THE EFFECT OF SELF-CONTROLLED AND EXPERIMENTER-CONTROLLED FREQUENCY OF MODEL DEMONSTRATION ON LEARNING A COMPLEX GYMNASTIC ROUTINE

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Abstract

The purpose of the present study was to examine the effectiveness of learning a complex gymnastic routine with different frequencies of model demonstration controlled by the experimenter or self-controlled by learners. Fifty undergraduate physical education (PE) students were randomly assigned to 5 training groups: GF100 (100% frequency), GF20 (20% frequency), GFF (faded frequency), GSF (self-controlled frequency) and GYF (yoked group). All five groups followed the same experimental design, with one difference: groups GF100, GF20 and GFF observed model demonstration under externally controlled frequency, whereas group GSF self-controlled that condition. Participants were asked to perform a complex gymnastic routine (maximum vertical jump) with swinging the arms forwards and upwards, pulling the knees up to the chest while grabbing the shins followed by a half-squat landing with arms extended sidewards. During the acquisition phase, all the participants completed a total of 150 trials, with 15 trials completed in three blocks during each of the ten practice sessions. In the present study, we used expert ratings based on the FIG-COP to evaluate movement quality. For each trial, three gymnastic judges assessed the performance. To assess the differences between the five groups, a repeated measures ANOVA was conducted on the last factor for retention and transfer (Group x Test) and practice (Group x Practice). Partial eta squared (η_p^2) effect sizes were calculated for multiple comparisons and Cohen's *d* effect sizes were calculated for pairwise comparisons. Post-hoc Fisher's LSD test was used for pairwise comparison. No significant Group x Test interaction or Group main effect was found, indicating that no group performed better than another in retention immediate, delayed and transfer tests. For each group, a significant improvement compared to baseline was observed in the retention and transfer tests ($d > 0.8$). The most important finding from the current study was that groups under self-controlled and experimenter-controlled frequency of model observing appeared similarly effective in learning a complex gymnastic routine. No significant differences were observed between the five groups in retention and transfer tests.

***Key words**:* observational learning, gymnastic routine, frequency, students, skill acquisition

Introduction

Physical education (PE) teachers and sports coaches commonly present learners with a variety of information intended to enhance motor learning or performance. One of the methods used in motor skill learning is observational learning (for a review, see McCullagh & Weiss, 2001; Ashford et al., 2007; Ste-Marie et al., 2011). The basic rationale for this come from the assumption that demonstration is more favorable than verbalization for conveying information during skill acquisition (Horn et al., 2002). Hence, video-modeling is extensively used by coaches as a teaching strategy to facilitate acquisition of motor skills, especially in sport settings. The observational practice enables the learner to extract information concerning coordination patterns of the task to organize and evaluate their own actions during a physical practice session. It has been shown that observation can improve motor learning, for example in gymnastics (Baudry et al., 2006; Maleki et al., 2010; Ste-Marie et al., 2011; Robertson et al., 2018), swimming (Clark & Ste-Marie, 2007), trampolining (Ste-Marie et al., 2013) rowing (Anderson & Campbell, 2015) and dance (Fagundes et al., 2013; St. Germain et al., 2019). Throughout the literature, it has been widely confirmed that observational learning enhances motor skill acquisition (for a review, see

Ste-Marie et al., 2012; Ste-Marie, Lelievre & St. Germain, 2020).

Ste-Marie et al. (2012) reported that it is possible to increase the effectiveness of observational learning by manipulating several characteristics (e.g. the angle of viewing, the speed or the frequency of model demonstration). One of such factors is the frequency of model demonstration. To date, the frequencies of model demonstration have been studied under experimenter-controlled conditions (the experimenter sets the frequency of model demonstration for the learners) and under self-controlled conditions (the learner is given the choice of the frequency to observe the model demonstration). Sidaway & Hand (1993) compared the learning effectiveness of hitting a wiffle ball at a target. The participants observed a video recording with experimenter-controlled frequency: 100%, 20% and 10%. The greatest effect occurred in the group with 100% frequency of model demonstration. Similarly, Lofti et al. (2018) found that expert model observation group with 100% feedback frequency on learning a complex serial aiming task had less spatial error than 50% feedback group. In contrast, the study by Bruzi et al. revealed that the number of visual model demonstrations (10 versus 2) of how to throw a dart appeared similarly effective.

Winstein & Schmidt (1990) proposed that the feedback should be adapted to the learning stage by means of a fading feedback strategy. In a faded feedback schedule, the learners receive relatively relative high frequency of feedback early in a skill acquisition phase which is then systematically reduced. Thus, there is no excessive feedback dependency of the learner, leading to subsequently high performance in a retention test. A number of studies have been conducted that prove the positive impact of the fading feedback strategy on the effectiveness of motor skill learning (Winstein & Schmidt, 1990; Lai & Shea, 1999).

In recent years, practitioners have been increasingly interested in self-regulation learning (for a review, see Sanli et al., 2013; McCardle et al., 2017). The reasoning behind this comes from findings which showed that giving the learner control over certain aspects of the practice conditions enhances the motor learning process (Sanli et al., 2013; Wulf & Lewthwaite, 2016; Razaghi et al., 2020). Several explanations have been forwarded to account for self-controlled benefits in the learning process. Janelle et al. (1995, 1997), McNevin et al. (2003), Sanli et al. (2013), Lim et al. (2015), Kok & van der Kamp (2018) suggested that self-controlled feedback stimulates learners to process information on a deeper cognitive level and increases intrinsic motivation and confidence in learners' actions promoting a learning process. Chiviacowsky and Wulf (2002, 2007) suggested that the benefits of self-controlled feedback are related to learners' capabilities to self-evaluate their performance and tailor feedback requests to fit their learning needs or performance. A great body of research has focused on comparing self-controlled feedback with experimenter-controlled frequency of feedback (i.e. the experimenter controlling when feedback is delivered). The participants from the self-controlled group recived feedback on request but those from the externally regulated feedback group were "yoked" to their counterparts from the self-controlled group. The benefits of learning under self-controlled conditions in observational learning was shown, for example, in basketball set shot (Aiken, Fairbrother & Post, 2012), skill sequences on a double-mini trampoline (Ste-Marie et al., 2016), classical ballet tasks (Fagundes et al., 2013; Lemos et al., 2017), pirouette en dehors (St. Germain et al., 2019). These studies showed that groups that self-controlled the conditions during physical practice achieved better outcomes than yoked groups. However, some studies showed no benefit of giving the participants any choice (Wrisberg & Pein, 2002; Liu et al., 2014; McRae et al., 2015; Chiviacowsky & Lessa, 2017; Kim et al., 2019; Nunes et al., 2019). For instance, Wrisberg & Pein (2002) found no differences in the effectiveness of learning a badminton long serve in groups with different frequencies of model observation. In their study, one group used 100% frequency of model demonstration, while another group was allowed to self-control the frequency of model demonstration. For both groups, the results were significantly high and did not differ between the groups. Research by Fagundes et al. (2013) showed that higher self-selected frequencies of model observation could be better than low frequencies. Moreover, in retention, there were no significant differences between groups for physical performance of the learning task (ballet passé relevé) with self-controlled and experimenter-controlled frequency. On the other hand, self-controlled group with high frequency of modeling had cognitive representation significantly better than experimenter-controlled groups. Also, in a group of older adults learning a golf putting task, similar performance was demonstrated by self-controlled and yoked groups (Nunes et al., 2019). Likewise, the self-controlled group of college students had similar performance compared to the group with regulated feedback in the acquisition of backhand return in tennis table (Liu et al., 2014). To date, it is not clear what frequency of model demonstration promotes learning a complex movement task under self-controlled and experimenter-controlled conditions the most. Some studies have reported that under controlled conditions, the participants who observed a video recording of 100% of the trials significantly outperformed those who viewed the recording of 20%, 10% or 0% of the trials (Sideway & Hand, 1993), while others have shown gain observation benefits on low frequencies of observation such as 30% (Ste-Marie et al., 2013), 27% (Aiken et al., 2012), 11,5% (Janelle et al., 1997), 10% (Wrisberg & Pain, 2002), 9% (Post et al., 2016) and 5.8% (Wulf et al., 2005). Moreover, in Wrisberg and Pain's (2002) research, the self-controlled group gained as much advantage as the group with 100% experimenter-controlled frequency. It is interesting to note that Germain et al. (2019) found no differences between groups with 25%, 50%, 75% imposed modeling frequencies and the group with no frequency imposed when learning pirouette en dehors. In addition, Janelle et al. (1997), Fairbrother at al. (2012) have shown that the participants under self-controlled conditions created a faded-feedback schedule as learning progress.

Although the benefits of self-controlled conditions in motor skill acquisition seem convincing, it cannot be the only reason for better learning. To date, only a few studies have been conducted with applied tasks in which video frequency was the independent variable (Sidaway & Hand, 1993; Wrisberg & Pein, 2002; Fagundes et al., 2013; Germain et al., 2018). Studies have rarely compared effectiveness of learning complex gymnastic routines enhanced by self-controlled and experimenter-controlled frequency of model demonstration (for a review, see Jimenez-Diaz, Chaves-Castro & Morera-Castro, 2020). Therefore, the knowledge about the frequency of model demonstration in the learning of complex movement skills under such conditions is ambiguous (Ste-Marie et al., 2012; Ste-Marie, Lelievre & St. Germain, 2020). Moreover, no comparison has been made regarding the effectiveness of the learning of complex movement skills in self-controlled conditions with different experimenter-controlled frequencies of model demonstration.

Due to the conflicting results of the previously reported research, the purpose of the present study was to examine the effectiveness of the learning of a complex gymnastic routine with different frequencies of model demonstration under experimenter-controlled and self-controlled conditions. Based on the above-mentioned literature evidence, it was hypothesized that the group with 100% experimenter-controlled frequency would achieve high performance scores during the acquisition phase compared to groups with lower experimenter-controlled or self-controlled frequency and lower performance scores during retention and transfer tests. It was also expected that the self-controlled group would create a faded-frequency schedule of observation as practice progress and would achieve higher scores for performing a complex gymnastic routine during acquisition, retention, and transfer tests compared to the experimenter-controlled faded-frequency schedule group.

Methods

Participants

The study included 50 undergraduate students (n = 50; 35 males, 15 females) selected randomly from 85 first-year physical education (PE) students who participated in gymnastic education classes (30 hours) as part of university education program. Additionally, the participants had to meet the following criterion: no lower extremity injury that prevented them from physical activity for more than one week over the last 3 months. The participants were randomly assigned to one of five practice groups: GF100 – 100% frequency (n = 10; age 20.3 ± 0.5 years; height 174.5 ± 5.8 cm; body mass 75.3 ± 4.5 kg); GF20 – 20% frequency (n = 10; age 20.3 ± 0.9 years; height 176 ± 7.8 cm; body mass 72.3 ± 13.1 kg); GSF – self-controlled frequency (n = 10; age 20.9 ± 0.9 years; height 171 ± 9.5 cm; body mass 68 ± 10.3 kg); GYF – yoked group (n = 10; age 20 ± 0.4 years; height 172.6 ± 8.2 cm; body mass 71.8 ± 10.6 kg); GFF – faded frequency reduced from 20% to 14% (n = 10; age 20.5 ± 1.1 years; height 180.1 ± 8.8 cm; body mass 77.8 ± 6.6 kg). All the students participated in the study voluntarily and they provided written informed consent before data collection. The research was conducted following the principles of the Declaration of Helsinki. Ethical approval was provided by the Scientific Research Ethics Committee of Józef Piłsudski University of Physical Education in Warsaw.

Experimental task

The participants were asked to perform a complex gymnastic routine (maximum vertical jump) with swinging the arms forwards and upwards, pulling the knees up to the chest while grabbing the shins followed by a half-squat landing with the arms extended sidewards (Fig. 1). At the beginning of the task, the participants stood barefoot with their feet together and their arms extended downwards. The experimental task was unknown to them. No feedback was provided to the participants.

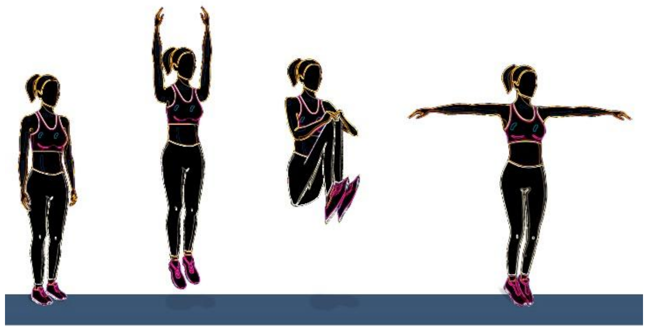

Fig. 1. Four selected phases of a learning gymnastic routine presented by the animated model.

Experimental design and procedures

Research was conducted over a 3-week period on non-consecutive days in a gymnastic hall on a standard surface (wooden floor). Baseline and immediate retention tests were administered before and after the final acquisition session. Delayed retention and transfer tests were conducted seven days after the final session. All tests involved 5 trials. The transfer test was completed in other environmental conditions. The participants performed the experimental task from 50 cm high platform. Prior to commencing the baseline test, they were permitted to observe a video recording (3 times) of model demonstration (expert gymnasts performing the task). The practice session was separated from baseline and immediate tests with a 20-minute break.

All five groups followed the same experimental design, with one difference – groups GF100, GF20 and GFF observed model demonstration under externally controlled frequency but group GSF self-controlled that condition. Group GF100 observed the model demonstration before each trial (15x; 100%), group GF20 observed the model demonstration before each of the 3 blocks (3x; 20%), while group GFF was provided the faded frequency schedule as follows: practice 1-3 – 3 times per session (before each block); practice 4-8 – twice per session (before block 1 and 2); practice sessions 9-10 – once per session (before block 1). The participants from group GSF were told that they could ask for model demonstration after any trial if they requested it. The participants from group GYF were told that they would receive model demonstration after some trials. GYF condition schedules matched the schedules created by their counterparts in the GSF condition.

Prior to commencing each session, the participants performed a standardized warm-up (running /10 minutes, stretching exercises /10 minutes). All the groups were given standardized instructions before they observed the model demonstration. The instructions informed them that after observing the model demonstration, they should emulate the model technique in each trial. A 24-in, 60 Hz AOC monitor (230LM00024 Taiwan) presented the image. The monitor was placed 5 m from the participants so that the model subtended a realistic visual angle of 18º. In the acquisition phase, the participants were presented with one repetition of the model demonstration at a normal speed. All the participants viewed the same modeling video.

During the acquisition phase, all the participants completed a total of 150 trials, with 15 trials repeated in three blocks during each of the ten practice sessions. There were 60-second intervals between each trial and a 20-minute break between each practice block, respectively. In the present study, we used expert ratings based on the Inernational Gymnastics Federation (FIG) – Code of Points 2017-2020 (2016) to evaluate movement quality. For each trial, three gymnastic judges assessed the performance. The errors made by the participants during performance were penalized by deduction of 0.10 to 0.50 points (on a scale of 10 points in accordance with the Code of Points – FIG, 2016). The average of the three scores was the final performance score. The judges were blind with respect to the purpose of the study. The kappa coefficient for inter-rater agreement was k = 0.891. The learning effect was evaluated on the basis of the mean absolute error value (AEr).

Statistical analyses

The sample size for the current study was guided by the sample sizes and analyses of similar studies (Sidaway & Hand, 1993 (n =10); Winstein, Pohl & Lewthwaite, 1994 (n = 10); Park, Shea & Wright, 2000 (n = 9); Anderson & Campbell, 2015 (n = 8); Ghorbani & Bund, 2016 (n = 10, n = 11)). Power analysis of the research using G*Power Version 3.1.9.4 (Faul et al., 2007) showed that with estimated moderate effect size, it was determined that a minimum of ten participants were required in each group (effect size f = 0.60, power = 0.95, p = 0.05). Therefore, the recruited sample of 10 participants in each group was considered appropriate.

Normality of distribution and homogeneity of variances were tested with the Shapiro-Wilk test. To assess the differences between the five groups, a repeated measures ANOVA was conducted for retention and transfer (Group x Test) and practice (Group x Practice). Partial eta squared (η_p^2) effect sizes were calculated for multiple comparisons (0.01 – small; 0.06 – moderate; 0.14 – large) and Cohen's *d* effect sizes were calculated for pairwise comparisons (0.2 – small; 0.5 – moderate; 0.8 – large) (Cohen, 1992). Post-hoc Fisher's LSD test was used for pairwise comparison. Statistical significance was set at $p < 0.05$. Data were analysed using STATISTICA 12 (StatSoft, Inc. 1984-2014, USA).

Results

Analysis of variance at baseline revealed no significant differences between the five groups ($F_{4,45} = 0.11$; $p = 0.98$; $\eta_p^2 < 0.01$), allowing findings during acquisition and post-acqusition phases to be reasonably attributed to the effects of the frequency of the modeling manipulation.

The overall frequency of model demonstration imposed on groups GF100, GF20, GFF was 150 times, 30 times, 21 times, respectively. The partcipants in the SCF condition asked to see video-modeling an average of 57.5 times (38%) out of 150 possible. The frequency of observing the model gradually decreased from 67.3% to 25% from practise sessions 1 to 10.

Figure 2 shows AEr scores for self-controlled and experimenter-controlled conditions during the acquisition phase. Both conditions showed increased performance across practice sessions. There was a significant main effect of group ($F_{4,45} = 3.33$; $p = 0.02$; $\eta_p^2 = 0.23$). However, only results of GSF were significantly better than the results of GF20 ($p < 0.007$) and GFF ($p < 0.03$). Also, GYF showed better results than G20 ($p < 0.014$). There was no difference between GF100 and other groups during the pre-acquisition and post-acquisition phases. During immediate, delayed retention and transfer tests, all the groups reduced their error.

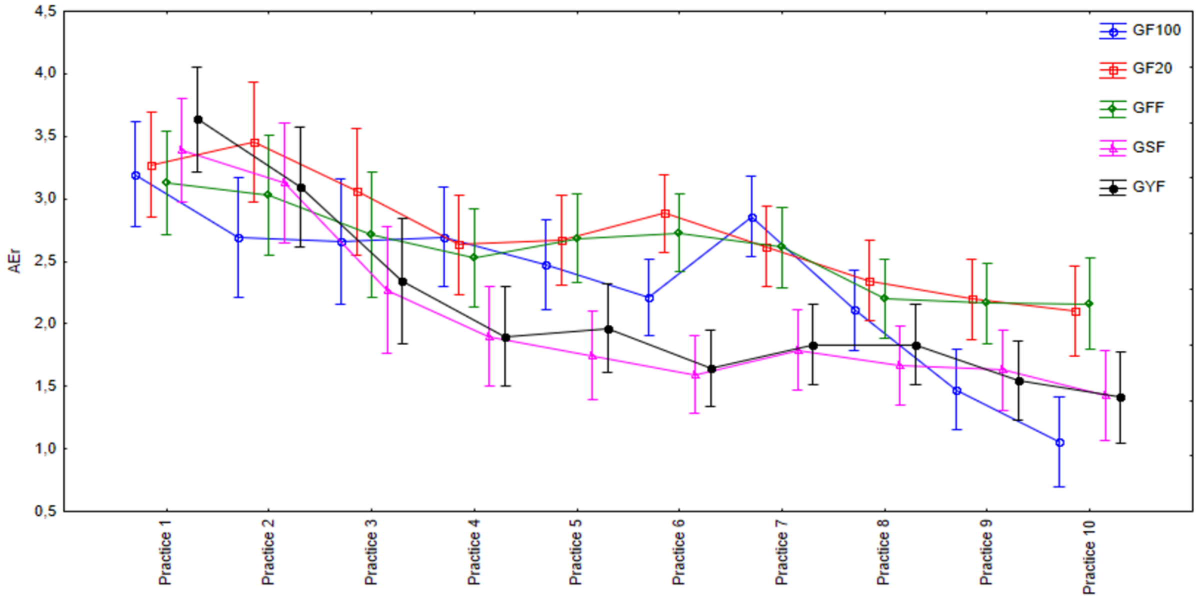

Fig. 2. Mean AEr values in GF100, GF20, GFF, GSF and GYF during the acquisition phase.

ANOVA revealed a significant main effect of practice in each group ($F_{9,405} = 112.78$; $p < 0.001$; $\eta_p^2 = 0.71$). Four of the groups performed similarly and showed a significant decrease in Aer from the third practice session ($p < 0.001$, $d > 0.8$) but group GF20 from the fourth practice session. Compared to baseline, the biggest reductions in Aer were noted in GF100 (68%, $p < 0.001$, $d = 4.46$), GSF (57%, $p < 0.001$, $d = 2.74$), GYF (56%, $p < 0.001$, $d = 3.56$), G20 (37%, $p < 0.001$, $d = 2.15$) and GFF (33%, $p < 0.001$, $d = 2.32$). These observations were supported by the significant Group x Practice interaction effect ($F_{36,405} = 6.71$; $p < 0.001$; $\eta_p^2 = 0.37$).

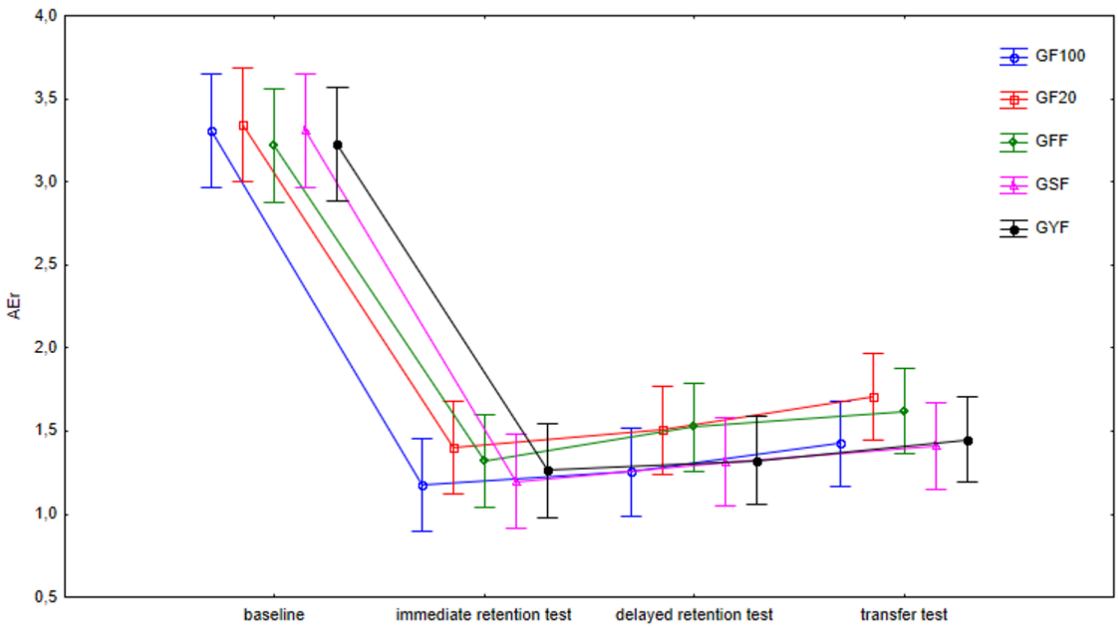

Fig. 3. Mean AEr values in GF100, GF20, GFF, GSF and GYF during the two phases of the experimental design: pre-acquisition and post-acquisition.

Figure 3 shows mean AEr values for each group during the pre-acquisition and post-acquisition phases. During immediate, delayed retention and transfer tests, all the groups reduced their error scores compared to baseline. There was a significant main effect of Test ($F_{3,135} = 583.56$; $p < 0.001$; $\eta_p^2 = 0.93$).

No significant Group x Test interaction (F12,135 = 0.62; $p = 0.82$; $\eta_p^2 = 0.05$) or Group main effect ($F_{4,45} = 0.51$; $p = 0.73$; $\eta_p^2 = 0.04$) was found, which indicates that no group performed better than another in immediate retention, delayed retention and transfer tests.

A similar improvement in AEr in the immediate test was observed in groups GF100 (64.3%, $p < 0.001$, $d = 4.60$) and GSF (63.8%, $p < 0.001$, $d = 4.47$), followed by GYF (60.9%, $p < 0.001$, $d = 4.18$), GFF (59.0%, $p < 0.001$, $d = 4.64$) and GF20 (58.1%, $p < 0.001$, $d = 3.15$). The AEr performance in the delayed retention and transfer tests was deteriorating relative to the immediate test. The smallest deterioration in AEr was observed in the delayed retention test in GYF (4.8%, $d = 0.16$), followed by GF100 (6.6%, $p > 0.05$, $d = 0.2$), GF20 (7.6%, $p > 0.05$, $d = 0.17$), GSF (9.5%, $p < 0.05$, $d = 0.31$) and GFF (15.6%, $p < 0.001$, $d = 0.68$). Further deterioration in AEr results occurred in the transfer test and was the lowest in GFF (6.1%, $p < 0.05$, $d = 0.26$), followed by GSF (7.5%, $p < 0.05$, $d = 0.30$), GYF (9.5%, $p < 0.01$, $d = 0.31$) , GF20 (13.7%, $p > 0.001$, $d = 0.37$) and GF100 (13.4%, $p > 0.001$, $d = 0.42$).

Discussion

The aim of the current study was to examine the effectiveness of learning a complex gymnastic routine with different frequencies of model demonstration controlled by the experimenter or self-controlled by learners.

It was expected that groups with more experimenter-controlled frequency (100%) of model observation would guide the learner to better performance in the acquisition phase and worse performance in the post-acqusition phase compared to the group with self-controlled frequency and the groups with lower experimenter-controlled frequency. On the other hand, it was also anticipated that those groups would manifest a lower decrease in performance during the post acquisition phase. According to the guidance hypothesis (Salmoni et al., 1984), frequent feeback may have positive effects guiding the learner to better performance during the acquisition phase but too frequent feedback may decrease performance in the retention test or when feedback is removed. However, many studies have revealed that principles derived from the study of learning simple skills are not necessarily generalizable to the process of learning complex skills (for a review, see Wulf & Shea, 2002). The most important finding from the current study was that groups under self-controlled and experimenter-controlled frequencies of model observation appeared similarly effective in learning a complex gymnastic routine. No significant differences between the five groups in retention and transfer tests were observed.

The complexity of movement skill could have had an impact on the results of this study. Few research results indicate that the increased frequency of feedback during the learning of complex movement skills may have positive effects leading the learner to achieve the set goal (for a review, see Wulf & Shea, 2002). Sigrist et al. (2013) suggested that with the growth of a task complexity, feedback should be provided more often, leading to prevent the learner from cognitive overload. Sidaway et al. (2012) established that 33% feedback frequency is effective in learning simple movement skills, while 100% feedback frequency – in the case of complex movement skills. Wulf, Shea & Matschiner (1998) and Wulf et al. (2010) also confirmed that 100% feedback frequency enhances the learning of complex movement skills (100% vs. 50%; 100% vs. 33%). In general, we were not able to support our first hypothesis. Our findings showed that 100% frequency of model demonstration may not be needed to maximize the effectiveness of motor skill learning. Present results corroborate previous works which reported beneficial effects of reduced knowledge of results frequency for observational learning (33% vs. 100%) (Wrisberg & Pein, 2002; Badets & Blandin, 2004).

However, the values of Cohen's *d* effect size achieved by the five groups during the post-acquisition phase confirmed that the model demonstration promotes the learning of complex movement skills. In their review, Wulf & Shea (2002) noted that during observational learning, there may be more to extracted information about relatively complex skills, as compared with simple skills. In addition, observation may facilitate the memories structure supporting the movements, thus leading to effectively reduced total memory demands. This result may be explained by the fact that participants had higher level of physical fitness than less active people of the same age (Fairbrother et al., 2012). Also, Marchal-Crespo et al. (2013) established that the use of visual feedback is more effective for people who represent higher levels of physical fitness. Guadagnoli et al. (2002) showed that task complexity and task-related experience interacted with the optimal number of trials. Huang (2000) argued that the effect of model demonstration strategies depends on the participants' ability to detect performance errors. Our participants were semi-skilled in gymnastics, which allowed them to create a clear mental image and develop a skill of judging correctness of an observed model demonstration after a few presentations. These inconsistent results point to the important role that the participants' level of motor competence may play in different learning protocols. Following this rationale, it might also be speculated that the task learned and the participants' fitness levels could influence the result of a particular model demonstration study. Perhaps the gymnastic routine chosen to learn turned out to be to simple for the participants.

Our second hypothesis was that the group with self-controlled frequency of model observation will be more efficient in improving performance and learning a complex gymnastic routine than groups with experimenter-controlled frequency. Also, it was proposed that group GSF would create a faded frequency schedule of learning. Those hypotheses were partly confirmed and supported by many studies (Wrisberg & Pein, 2002; Wulf, Raupach & Pfeiffer, 2005; Aiken, Fairbrother & Post, 2012).

In the case of group GSF, the participants asked for model demonstration in 39% of the cases and frequency gradually decreased from 60.1% to 24% from practice sessions 1 to 10. Moreover, 60% of these requests occurred during the first trials but only 28% during the last practice trials. In previous studies, self-controlled frequency was reported, i.e. 27% (Aiken, Fairbrother & Post, 2012), 48.9% (Ste-Marie et al., 2013), less than 10% (Wrisberg & Pein, 2002) and 5.8% (Wulf, Raupach & Pfeiffer, 2005). Despite such a low frequency of observing the model demonstration, the participants significantly improved the performance of the gymnastic routine. Also, during the acquisition phase, group GSF demonstrated significantly better performance compared to groups GF100, GF20 and GFF ($p < 0.05$). These results confirmed that self-controlled conditions during physical practice of the skill lead to better outcomes by the learners (Sanli et al., 2013; Wulf & Lewthwaite, 2016). The findings are consistent with the results of previous research which showed that self-controlled frequency of observing the model demonstration is better compared to externally imposed one, e.g. in a ballet passé relevé (Fagundes, Chen & Laguna, 2013), skill sequences on a double mini-trampoline apparatus (Ste-Marie et al., 2013) or golf-chipping task (Post et al., 2016). Contrary to our hypothesis, the findings of this study showed no benefit of giving the participants any choice during retention and transfer. There were no significant differences between five groups. The current results corroborate earlier findings, e.g. Wrisberg & Pein, 2002; Liu et al., 2014; McRae et al., 2015; Chiviacowsky & Lessa, 2017; Kim et al., 2019; Nunes et al., 2019.

The values of Cohen's *d* effect size during the acquisition phase revealed that group GF100 demonstrated the fastest significant improvement in practice performance ($d > 0.8$) compared to other groups, as it was already possible during practice session 2. This result is consistent with the established findings of research indicating that frequent feedback has a beneficial immediate effect on the learning of complex movement skills (Wulf & Shea, 2002). However, the results of five groups, reported both during the acquisition and post-acquisition phases of the experiment, indicate that the quality of performance during practice sessions does not always reflect the final motor skill learning result.

The practical implications of our study are that observational modeling during early stages of learning a complex gymnastic routine, when participants are attempting to create an appropriate pattern of the task rather than produce more outcomes, may by similiarly effective with different experimenter-controlled and self-controlled frequencies. However, self-controlled frequency of observing the model is more effective during the acquisition phase than when frequency is externally imposed. It is useful because coaches, PE teachers and physiotherapists are not always available during the learner practice.

Further research is required with the use of motor skills of different complexities as well as participants with high and low levels of physical fitness.

Conclusion

The aim of this study was to investigate the effectiveness of learning a complex gymnastic routine with different experimenter-controlled and self-controlled frequencies of model demonstration. It was proved that observational learning with self-controlled frequency of model demonstration proved to be equally effective compared to the group with high and low experimenter-controlled frequency. The differences between the groups were found only during the acquisition phase. The self-controlled group outperformed groups with externally imposed frequency. It worth highlighting to practitioners that the learner performance during the acquisition phase does not necessarily guarantee the final effect of motor skill acqusition. To date, knowledge about the optimal frequency of model demonstration in the learning of complex movement skills is incomplete. Further research in this vein is recommended.

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