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Research Article

Effect of self-controlled feedback on the learning of dive roll in children and adults

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HIGHLIGHTS

- Knowledge of performance feedback had positive effects for adults.
- Self-controlled can produce different effects in adults and children.
- Children use the same criteria as the adults to request information.

ABBREVIATIONS

FDR	False discovery rate
GC	Control group
GSA	Adult group with SKP
GSC	Group of children which received SKP
GYA	Adult group with yoked KP
GYC	Group of children with yoked KP provision
ICC	Intraclass Correlation Coefficient
KP	Knowledge of Performance
PRE	Baseline
POST	After the practice sessions
RET	4 days after POST
SKP	Self-controlled Knowledge of Performance

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BACKGROUND: Self-controlled feedback has been identified as an efficient strategy for teaching motor skills, however, different results have been shown in adults and children. Researchers point out that the different characteristics in the information processing of these populations can explain these discrepancies.
AIM: The objective was to investigate the effects of providing Self-controlled Knowledge of Performance (SKP) on learning the Dive Roll, a specific Artistic Gymnastic skill, in children and adults.
METHOD: A total of 24 children participated, divided into two groups: a group which received SKP (GSC) (n=12) and a group with yoked Knowledge of Performance (KP) (GYC) (n=12). In addition, 20 adults participated, divided into 2 groups: a group which received SKP (GSA) (n=10) and a group with yoked KP (GYA) (n=10). Descriptive analyses were performed and the permutation test was applied to compare groups and evaluation times (pre-test, post-test, and retention).
RESULTS: The results indicated significant improvements for the adult groups (self-control and yoked). The groups of children did not show improvements in performance over the evaluation times, but there was a difference between the groups in retention, with the GSC performing better compared to the GYC.
CONCLUSION: It is concluded that self-controlled feedback has different effects between children and adults.

KEYWORDS: Motor learning | Feedback | Knowledge performance | Self-control | Artistic gymnastic

INTRODUCTION

Artistic gymnasts are awarded scores resulting from the combination of the difficulty of the intended movements and how well they are actually performed, with points being deducted for errors. Watching these athletes repeat their routines could be described as witnessing a fascinating ode to flawless movement patterns. However, our understanding of how these motor actions can be mastered with such a high level of performance is still not well understood. The learning of sports skills depends on the control of different fundamental and specific motor skills, which, when combined, gain a greater degree of complexity, considering the number of elements that compose them [1]. In the process of acquiring and refining these skills, teachers and coaches adopt different strategies for providing information to learners. The provision of augmented feedback is commonly used, considered as a fundamental component of the motor learning process [2,3].

The frequency of augmented feedback in the learning of motor skills is a source of investigation in different studies [4,5,6,7,8]. Some research has shown positive effects for learning under conditions in which the learner has greater autonomy to decide when to receive feedback, denominated self-controlled feedback, when compared to conditions in which the learner has no control over this frequency (yoked) [9,10,11,12].

The hypotheses that explain the benefits of self-controlled feedback demonstrate that learners request information according to their needs, actively participating in the learning process [12], providing relevant demand for information processing and increased intrinsic motivation [13]. According to Sanli's review [14], self-controlled practice context can facilitate factors such as learner autonomy and competence, thus supporting the learner's psychological needs, leading to changes in behavior. A practice context created to meet the

learner's psychological needs subsequently leads to changes in motivation experienced by the individual. Studies conducted with adults indicated beneficial effects of self-controlled feedback for learning different motor skills [15,16,17,18].

However, it is well established that children differ from adults in terms of their ability to process information [19,20], and plan and organize movements [21,22]. There are also arguments that the greater cognitive effort present in a self-controlled practice condition could be disadvantageous for some subjects if it exceeds their individual capacity [23]. In line with this reasoning, some studies found differences in the effects of feedback frequencies (KR and reduced feedback) between adults and children, suggesting that the information processing capacity of children should be taken into account when structuring practice and providing feedback [24,25]. The studies by Kok et al. [26], Chiviacowsky et al. [27], and Chiviacowsky et al. [28] who investigated the effects of self-controlled feedback with children, found no differences between groups in learning different tasks (video feedback for learning shot put, KR for learning bean bag target throwing, and KR for learning a numerical sequencing task, respectively). Chiviacowsky et al. [28] argue that the benefits of self-controlled feedback were not evidenced in children due to differences in the processing of information that they present in relation to adults.

In view of these arguments, the current study questions whether self-controlled feedback can be an efficient strategy to enhance the learning of adults and children in a complex Artistic Gymnastic motor skill. The objective was to investigate the effects of providing self-controlled feedback on the learning of the Dive Roll by children and adults. Since the participants of this study were not familiar with the context of Artistic Gymnastics and did not have knowledge about the skill of the Dive Roll, it was decided to use Knowledge Performance feedback. To guide this study, the following hypotheses were formulated: a) all groups with feedback, regardless of the condition (self-controlled or yoked), will perform better after the acquisition phase; and b) the groups in the self-controlled condition will present better retention performance when compared to the yoked groups. It is hoped that the results of this study can contribute to the understanding of the effects of self-controlled feedback on the learning of a complex motor skill, especially in children.

METHODS

Participants

In total, 24 children participated, divided into two groups: a group which received Self-controlled Knowledge of Performance (SKP) (GSC) (n=12) and a group with yoked Knowledge of Performance (KP) (GYC) provision (n=12). For the composition of the adult group, 20 individuals participated, divided into 2 groups: a group with SKP (GSA) (n=10) and a group with yoked KP (GYA) (n=10). All participants in the yoked KP groups (GYC and GYA) were matched by sex and baseline performance level with participants in the corresponding self-control group (GSC and GSA, respectively). In addition, four children who started the experiment in the self-controlled group, did not request any information throughout the intervention process, so they were excluded from the GSC and formed a control group (CG), since they performed all the practice without any information. The characterization and division of groups are presented in Table 1.

Table 1 – *Characteristics of the groups.*

Group	N	Female	Male	Mean age	SD
GSC	12	4	8	10.6	0.8
GYC	12	4	8	10.8	0.6
GSA	10	4	6	22.8	2.2
GYA	10	4	6	23.7	2.1
CG	4	2	2	10.5	0.7

All participants and those responsible for the children were informed about the collection procedures and signed an informed consent form approved by the ethics and research committee of the local university (CAAE: 56871816.6.0000.5231; number: 2.568.407).

Instruments

To assess the ability in the skill, the checklist elaborated by Medina-Papst [29] and validated by Costa et al. [30] was used. This instrument contemplates five phases of the skill to be observed in the learning evaluation, namely: impulsion, flight, landing, rolling, and finalization.

The learning assessment was carried out based on the deduction of the scores obtained by the learner, with the same starting scores assigned for all participants. In this way, everyone started with the same score (10.0) and the deductions (discounts) were made

according to the errors observed in the performance of the skill. The evaluations were conducted by 3 trained evaluators, who watched the filmed images and recorded the observations in an excel spreadsheet. The videos were presented to the evaluators in random order in relation to the participant and moment of evaluation (PRE, POST, and RET).

For filming the skill in the PRE, POST, and RET phases, a Sony digital camera, model Handycam DCR-SR42, with a sampling frequency of 60 Hz and programmed with automatic shutter speed was used. For the intervention, as well as for filming the evaluation phases (PRE, POST, RET), three large gymnastic mats were used. In addition, a questionnaire[16] was applied at the end of the intervention phase to identify the learners' preference in requesting information.

To support the intervention, a list of KPs was created, showing the errors and the respective correction information. This list was submitted for evaluation by 3 specialists in the field of Motor Behavior before its implementation.

Procedures

Before starting the intervention, all participants were evaluated in relation to their performance in the basic skill of grouped rolling and they should have presented proficient performance based on the standard proposed by Gallahue and Donnelly [31]. This procedure was adopted to guarantee that the participants presented mastery of the basic skill, allowing the specialization of the movement [32].

After verifying the stabilization of performance in the basic motor skill, the study began on the investigation of the effect of KP at a self-controlled frequency on learning of the complex skill of dive roll.

The subjects' motor performance in the skill was assessed at baseline (PRE), after the practice sessions for learning the dive roll skill (POST), and a third time, 4 days after the POST (RET). The practice period consisted of 5 sessions, with 30 practice trials of the skill, totalling 150 trials. The sessions took place twice a week, on alternate days, lasting approximately 20 minutes each and were taught by the researcher with the help of a previously trained Physical Education teacher.

During the sessions, the participants were instructed on the amount of practice included in the session and viewed a video demonstrating the dive roll motor skill in a notebook before starting the first and third sessions. The GSC and GSA were instructed, at the beginning of all practical sessions, to request information when and as many times as they wanted it. Throughout the practice, the attempts for which the participants requested feedback, as well as the information provided, was recorded to enable pairing with participants in the yoked groups. Thus, the GYC and GYA received feedback controlled by the experimenter, in a paired way with the self-controlled groups (GSC and GSA, respectively). All participants received KP according to their learning needs and progressively. The experimenter defined what information the learner needed progressively following the order of movement phases (from 1 to 11 as per the table below).

Table 2 – *KP information provided.*

Thrust	1 - Bend your knees and push off the ground to jump
	2 - Jump up and forward, keeping your arms glued to your ear
Flight	3 - Stretch your legs after you jump;
	4 - Keep your legs straight after you jump
	5 - Stretch your arms and place your hands as far away as you can
Landing	6 - Fly before putting your hands on the ground
	7 - Keep your chin on your chest
Rolling	8 - Scroll forward
	9 - Roll the body into a ball
Finalization	10 - Keep your body curled up until you touch your feet to the floor to get up
	11 - As you place your feet on the floor, quickly throw your arms forward to get up and keep your eyes straight ahead

At the end of the practice sessions, the same questionnaire used in the study by Chiviacowsky and Wulf [16] was applied to understand when and why learners requested feedback.

Data Analysis

Data were analyzed descriptively using median and frequency. To determine the agreement between the three evaluators, the Intraclass Correlation Coefficient (ICC) was applied through the scores obtained in the observations, showing a good level of agreement (PRE ICC=0.81; p=0.000; POST ICC=0.88; p=0.000; RET ICC=0.88; p=0.000). After verifying the agreement of the evaluators, it was

decided to use the score that represented the median of the 3 analyses in each attempt, followed by the median of the three attempts of each phase.

Subsequently, the data were organized and analyzed using R, adopting a significance level of $p < 0.05$. A comparison was made between the PRE and POST evaluation moments within each group using the non-parametric permutation test (1 group x 2 moments). The same test was used to compare the RET of the groups of children (GSC and GYC) and adults (GSA and GYA) (2 groups x 1 moment). To compare the frequency of KP throughout the sessions, a permutation test (2 groups x 5 sessions) was performed with repeated measures on the last factor. The *post hoc* analysis was performed using permutation tests. To compare the frequency of KP in each phase of the skill, the permutation test (4 groups x 5 phases) with repeated measures on the last factor was applied. The *post hoc* test was performed using the paired t-test, with FDR correction - false discovery rate (as proposed by Benjamini, Hochberg to adjust the *p* value due to multiple comparisons).

RESULTS

The results revealed that children requested very similar amounts of information (GSC=10.7%; max=25.3%; min=4.7%) to adults (GSA=9.6%; max=17.3%; min=2%). In addition, they maintained a similar frequency of KP requests throughout the sessions, while adults requested more information in session 1, decreasing over the course of practice. Statistical analysis confirmed these results with session effects (p=0.021) and interactions between groups and sessions (p=0.005). The *post hoc* test indicated differences only in session 1, with a higher frequency of KP being observed for the GSA group. Figure 1 presents the results of the KP frequency throughout the practice.

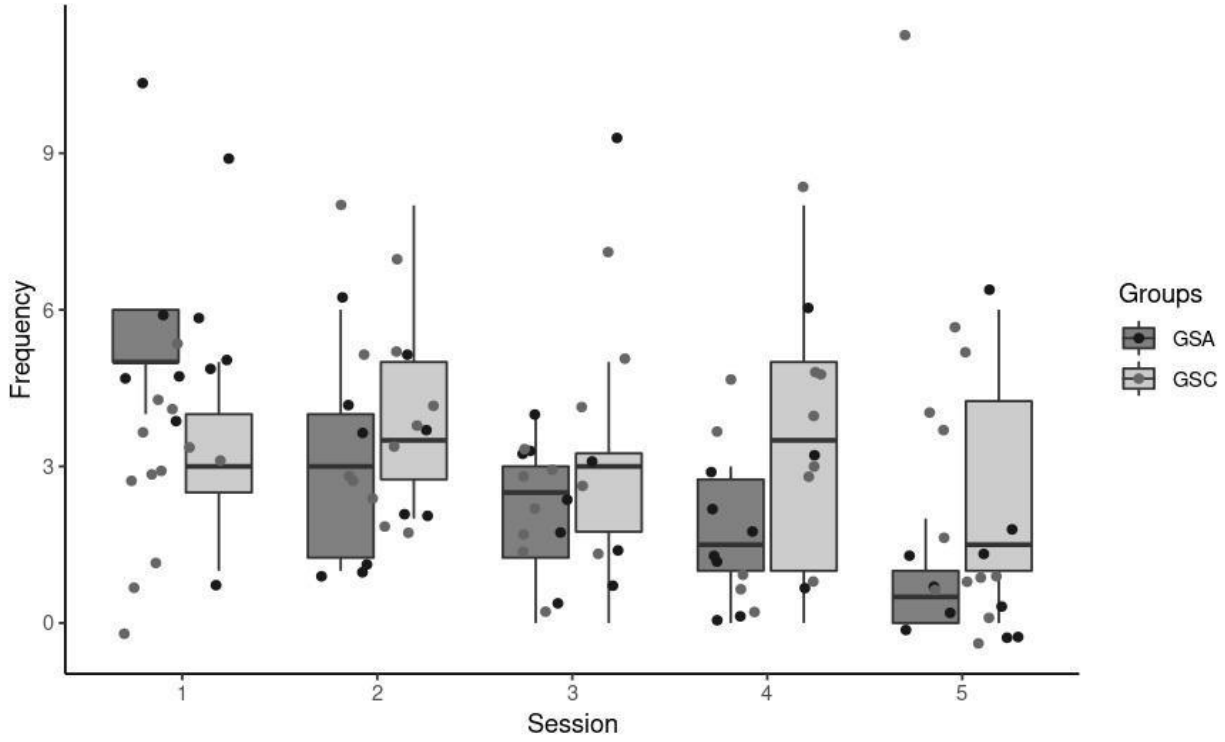

Figure 1. Amount of KP requested by the GSC and GSA groups throughout the practice sessions. Source: The authors

Regarding the skill phases (Figure 2), it was observed that most participants received more information regarding the Impulse phase (GSC=40.6%; GYC=41.6%; GSA=45.8%). Only the GYA received the most information regarding the Flight phase (GYA=39.5%) and the least amount of information in the Finalization phase (2.8%). Figure 2 summarizes this information.

Statistical analysis demonstrated effects only of the skill phases (p=0.000). *Post hoc* demonstrated differences between different skill phases, as shown in the table 3.

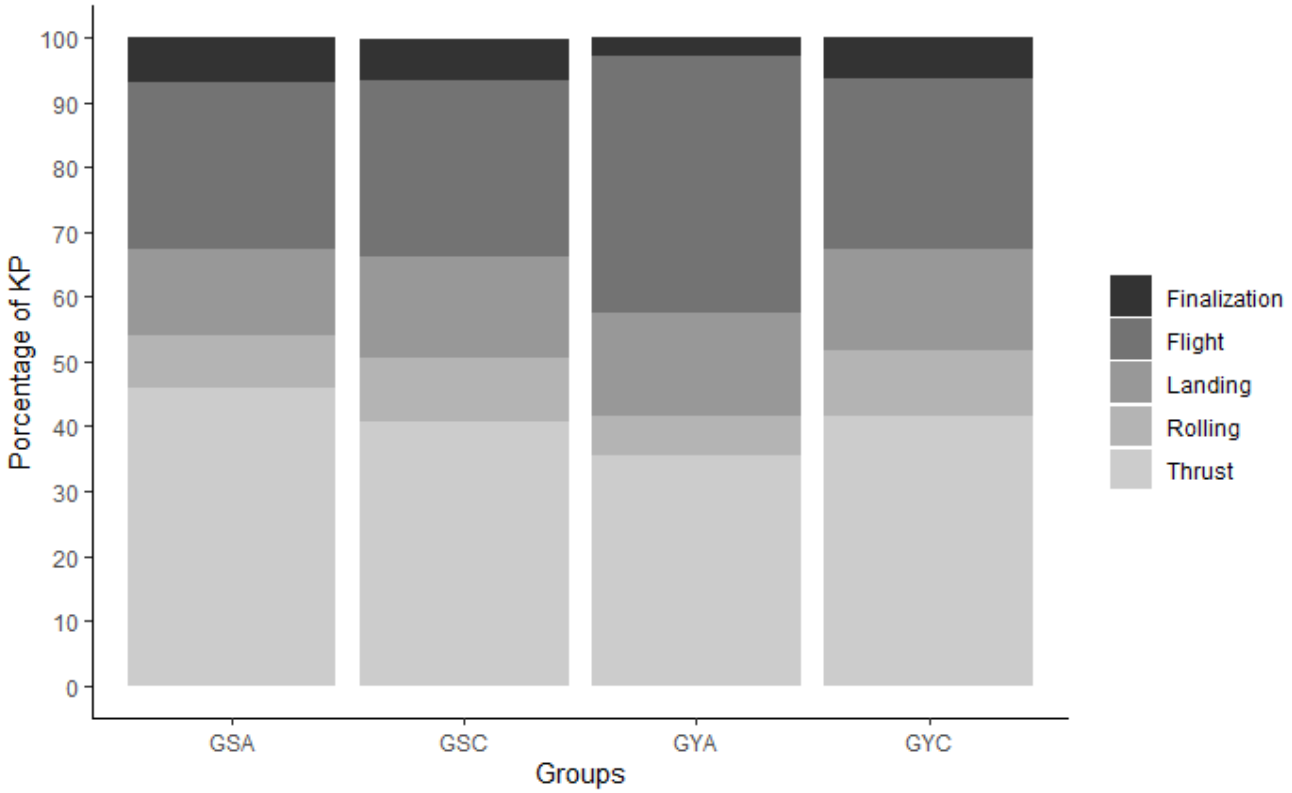

Figure 2. Amount of KP (%) in relation to the skill phases. Source: The authors

Regarding the group of children (Figure 3), the comparisons between the PRE and POST moments did not indicate significant intragroup differences (GSC p=0.171; GYC p=0.757). However, there was a significant difference between the groups in the RET (p=0.049), with the GSC performing better compared to the GYC. With regard to the performance of the CG, the children presented the following medians, PRE=5.75, POST=4.00, and RET=3.75.

Regarding adults, the comparisons between PRE and POST indicated a significant difference for the GSA (p=0.000) and for the GYA (p=0.000). The comparisons between groups in the RET, however, did not indicate significant differences (p=0.797). Figure 4 shows the performance results of the groups at the evaluation times (PRE, POST, and RET).

Regarding the results of the questionnaire applied at the end of the intervention, 9 GSC participants (80%) reported that they preferred to receive KP after a bad attempt, 2 (16%) preferred to receive KP after a good attempt, and 1 (8%) preferred to receive it randomly. Regarding the GSA, 8 participants (80%) preferred to receive information after a bad attempt and 2 (20%) responded that they preferred to receive it in other ways (1 participant preferred to receive it randomly and 1 participant preferred to receive KP to confirm their performance).

With regard to the groups receiving experimenter-controlled information, 9 participants (75%) from the GYC reported believing they received the information they needed after the trials and 3 (25%) stated that they did not receive the KP they needed after the trials. When these three participants were asked when and how they preferred to receive KP, one said they would prefer to receive information after a good attempt to confirm their performance, and two preferred to receive KP after a bad attempt to improve on the next attempt.

Table 3 – *Results of the comparison between the skill phases.*

	Finalization	Flight	Landing	Rolling
Flight	p>0.001*	-	-	-
Landing	p>0.001*	p>0.001*	-	-
Rolling	p=0.168	p>0.001*	p=0.012*	-
Thrust	p>0.001*	p=0.005*	p>0.001*	p>0.001*

In the GYA, 8 participants (80%) reported that they received information after the attempts they needed and 2 (20%) believed that they did not receive information when they needed it, of which 1 indicated that they preferred to receive information after a bad attempt and 1 reported that they preferred to receive it after a good attempt. Regarding the CG, at the end of the intervention phase, the participants were asked why they did not request information throughout the entire practice. In general, these participants reported not asking for information because they felt were performing well in the proposed skill.

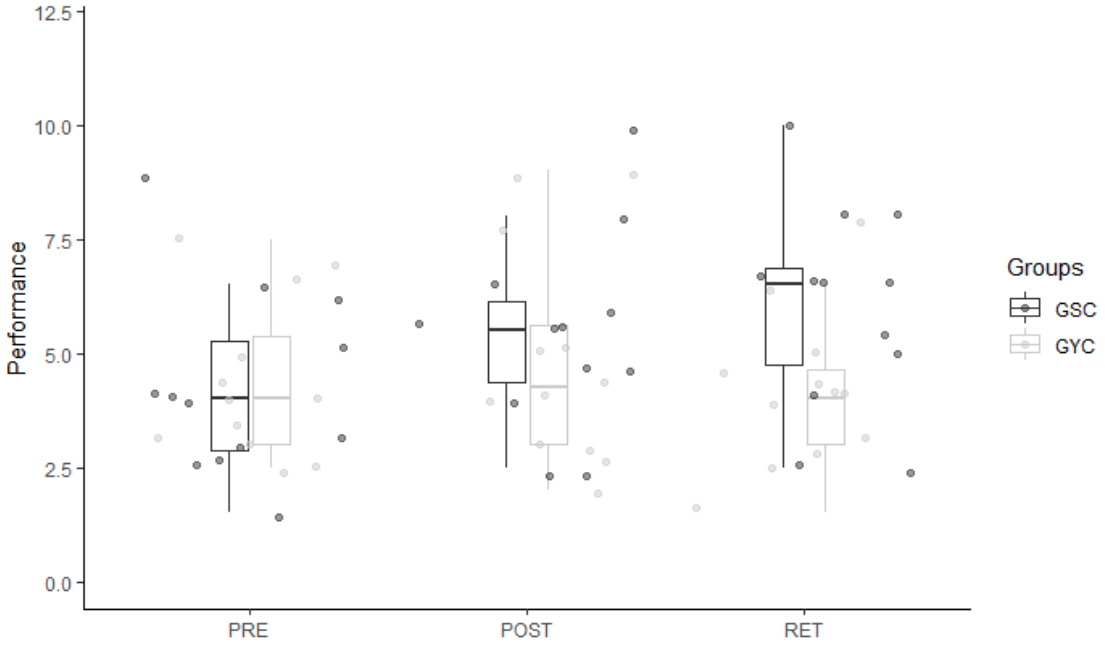

Figure 3. Performance of the GSC and GYC groups at the three evaluation moments. Source: The authors

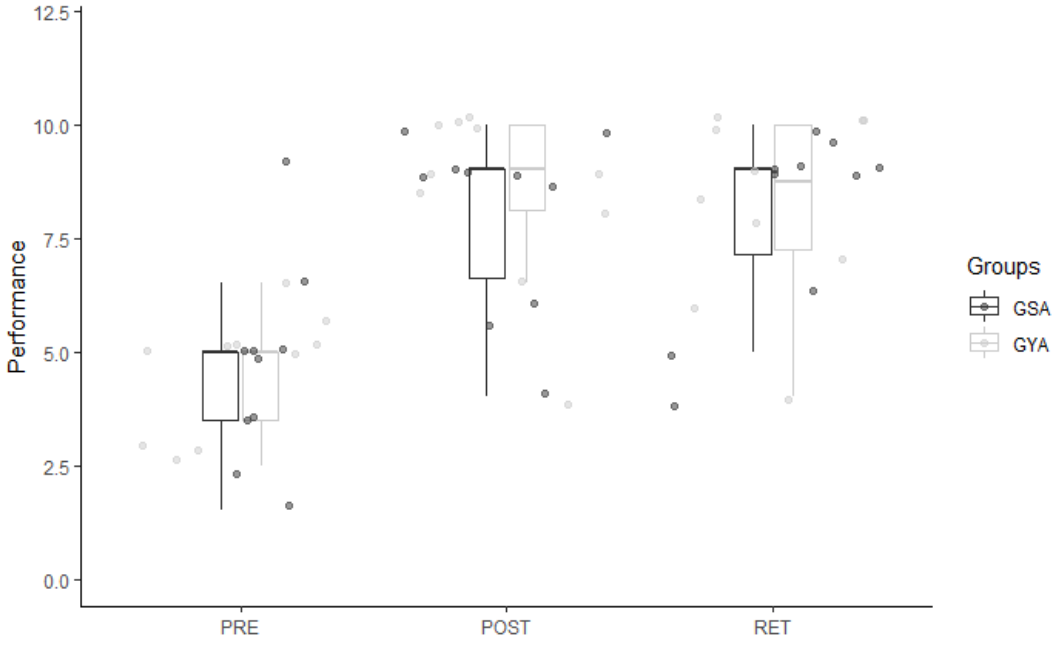

Figure 4. Performance of the GSA and GYA groups at the three evaluation moments. Source: The authors

DISCUSSION

The objective was to investigate the effects of providing self-controlled feedback on the learning of the Dive Roll by children and adults. The results indicated a significant improvement for the groups of adults, however, there was no improvement in the performance of children in the POST or RET.

Our findings showed that the two self-controlled groups (GSA and GSC) presented a similar frequency of feedback requests. However, the decrease in the amount of information associated with improved performance after the intervention was only observed in the GSA, which seems to indicate that this group found it easier to deal with self-controlled KP. In the GSC, however, this decrease in the request for feedback was not observe, nor were significant differences verified after the intervention (PRE and POST). It is known that learners in the initial to intermediate stages of motor learning require more information to correct their movements and, throughout practice, they need less information [7,33]. It may be that for children to learn complex skills, a greater amount of experience in the task is needed and, consequently, more feedback [25].

Medina-Papst, Ladewig, Rodacki and Marques [34] investigated the use of tips for learning the dive roll by children and did not find a significant improvement in performance in the skill. The authors justified that the effects were not observed because the children were afraid to perform the impulsion, flight, and landing phases. Similarly, Guadagnoli and Lee [23] suggest that task demands, learner characteristics, and practice conditions interact to influence the level of challenge presented during practice, as proposed by the Challenge Point Framework. According to the Challenge Point Framework, if the challenge level exceeds this ideal challenge point, the cognitive effort may be far beyond the learner's information processing capacity, thus interfering with the benefits of learning. The ideal challenge point is different for learners with different information processing abilities and skill levels, such as children and adults. In this study, the practice conditions and the challenge level proposed by the task may have influenced the children's performance. Thus, these aspects must be taken into account when structuring interventions with children, especially when the skill demand seems to be very high [25].

An interesting fact observed in this study was that some children who were free to request information, did not (CG). At the end of the intervention, these children were asked about the reasons that led them not to request information, and they reported that they felt they were performing satisfactorily. However, this group of children did not perform satisfactorily and did not in fact show improvements over the evaluation periods, which in this case may indicate their difficulty in evaluating their own performance, discriminating between good and bad attempts, as proposed by Chiviacowsky and Wulf [16].

The results of the questionnaire indicated that, in general, the children (GSC) used the same criteria as the adults to request information (after bad attempts), which suggests that the difficulty may not be centred only on the evaluation of their own performance, but also on the ability to use information effectively. Taken together, these results reveal that there is heterogeneity in the group of children in the same age group. This aspect makes us question whether we can consider children and their ability to process information according to their age group, with further studies being necessary to understand whether children are able to identify the segment or phase of the skill requiring correction with the same accuracy as adults.

Although the groups of children did not show improvements in performance after the intervention, the groups showed differences in the RET, with the GSC performing better compared to the GYC. The study by Gonçalves et al. (2011) [35] also did not verify the effects of self-controlled KP on learning a sport motor skill in children. Sullivan, Kantak and Burtner [25] indicated that children need more time of practice with feedback to learn a task. Thus, self-control can favor the learning of skills by children, however, the practice time, as well as the challenge, must be considered when structuring the intervention.

Considering the groups of adults (GSA and GYA), although there were no significant differences observed between the groups in the RET, differences were found between the evaluation moments (PRE and POST). This result indicates that both self-controlled and yoked practice, as well as the amount of KP, promoted the learning of dive roll for adults.

These results contrasted with the classic study by Janelle, Kim and Singer [15] using KP for learning to underhand ball throwing in adults, where the self-controlled group outperformed the yoked group in retention. However, the studies by Ferreira et al. [36] and Chiviacowsky et al. [27] did not verify significant differences between groups with the use of self-controlled and yoked KR for learning a laboratory task in adults and a specific golf skill in adults, respectively. It is possible to assume that the similar learning between groups of adults is due to a motivational effect [14]. Specifically, we believe that the autonomy of the GSA group was preserved, increasing intrinsic motivation [14], which provided improved performance. In turn, we believe that the GYA group also felt motivated throughout the practice, since most participants (80%) reported having received KP after the trials they needed. Thus, if there was a motivational effect, although in different ways, it provided a similar result between the learning conditions (self-controlled and yoked).

CONCLUSION

The results of this study allow us to conclude that self-controlled KP can produce different effects in adults and children. In relation to adults, both self-controlled and experimenter-controlled feedback helped subjects to learn the dive roll. Motivation seems to play an important role in this process. Regarding the children, the level of complexity of the task was shown to interfere with the effects of the KP, but self-control favored the learning of the skill. The children presented a heterogeneous group in the evaluation of their own

performance. Thus, it is important that the characteristics of individuals for providing feedback, the conditions of practice, and the level of challenge proposed by the task are considered when structuring the practice.

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