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THE EFFECT OF DIFFERENT TEACHING CONDITION IN KINEMATIC PARAMETERS ON LEARNING A GYMNASTIC SKILL ON THE HIGH BAR

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Abstract This study examines the effects of implementing different instruction strategies with the use of visual observation, physical guidance and kinematic information as feedback, and presents the differentiation of kinematic parameters in learning and retention of learning a complex gymnastic skill on the high bar. Eighty-four (84) undergraduate students were assigned to four groups that had an equal practice schedule. Group 1 observed other participants' personal presentations (O), Group 2 observed other participants' performance and received kinematic information feedback (KFb), Group 3 observed the performance and received additional physical guidance plus kinematic information (PhG+KFb), and Group 4 observed the performance and received additional physical guidance (PhG). The subjects participated in the kip action on the high bar for six days, every second day, and performed 12 trials in every session. The MANOVA model with repeated measures was applied, followed by a Univariate ANOVA model for each dependent variable separately. In each case the group, the measurement, as well as the group • measurement interaction effect was examined. According to the results, the measurement effect was not significant, while there was as overall significant group effect which was further qualified by a significant group • measurement interaction effect. The mean values for the total score of the four groups at the two measurements show the absence of any significant measurement effect. Conversely, there were significant differences between the four groups, where groups three and four scored significantly higher than groups one and two. Also, there was a significant group effect in temporal and spatial parameters in the two measurements. In practically all the cases statistically significant differences involved the differences mainly between Group 3 and the other groups. It was concluded that the combination of physical guidance and kinematic information feedback led to higher scores in this complex gymnastic skill.

Key words: motor skill, kinematic feedback, physical guidance, learning

INTRODUCTION

Teaching of motor skills often involves the use of various guidance techniques such as verbal information [7, 27, 28, 30, 31, 32, 33, 36], physical guidance [12, 14, 15, 44], and visual demonstration (model demonstrations or observational learning) [6, 10, 17, 26, 34, 40], either as model demonstrations prior to any overt movement [11, 24], or concurrent feedback during an overt movement [5], or augmented feedback in the form of KR after the completion of an overt movement [41, 46].

While the use of visual models and verbal feedback and/or physical practice has a relatively long history of investigation in motor learning, no published investigations have considered how they interact in a learning situation and how they may provide similar or distinct information to the novice to aid skill learning [18, 22, 43, 45]. Also, from a practical point of view and in real life teaching condition during practice, the combination of observational learning, verbal kinematic feedback and physical guidance is one of the most common phenomena of practice during teaching a motor skill. Only few studies have examined the effect of physical guidance on learning motor skills with contrary results [12, 44]. However, it has been pointed out that the benefits of guidance seem to be mainly temporary in nature [38, 39], while other studies support the beneficial effect of guidance during learning [45]. But it is not well known if some of this information is redundant or more effective than others during practice and if it leads to more learning. It was the purpose of this study to determine the effect of such information on learning a complex gymnastics skill, the kip on the high bar, and present the differentiation of kinematic parameters in learning and retention of learning of this skill.

MATERIALS AND METHODS

SUBJECTS SAMPLE

Eighty-four (84) students of physical education aged 18 - 22 participated in this study. The mean chronological age, body mass and body height of the participants were 19.33 ± 1.08 yrs., 80.08 ± 5.66 kg and 176.06 ± 5.44 cm, respectively. The mean differences in these characteristics were not significant between groups. All participants provided informed consent prior to initiating the experiment. They were assigned to one of four groups according to the type of information that they were to receive and all groups had the same number of practice sessions. Group 1, referred to as the observation group (O) observed the other participants' performance. Group 2 observed the other participants' performance and received kinematic information feedback (KFb) in order to correct the next trial. Group 3 observed the other participants' performance and received kinematic information feedback as well as physical guidance by the instructor in order to guide the body position simultaneously (PhG + KFb). Group 4 observed the other participants' performance and received physical guidance. Each type of the information was given in every trial during practice. All participants were new to the task; however, prior to inclusion into the study each had successfully completed a basic fitness test to ensure that they had the necessary muscular strength and flexibility to attempt the task.

TASK AND APPARATUS

The task was the kip in high bar (255 cm height) in artistic gymnastics. The participants were on a raised surface (height: 80cm) having a stable grip of the bar. They started with the forward swing at the end of which they bent the hips to the bar in order to achieve the kip position (bent hips with the legs near the bar). After this they stretched their legs diagonally upward. The body moving backward, they pushed the bar downwards with arms straight and reached the front support position on the bar (Figure 1). All practice trials were captured on videotape by a single JVC VHS (model GR-AX2) placed perpendicular to the plane of motion at a distance of 7 meters from the performer and at the height of 120 cm from the floor. The videotaped trials were later digitized at a simple rate of 24 frames per second and two dimensional kinematics were calculated using BIOKIN kinematic analysis [9]. A scale placed parallel with the plane of motion was used to correct the values derived from the digitizing process to real-life units.

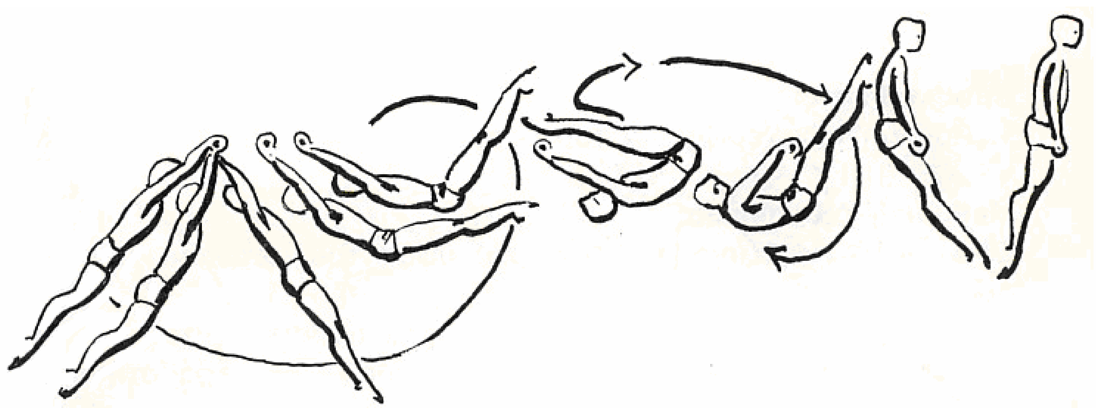

Figure 1. Kip performance on the high bar from a supported surface

PROCEDURE

On the first day all participants were informed about the experimental conditions, and they performed some preparatory floor exercises that related to the hip action during the kip. After this, all participants performed a pre-test in order to verify the initial level of performance. The groups practiced the task every second day for two consecutive weeks. All participants completed twelve practice trials on each of the six separate days for a total of 72 trials. The participants in each group practiced the task together in serial order so that a trial for a given participant was always bracketed (proceeded and followed) by the same participants. After each trial the participant would return to the rest of the participants until called for the next trial. Prior to each practice session the experimenter described the technical aspects of a successful performance of the task and presented the task in real life according to the experimental condition.

Prior to practice each day, all participants followed a 10-minute warm-up that consisted of stretching exercises and special preparation of the muscular group that took part in the experimental task. Also, before starting the practice each participant performed two trials in order to reduce the error of performance (warm-up decrement) for the rest day [9, 23]. To aid the digitizing process and subsequent derivation of movement kinematics, light-reflective markers were attached to the major joint centers (hips, shoulder). The digitizing frames were: 1) Last frame at the end of the forward swing to calculate the horizontal distance of the hips from the perpendicular axis of the bar, 2) the frame that showed the first touch of the feet at the bar (hip flexion after the forward swing) in order to calculate the horizontal distance of the hips from the perpendicular axis of the bar, and 3) the last frame at the end of the forward swing that represented the angle between the arms and the torso.

One day after the last practice session all participants performed a post-test in order to verify the amount of learning, and seven days after the post-test they performed a retention test in order to verify the retention of learning of the task. For these three measures (pre-, post-, and retention) each participant performed three trials. The score was the best trial. According to Little and McCullagh [21], in the cases where learners receive instructions about the form and the outcome of a skill it should be assessed by its form and the outcome. For this reason the qualitative evaluation was done through a subjective rating system by two judges who evaluated 10 important factors in technical performance of the skill on a scale of zero (0) (very poor body position) to ten (10) (excellent body position).

MEASUREMENTS

The dependent variables were: a) the total score, b) the seven spatial parameters (Sp 1-7) and c) the five temporal parameters (Temp 1-5). The seven spatial variables were: 1) the angle between the torso and the hips at the instant of the beginning of the forward swing, 2) the angle between the torso and the hips at the instant that the feet passed through the vertical plane under the bar (hang position), 3) the angle between the body and the vertical plane of the bar at the instant that the body straightened, 4) the angle between the body and the vertical plane of the bar at the instant of completion of the full forward swing, 5) the angle between the torso and the body at the instant of the full forward swing, 6) the horizontal distance of the hip joint from the perpendicular axis of the bar at the instant of maximum forward swing, and 7) the horizontal distance of the hip joint from the perpendicular axis of the bar at the instant of maximum pike of the body when the feet are close to the bar (kip position). The five temporal parameters were: 1) the whole duration of the swing (1^{st} frame at the instant that the feet left the supporting surface until the moment that the participant completed the full forward swing), 2) the duration of the hip flexion (1^{st} frame after the completion of the forward swing until the instant that the feet "touched" the bar after the hip flexion), 3) the duration of the hip extension (1^{st} frame after the completion of the hip flexion until the moment that the feet completed the hip extension), 4) the duration of the hand action to "support the body" on the bar, and 5) the total time of the whole movement.

STATISTICAL ANALYSIS

The dependent variables were the seven spatial and the five temporal measurements, as well the total score. The four groups were the between-subjects factor, while the two measurements (the post - test and the retention test) were the within-subjects factor. In line with the above an initial multivariate ANOVA model with repeated measurements was applied, followed by an univariate ANOVA model for each dependent variable separately. In each case the effects of the group, the measurement, as well as the group x measurement interaction were examined. Post hoc pair - wise comparisons were conducted with the Bonferroni correction. The significance level was set at 0.05.

RESULTS

According to the MANOVA model the measurement effect was not significant (Pillai's trace = 0.080, p = 0.461), while there was an overall significant group effect (Pillai's trace = 1.141, p = 0.001), which was further qualified by a significant group X measurement interaction effect (Pillai's trace = 0.332, p = 0.046).

Figure 2 shows the mean values for the total score of the four groups at the two measurements. The figure clearly shows the absence of any significant measurement effect. Conversely, there were significant differences between the four groups. Groups 3 and 4 scored significantly higher than groups 1 and 2.

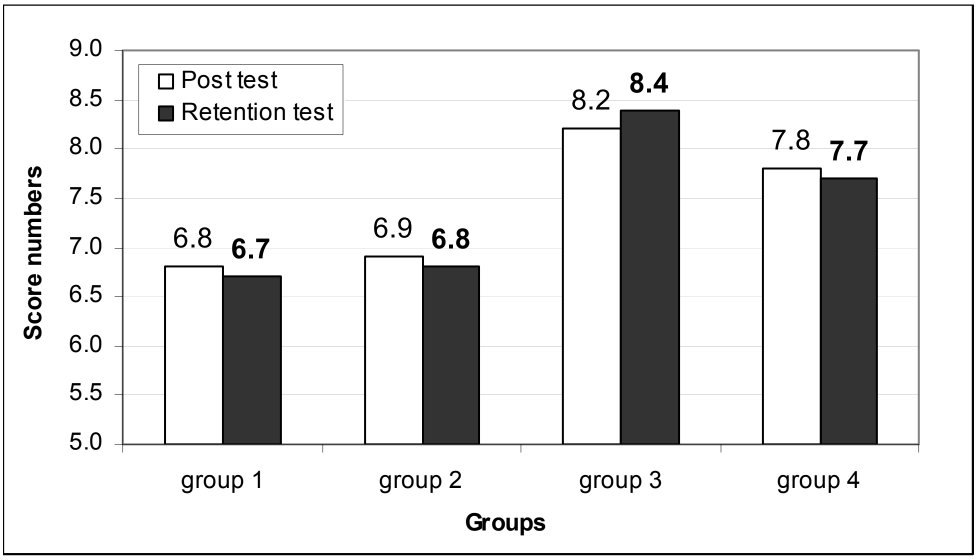

Figure 2. Basic descriptive statistics data of the score in two measurements

The means and standard deviations of all the spatial and temporal variables in the two measurements are presented in Table 1 and Table 2. According to the univariate ANOVA model there was a significant group effect in temporal 1, 2, 3, 4, 5, and spatial 3, 6, 7 in the post-test, and in temporal 1, 3, and spatial 5 and 7 in the retention test. In practically all cases statistically significant differences involved differences mainly between Group 3 and the other groups.

Table 1. Basic descriptive statistics data of the spatial and temporal variables in the post test

Variables	Group 1	Group 2	Group 3	Group 4	F value
Temp 1	0.92 ± 0.06	0.88 ± 0.06	0.84 ± 0.08	0.93 ± 0.06	0.000
Temp 2	0.50 ± 0.07	0.56 ± 0.07	0.52 ± 0.04	0.58 ± 0.09	0.000
Temp 3	0.35 ± 0.07	0.42 ± 0.04	0.43 ± 0.05	0.41 ± 0.03	0.000
Temp 4	0.21 ± 0.03	0.28 ± 0.16	0.24 ± 0.05	0.25 ± 0.05	0.008
Temp 5	1.98 ± 0.17	2.15 ± 0.14	2.04 ± 0.13	2.18 ± 0.11	0.000
Sp 1	159.09 ± 8.96	163.62 ± 9.05	163.62 ± 7.20	161.91 ± 7.14	0.120
Sp 2	149.14 ± 10.78	149.52 ± 15.51	144.95 ± 20.43	147.91 ± 9.75	0.672
Sp 3	22.62 ± 12.94	12.24 ± 5.50	18.52 ± 10.92	22.81 ± 11.33	0.002
Sp 4	24.48 ± 11.91	21.48 ± 6.63	27.29 ± 9.86	27.48 ± 8.49	0.101
Sp 5	174.52 ± 3.86	176.09 ± 2.05	177.09 ± 2.45	175.24 ± 4.07	0.061
Sp 6	88.81 ± 18.97	87.62 ± 18.07	100.48 ± 17.95	101.67 ± 10.29	0.016
Sp 7	75.24 ± 28.83	99.52 ± 15.40	99.76 ± 18.19	94.05 ± 13.19	0.000

Table 2. Basic descriptive statistics data of the spatial and temporal variables in the retention test

Variables	Group 1	Group 2	Group 3	Group 4	F value
Temp 1	0.93 ± 0.05	0.89 ± 0.06	0.86 ± 0.08	0.92 ± 0.04	0.003
Temp 2	0.52 ± 0.05	0.55 ± 0.07	0.54 ± 0.06	0.55 ± 0.05	0.315
Temp 3	0.37 ± 0.05	0.43 ± 0.03	0.39 ± 0.06	0.41 ± 0.04	0.002
Temp 4	0.25 ± 0.04	0.22 ± 0.04	0.24 ± 0.05	0.24 ± 0.25	0.672
Temp 5	2.07 ± 0.14	2.09 ± 0.07	2.04 ± 0.12	2.11 ± 0.13	0.261
Sp 1	161.52 ± 6.45	163.91 ± 4.07	164.95 ± 4.32	164.38 ± 6.77	0.402
Sp 2	147.81 ± 5.09	154.05 ± 15.20	145.67 ± 10.75	149.71 ± 12.45	0.209
Sp 3	23.05 ± 10.48	17.38 ± 9.49	20.91 ± 9.35	22.91 ± 9.67	0.240
Sp 4	26.57 ± 9.78	24.57 ± 8.92	28.26 ± 6.23	26.71 ± 8.14	0.608
Sp 5	174.47 ± 5.02	176.38 ± 2.06	177.91 ± 4.30	176.24 ± 3.34	0.009
Sp 6	100.24 ± 16.16	98.09 ± 19.90	105.00 ± 17.25	99.29 ± 23.99	0.628
Sp 7	85.24 ± 15.45	96.43 ± 14.33	97.86 ± 8.74	98.81 ± 12.73	0.034

The significant group X measurement interaction effect was manifested in three temporal variables, namely, temporal 3, temporal 4 and temporal 5. Figure 3, showing the mean values for the temporal 5 variable of the four groups at the two measurements, helps to unveil the nature of this crossover effect. Groups 2 and 4 had a significant decrease of the mean time of temporal 5 from the post to the retention measurement, while Group 1 showed a significant increase. Group 3's times remained constant.

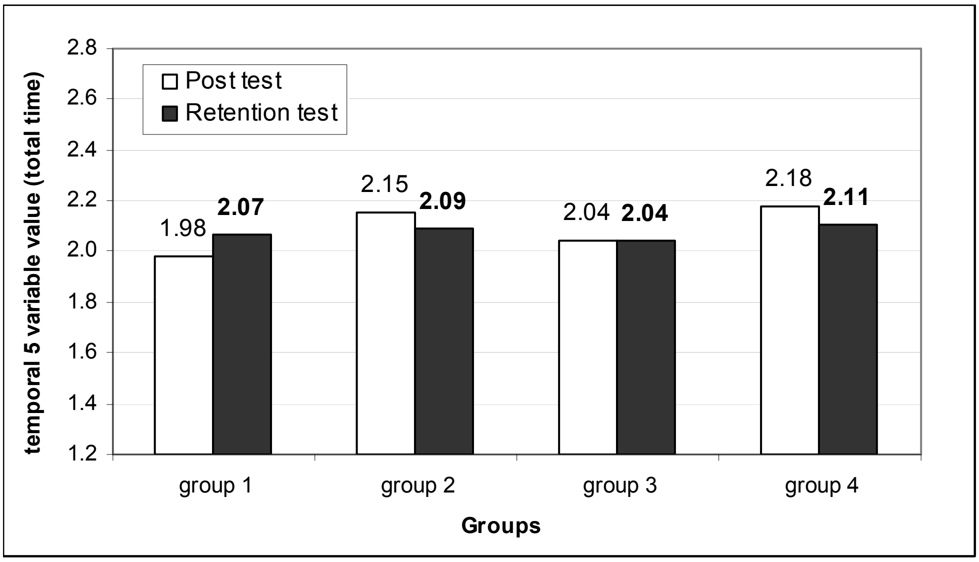

Figure 3. Basic descriptive statistics data for the temporal 5 variable of the four groups in two measurements

DISCUSSION

According to the results, the groups that had received additional physical guidance and kinematic feedback achieved higher score than the other groups in two evaluation measurements (post-test and retention test). The higher score of Group 3 is the evidence that none of the sources of information provided to the participants were redundant. Additionally, although kinematics information feedback had a positive effect in learning the skill on Group 2, which had a higher score than Group 1, it is not adequate to give solutions to these participants in order to achieve a higher level of learning in comparison with Groups 3 and 4. The same was shown in the retention test, where Group 1 had the lowest score. Also the groups' score dropped in the retention test except in Group 3 that had a non-significant increase. It is important that scoring of this experimental skill is related to the position of various parts of body (error form), when the provision of physical guidance is necessary in order to understand their correct position. Considering the kinematic parameters it is worthwhile to note that Group 3 had a constant performance in relation to the total performance time. It is characteristic that the increment of the 1st and 2nd temporal parameters was balanced from the 3rd temporal parameter that referred to hip extension, which is responsible for the successful performance of the skill.

The results of the present study support the previous data which state that model demonstration itself provides additional task-related information, thereby reducing the need for another source of information, regardless of whether the model was skilled at the task or just learning it [35] and that model demonstrations in conjunction with overt physical practice can influence motor skill performance [16, 18, 37, 43]. This means that the participants of Group 1 guided their performance according to the demonstrations, which they received by observing a learning model; besides, the proprioceptive feedback obtained through physical practice served as an additional source of information and helped the observers remain more involved. However, when observing a learning model, each model demonstration itself provides additional task-related information, thereby reducing the need of another source of information [1, 20]. Also, this finding is in accordance with other experimental studies which state that observation of the model before and during practice is beneficial, depending on the task and the age of the performer [2, 19, 42]. Furthermore, better observational learning resulted from observing unskilled models rather than skilled ones, because watching someone improve the performance on a task engages the observer in many of the problem-solving activities undertaken by the learning model [25].

The results of Group 2 (which received additional kinematic feedback) support previous findings, which state that augmented feedback helps the participants become more involved in the learning process [13, 20, 22]. The non-significant differences between Groups 1 and 2 in the post-test could be explained by the fact that observing a model provides information via the visual system that establishes the appropriate task constraints and, as a result of practice, enables the person to perform the skill as required [40]. Knowledge of performance, on the other hand, provides similar information that establishes kinematic constraints to the body and limbs, but this information is based on the person's actual performance [29, 32]. Also, presumably learning by observation via visual and auditory sources was sufficient to support error recognition at a level close to that achieved following physical practice [4].

The groups that received additional physical guidance and/or kinematic information feedback during practice enhanced their performance at a higher level than Groups 1 and 2, which did not receive physical guidance. This finding verifies previous data by Wulf, Shea, and Whitacre [45] which support the notion that physical guidance is an important tool for learning a complex motor skill which involves coordination and control of limbs and body movements to act according to the constraints imposed by time and space in order to accomplish the goal of the skill. Contrary to what would be expected from a guidance hypothesis, according to Schmidt's notion [39, 40] which states that the benefits of guidance seem to be temporary in nature so that when it is withdrawn from the learners in retention, performance is usually no more effective than that of the learners' who practiced the skill without guidance, the use of a spotter enhances not only the performance during practice but also the learning of an efficient movement pattern. The amount of learning of the groups that received physical guidance verifies the notion that the guidance technique is designed to help learners acquire a certain movement pattern with a minimum of error because the instructor has the capability of physically guiding the limbs of a learner through an entire movement pattern or a portion of it. In other words, physical guidance may have been used to convey the general idea of a movement pattern, to help learners in our study to understand different parameters of the skill, such as the full swing, the correct way to act and the correct body position.

CONCLUSIONS

The results of the present study showed that the situation where the instructor, during practice, provided physical guidance and kinematic feedback while learners observed performances by other participants indeed enhanced learning at a higher level than when these two sources of information were provided separately. This means that no such information is redundant. The verbal kinematic feedback may have activated the internal sensory feedback in a different way, which helped learners to perform this gymnastic skill more correctly. Additionally, physical guidance provided to the learners did not degrade learning but suggested that the beneficial effects of guidance procedures were not temporary in nature but could also positively affect the learning of a motor skill. It seems also that physical guidance in conjunction with kinematic information feedback, during practice, was beneficial for learning because it enabled the learners to produce a pattern of coordination that they would not be able to perform without that help.

According to Bandura's social cognitive theory of modeling [3], information is conveyed by modeled performance; the information is then extracted through selective attention to critical features and transformed into cognitive representations of the actions by symbolic coding and cognitive rehearsal. Then, this cognitive representation is used for guided response production and provides a standard against which performance feedback is compared for corrective adjustments, so that the desired behavior may be properly executed. Viewing a live model is a dynamic observation situation, so regardless of whether the model is skilled at the task or just learning the task, observation is beneficial [35]. When the observer then has the opportunity to perform the task, the cognitive representation developed through observation has obviated some of the initial problem solving a novice must learn through physical practice.

PRACTICAL APPLICATION

The results of this study could have important practical implications for instructional settings in which it is usually assumed that giving the learner as much information as possible about the technical aspects of the skill to be learned will enhance learning. It is concluded that physical guidance has an important role during practice, which helps learners to enhance performance and maintain this ability in future situations where such guidance will be absent. A future goal will be to repeat this experimental procedure with a different frequency of kinematic information feedback and physical guidance, in order to verify the importance of these schedules in learning such a complex gymnastic skill.

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