some studies have argued that observing the expert model is the most effective learning method [4,9,22–26,28].

However, Shin and Kwon (2015) found self-modeling was more effective than expert modeling regarding the learners’ ability to identify and correct their performance errors [10]. Essentially, self-modeling means learners obtain information by watching their movements, allowing them to identify errors and correct them [4,29,30]. They can learn how to carry out the task properly, improve their self-efficacy, and overall develop confidence in their ability [23,29]. By using a cognitively oriented learning approach, the influence of both expert and non-expert models can be applied based on a mutually deterministic perspective on the environment, oneself, and behavior [31–33]. However, self-modeling has difficulties establishing reference criteria that can be used to determine performance accuracy [34], and the effect differs significantly from expert modeling [4]. In addition, van der Loo et al. (2021) found no main effects of modeling type (expert or novice) and no interaction effects. Therefore, it is still unknown if self-modeling is an effective form of modeling presentation [35].

Artistic activities such as rhythmic gymnastics, dance, and ballet are primarily assessed subjectively [9,36]. As an elaborate and objective criterion is needed for impartiality [37], recent studies have attempted to correlate artistry and joint kinematics [38,39]. Therefore, this study compares how different modeling methods affect learning in an online environment based on kinematic variables and expert evaluation. The results of this study are anticipated to provide essential information that can offer efficient learning strategies for practical classes—including the online learning system.

2. Methods

2.1. Participants

Female college students in their 20s with no experience in ballet and no mental or physical impairments volunteered to participate in the experiment. Except for one dropout, 26 individuals were randomly divided into three groups based on the different modeling techniques. There were nine females in the expert modeling group (EXP, height: 160.8 ± 4.9 cm, weight: 52.7 ± 6.4 kg, age: 21.7 ± 0.8), eight females in the self-modeling group (SELF, height: 160.6 ± 4.5 cm, weight: 54.2 ± 6.6 kg, age: 21.9 ± 0.7), and eight females in the control group (CON, height: 161.2 ± 1.4 cm, weight: 53.4 ± 8.7 kg, age: 22.1 ± 1.2). A sufficient explanation of the experiment was conducted before the investigation, and the participants consented to proceed. This study was conducted during COVID-19, and due to the limited sample size, it is necessary to interpret the results carefully.

2.2. Task and Apparatus

2.2.1. Task

Participants were asked to perform a Pas de basque, which is explained in detail in Table 1. The movement was selected after the deliberation of three experts currently working as ballet instructors and one professor in motor learning. The task difficulty was supplemented based on previous research [36]. The camera (iPhone) that was set in front of the participants recorded the performance. Five researchers—including two ballet experts—validated the assessment table of movement. The assessment table of movement

was made up before the experiment, similar to those used by Lee and Kim (2010). The expert assessment was evaluated independently by the two ballet experts who did not know the experiment procedure. The task involved four sections, which were scored using five questions—each specifically addressing their corresponding section.

Table 1. Pas de basque assessment.

Section	Description
Plie-Tendu	<ol style="list-style-type: none"> 1. Did you do demi plie? 2. Was the gaze in front of the hand when turning? 3. Were the hips and upper body positioned vertically and horizontally? 4. Was it pointed with the right foot forward on the ground?
Demi-rond	<ol style="list-style-type: none"> 1. Did the gaze move to the left side? 2. Were the hands and feet open simultaneously to the right? 3. Were the hips and upper body in the front? 4. Did you have a right-foot turnout at the end of the rond?
Glissade	<ol style="list-style-type: none"> 1. Did the pelvis keep the A shape symmetrically when jumping? 2. Did you keep both feet at the point? 3. Did your gaze move from your left hand to your right hand? 4. Did both feet maintain position 1?
Tendu-Glisse	<ol style="list-style-type: none"> 1. Is it pointed with the left foot forward on the ground? 2. Is the gaze in front of the hand? 3. Did you land with both feet in position 5? 4. Do your arms spread out upon landing?

2.2.2. Acquisition of Kinematic Data

The 8 motion capture system (VICON, MX-F20, Oxford Metric Ltd, Oxford, UK) was used to analyze kinematic data during Pas de basque. In order to use the plug-in gait lower body model, 15 reflective markers were placed on the anterior/posterior superior iliac spine, sacrum, left/right thigh, left/right lateral epicondyle, left/right tibia, left/right lateral malleolus, left/right calcaneus, and left/right 2nd metatarsal phalangeal joint.

Kinematic data were obtained during Glissade, which required displacement of the participant's center of mass (CoM). The initial Glissade was set when the CoM velocity was over -15 mm/s—the analyzed events are demonstrated in Figure 1.

2.3. Experimental Procedure

2.3.1. Pretest

The participants viewed the model video that explained the Pas de basque for about 5 min and after watching the video, they performed 10 trials.

2.3.2. Acquisition Phase

The acquisition phase was conducted on Zoom. Participants in each group performed six blocks of 10 trials (a total of 60 trials). EXP viewed the video of an expert with more than 10 years of ballet experience, and SELF viewed the video of their successful performance during their pre-test. EXP was provided with expert model videos via screen sharing throughout the Zoom meeting, and SELF was provided with videos individually but was only allowed to view their videos during the acquisition phase. CON did not observe a video and did not provide any feedback. The model demonstration was provided before each trial, with a 100% frequency in each group. Between each block, a one-minute break was provided.

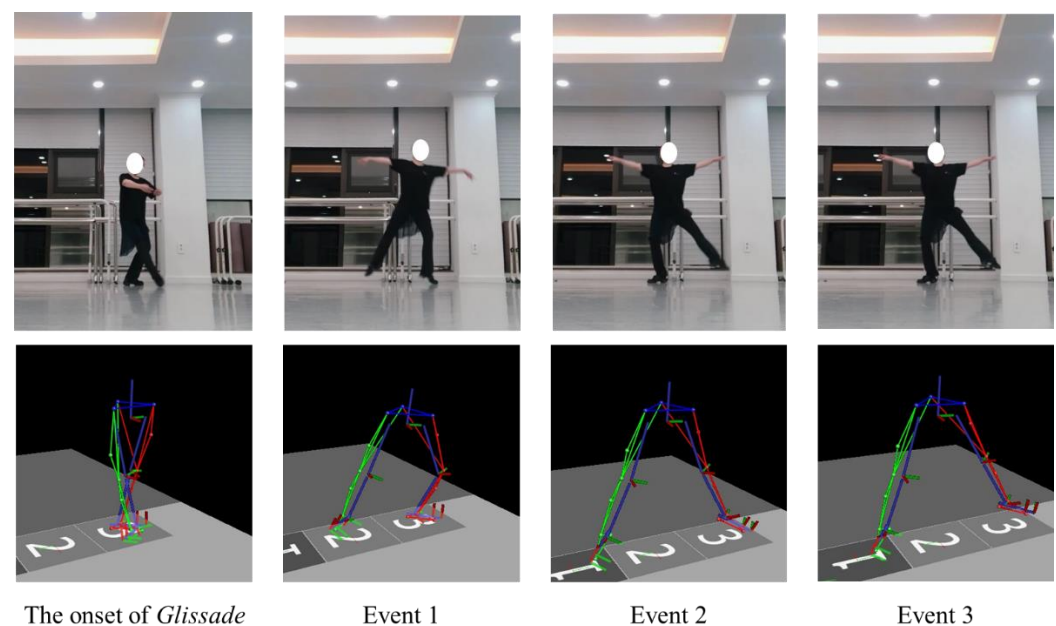


Figure 1. Analysis of events in Glissade. Event 1: the onset of Glissade. Event 2: the moment when CoM was the highest. Event 3: the moment when the right foot contacted the ground.

2.3.3. Post-test and Transfer Test

A total of 10 trials were performed in the post-test, which occurred as one block without model demonstration 24 h after the acquisition phase. The transfer test was performed after the post-test, and the Pas de basque skill was performed in reverse without a model demonstration. The experimental procedure can be seen in Table 2.

Table 2. Experimental procedure.

Group	Pre-Test	Acquisition Phase	Post-Test	Transfer Test
EXP	Performed 10 trials after watching a video about skill description for 5 min	Expert demonstration video provided after each trial	24 h later, 10 trials without demonstration video	After 10 min of post-test, perform 10 trials of <i>Pas de basque</i> skill in reverse
SELF		Self-demonstration video provided after each trial		
CON		No demonstration video		

2.3.4. Data Analysis

Expert Assessment

The expert conducted an independent evaluation based on Table 1. The average performance score was calculated by adding the scores the two ballet experts provided.

Analysis of Kinematic Data

The marker data were filtered using a fourth-order low-pass filter with a cut-off frequency of 10 Hz. The joint angle in the lower extremities was extracted by considering the expert assessment of each event [39], and the CoM displacement was calculated in the phase between event 1 and event 3 to assess balance. The data from the two trials used in the expert assessment were then averaged.

Statistics Analysis

In this study, the repeated measures ANOVA was used to verify the motor learning effect on the model demonstration's characteristics, and the one-way ANOVA was used for the pre-test and the transfer test. Post hoc analysis was performed using Bonferroni to determine whether there were differences between the groups. A normality test was

also performed before analysis, and if normality was not satisfied, non-parametric statistics (generalized estimating equation; GEE) were used for comparison.

3. Results

3.1. Pre-Test

In the pre-test, there was no significant difference in the performance scores between EXP (11.6 ± 3.3 points), SELF (9.6 ± 2.7 points), and CON (9.2 ± 1.7 points). These results indicated that each group did not differ before the acquisition phase.

3.2. Post-Test

In the post-test, EXP scored 15.14 ± 2.58 points, SELF scored 12.94 ± 2.54 points, and CON scored 11.91 ± 1.85 points. Compared to the pre-test, the post-test scores of all groups noticeably improved ($p < 0.05$). In addition, EXP demonstrated significantly greater scores than CON, and no differences were observed with SELF (Figure 2).

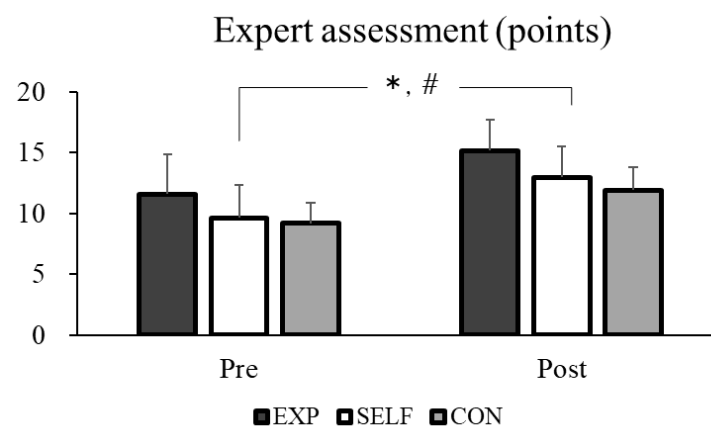


Figure 2. The expert scores depend on the modeling. Significantly different at $p < 0.05$ between pre and post (#) and groups (*; EXP > CON).

In the pre-test, there was no difference between groups regarding the angles in the lower extremities (Table 3). In all of the groups, the left knee and ankle joints were more flexed during event 1 in the post-test ($p < 0.05$). In addition, they also displayed a more adducted right hip joint ($p < 0.05$). Only EXP had an interaction effect on the ankle flexion angle between times. EXP performed with an increased ankle joint toward the plantar ($p < 0.05$), and a more flexed hip joint was shown in EXP and SELF than in CON.

During event 2, SELF demonstrated a more extended right hip joint and flexed left knee joint than EXP and CON. Overall, compared to the pre-test, the plantar flexion angle increased in all of the groups.

There was no difference in the displacement of vertical CoM among EXP, SELF, and CON. However, their anteroposterior and mediolateral movements changed in the post-test, unlike in the pre-test ($p < 0.05$).

Table 3. The joint angle of lower extremities in each event.

		Pre-Test			Post-Test		
Variables/Group		EXP	SELF	CON	EXP	SELF	CON
Event 1	(+)						
Left							
	Hip Flexion	6.97 ± 9.5	12.1 ± 6.7	5.9 ± 11.0	14.6 ± 10.2	15.0 ± 13.6	9.8 ± 8.3
	Hip Adduction	−1.2 ± 5.7	−5.4 ± 9.3	−0.8 ± 6.1	−7.8 ± 6.0	−4.86 ± 7.6	−4.7 ± 6.5
	Hip Internal rotation	−14.6 ± 16.1	−16.4 ± 12.9	−22.5 ± 8.6	−16.9 ± 12.3	−19.6 ± 13.7	−20.4 ± 8.6
	Knee Flexion #	15.1 ± 17.9	25.1 ± 15.9	18.4 ± 14.9	35.3 ± 12.7	34.9 ± 19.2	26.4 ± 9.8
	Ankle Dorsiflexion #	18.9 ± 6.19	22.0 ± 10.4	21.8 ± 9.8	28.2 ± 6.4	24.6 ± 11.7	29.5 ± 6.9
Right							
	Hip Flexion *c	18.9 ± 12.6	15.1 ± 15.1	9.9 ± 6.5	11.8 ± 7.0	19.8 ± 16.9	−3.2 ± 7.0
	Hip Adduction #	−8.31 ± 10.3	−13.7 ± 13.4	−16.1 ± 8.9	−19.7 ± 6.0	−15.6 ± 14.7	−22.9 ± 3.8
	Hip Internal rotation	−14.2 ± 13.0	−17.4 ± 10.9	−14.8 ± 17.4	−6.3 ± 17.7	−11.5 ± 15.8	−24.8 ± 15.3
	Knee Flexion	12.4 ± 13.1	8.7 ± 10.1	0.6 ± 5.6	0.2 ± 6.7	10.2 ± 18.1	−0.7 ± 6.3
	Ankle Dorsiflexion †, #	−7.4 ± 11.8 †	−18.7 ± 16.9	−26.9 ± 19.2	−40.6 ± 9.2 †	−23.5 ± 21.6	−37.2 ± 15.3
Event 2							
Left							
	Hip Flexion	−3.1 ± 9.7	1.8 ± 6.0	0.79 ± 7.5	−2.6 ± 10.3	−0.7 ± 10.7	−3.37 ± 10.0
	Hip Adduction	−19.0 ± 12.5	−14.6 ± 13.0	−13.3 ± 4.9	−22.0 ± 13.3	−16.3 ± 11.7	−17.79 ± 3.5
	Hip Internal rotation	−24.6 ± 12.0	−23.0 ± 8.7	−34.2 ± 9.6	−26.1 ± 11.9	−28.7 ± 13.2	−28.4 ± 11.8
	Knee Flexion #, *e, *s	0.3 ± 7.3	5.7 ± 10.0	2.6 ± 9.7	−2.2 ± 6.7	3.1 ± 8.8	−5.8 ± 5.5
	Ankle Dorsiflexion #	−27.5 ± 12.9	−30.9 ± 15.9	−28.9 ± 17.6	−36.4 ± 10.6	−39.0 ± 16.4	−43.2 ± 9.4
Right							
	Hip Flexion #	12.6 ± 12.1	7.3 ± 10.2	8.0 ± 6.6	2.8 ± 9.0	6.2 ± 6.2	1.9 ± 10.9
	Hip Adduction	−16.5 ± 8.2	−13.5 ± 7.5	−13.0 ± 8.3	−18.1 ± 7.2	−15.6 ± 11.0	−18.2 ± 6.7
	Hip Internal rotation	−18.9 ± 9.0	−19.0 ± 8.3	−17.9 ± 16.8	−11.5 ± 13.6	−15.8 ± 16.9	−21.5 ± 13.6
	Knee Flexion	3.7 ± 7.5	6.1 ± 10.7	4.6 ± 6.7	−3.2 ± 6.2	5.7 ± 9.7	0.5 ± 5.5
	Ankle Dorsiflexion #, *e	−35.0 ± 8.1	−31.1 ± 8.5	−27.7 ± 12.8	−48.5 ± 9.2	−34.8 ± 9.0	−42.9 ± 13.9

Significantly different at $p < 0.05$ in interaction effect depending on time (†), between pre and post (#) and between groups (*e; EXP vs. SELF, *s; SELF vs. CON, *c; EXP and SELF vs. CON). (+) denotes flexion (dorsiflexion) in the sagittal plane, adduction in the frontal plane, and internal rotation in the horizontal plane.

3.3. Transfer-Test

The expert scores in the Transfer test, EXP (15.1 ± 3.6 points) scored higher than SELF (11.2 ± 2.9 points) and CON (11.3 ± 1.7 points). There were no differences observed between SELF and CON (Figure 4).

4. Discussion

In this study, we compared the effect different modeling demonstrations had on motor learning when used in an online learning environment. Our study demonstrated that even in an online learning environment the use of modeling had a noticeable learning effect. In addition, using the expert model was considered the most effective technique to learn Pas de basque and acquire other movements.

4.1. Motor Learning Effect of Expert Modeling

Consistent with previous research [28,40–43], using the expert model in this study clearly demonstrated effective motor learning (Figure 2). Expert modeling induces an efficient learning process by allowing learners to compare and modify their movements while observing the model's characteristics [44]. Magill (1993) stated that by observing a skilled model, learners can easily acquire the movement patterns necessary to successfully perform a skill [45]. According to the social cognitive perspective of observational learning,

the visual system collects meaningful information about body positions by observing correct tasks and transforming this information into cognitive representations by extracting spatial and temporal features through selective attention [23]. This information contributes to movement production and is then transformed into appropriate motor commands that enable the learner to accurately imitate the skill. Therefore, the repeated observation of the expert model demonstration results in effective motor learning, leading to improved accuracy and durability of cognitive representation.

Furthermore, providing constant access to an expert model in a multi-degree of freedom movement created effective motor learning [46]. During every trial in the acquisition phase of this study, we gave the participants continual access to videos. Although providing constant feedback (100% frequency feedback) is also considered to improve motor learning [36], using expert modeling was most effective for novices to learn complicated tasks, which included turning and jumping. As a result, even in an online environment, providing beginners with continual access to expert videos was effective in learning difficult ballet movements.

However, according to the guidance hypothesis, while providing constant feedback improves delicate performance during the acquisition phase, it also inhibits the learner's memory development during the retention test [47]. Consequently, intermittent feedback has a greater retention impact by motivating students to exert effort in order to produce precise motions in the absence of feedback [36,47]. Nevertheless, this study found that effective transfer was induced when expert modeling videos were provided constantly—100% of the time. Therefore, the guidance hypothesis should be reconsidered [47–50].

4.2. Motor Learning Effect of Self-Modeling

Beginner model demonstrations can enhance error detection capabilities used to solve problems [32]. According to previous research [51–54], self-modeling not only improves performance levels but also increases self-esteem and self-efficacy. This occurs as a result of the learners' increased cognitive effort [55,56]. It was also suggested that learners evaluate kinematic information while watching a videos of their performance [57]; this allows them to detect performance errors and encourages problem-solving.

In addition, self-modeling demonstrations stimulate learners' motivation [55,58]. Previous studies reported that watching a video of one's previous movements indicated a higher level of motivation compared to not watching [58]. Therefore, the increased performance score in SELF might provide them with a stronger motivation to detect and solve any errors in their movement through videos.

In particular, using self-modeling leads to effective performance in high-difficulty tasks by increasing concentration and initiative to correct errors efficiently [30]. Although improved performance—which required accurate and continuous movement—was shown in SELF, the group did not differ from CON (as seen in Figures 2 and 3). Ikegami and Ganesh (2014) suggested that when using self-modeling, it is difficult to establish reference criteria for accurate movement according to the task difficulty [34]. Therefore, it was reconfirmed that the effect of modeling can vary depending on the characteristics of the learner and the task difficulty.

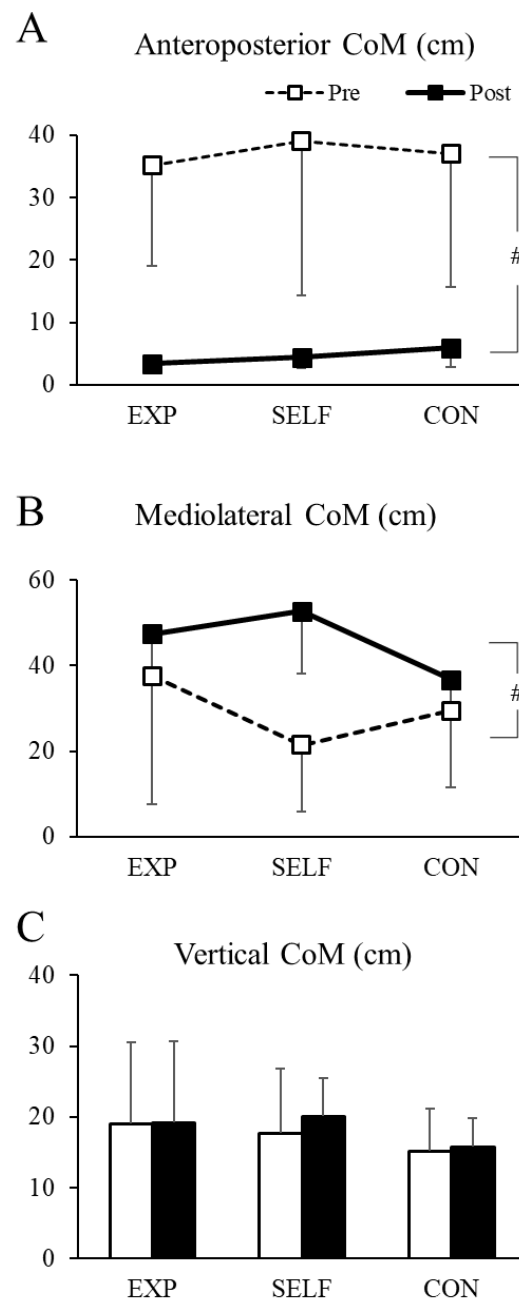


Figure 3. The anteroposterior, mediolateral, and vertical CoM during Glissade. Significantly different at $p < 0.05$ between pre and post (#).

4.3. Modeling Effect Based on Joint Kinematics

Glissade, which links one movement with another, requires the displacement of a person's CoM [59]. The stability of posture is crucial for a dancer to perform accurate movements and beautiful expressions [60]. The professional dancer performed the movement with less body sway and more well-coordinated joints than the novice dancers [61,62]. In this study, the task required a leap to be conducted with one leg. Because of the repeated training during the acquisition phase, all groups improved their stability and balance during Glissade when displacing the CoM (Figure 4) [63].

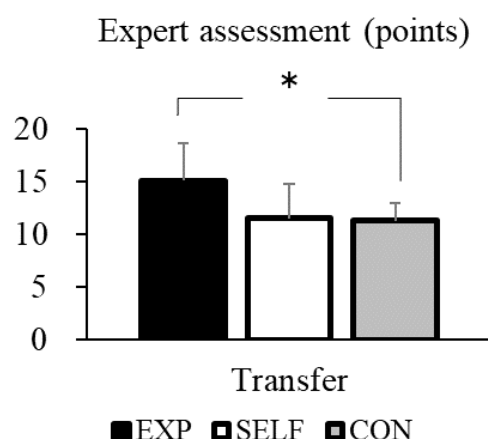


Figure 4. The expert scores in the transfer test. Significantly different at $p < 0.05$ between groups (*; EXP > CON).

Before jumping in Glissade, maintaining the turnout was important in both legs. All groups kept their hip joint with the abduction in the gesture leg (here all of the participants used their right leg) [64] and the “pointe” by increasing the plantar flexion angle [59] during the demi-rond phase (Table 3). When displacing CoM as propulsion, the coordination of each joint is essential to moving stably. Park et al. (2014) stated that professional dancers facilitate movement stability using greater ground reaction force [63]. Although we did not analyze the ground reaction force, the increased flexion in the knee joint indicated that all groups used the lower extremities to move their CoM.

During the Glissade, maintaining the plantar flexion and moving their mass as “A” were important [59]. They imitated the “A” by extending the lower extremities to the joints. However, while EXP and CON appear to stretch both knee joints similarly, SELF does not seem to have completely imitated the behavior on the Glissade. It appears to have caused an error in the self-modeling correction rather than in the control group without any information. Therefore, we support the previous results that conclude it is difficult to establish reference criteria for accurate behavior in self-modeling [34].

4.4. Limitation

This study increased the learning effect in all groups, even if no feedback was provided. This might be due to the practice that occurred during the acquisition phase. According to previous studies, the feedback group showed a greater performance improvement as practice progressed when compared to the no-feedback group [65,66]; however, all groups improved their performance overall. This suggests an effect of practice and supports the results that state performance improvement in all of the study groups.

Additionally, they may have obtained the information through peer modeling due to the online learning environment (Zoom). Although the process was controlled regarding the participants watching the video of the expert on their own, it is possible that groups created a synergy effect through comparisons with other people. If somebody used a mixed effect of peer modeling in each group, this proved more effective than relying solely on self-modeling, expert modeling, or no watching [67–69]. Using a mixed model improves the participant’s ability to recognize performance errors and distinguish them from correct performances, which strengthens the cognitive representation necessary to perform the skill they are learning [70]. Therefore, it is necessary to figure out the relative contribution modeling makes when used by learners in the actual field.

5. Conclusions

This study aimed to compare the effectiveness of learning ballet online depending on modeling presentation. Although there were some limitations to learning online when compared to face-to-face learning, all groups improved their ballet movements. Therefore,

it was possible for us to identify the motor learning effect even in an online learning environment. Using expert modeling maximized the learning effect, which transferred to learning other tasks. However, further research that depends on frequency, mixed methods, or verbal feedback is required to improve the online learning environment.

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Institutional Review Board Statement: Ethical review and approval were waived for this study and were intended to provide opportunities to students who had the restraint to physical activity due to COVID-19. Therefore, this study has an educational purpose rather than an experimental purpose.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The anonymized data set can be requested through the corresponding author.

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Conflicts of Interest: The authors declare no conflict of interest.

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