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Original Article

Effects of three Observational Learning Models with Contextual Interference on the Performance and Learning of Handball Skills

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Abstract

Introduction: Observational modeling combined with physical training involving contextual interference can impact the acquisition and execution of complex sports movement skills.
Objective: The purpose of this study was to determine the effects of three type of observational modeling accompanied without and with contextual interference on acquisition, retention, and transfer of handball skills.
Methods: 90 right-handed female students in the age range of 12 to 16 years old who had no participation experience in handball competitive training, randomly located into six experimental groups. Groups' interventions determined by combination of three types of modelling (live expert modelling, expert video modelling, self-modelling) and two type of practice conditions (blocked and random). Measurements of groups performance were conducted in four sections of pre-test, the end of acquisition period and 72 hours after finishing of acquisition period (retention and transfer tests) using overhead pass test, forward 9 meters free throwing test and 30 meters dribbling test.
Results: The results of repeated measures analysis of variance, two-way analysis of variance and follow-up test showed the interaction effect of modelling type and contextual interference, self-modelling in pass skill acquisition, live expert modelling in shoot skill acquisition, and expert video modelling in pass skill retention were the most effective method of modelling, and the effect of contextual interference were observed only in acquisition and retention of pass skill.
Conclusion: On the basis of the findings of the present study, random self-modelling resulted in more acquisition, and random expert video modelling resulted in more retention of pass skill.

Keywords: Learning, Observation, Videotape recording, Contextual Interference, Motor Skills.

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1. Introduction

Scholars in the motor behavior field suggest that utilizing modeling with various sensory inputs can enhance the development of motor skills. On the other hand, observational training and modeling are commonly used techniques in teaching sports skills. The research literature highlights the effectiveness of live skill demonstrations by skilled performers, coaches, and peers in modeling observation (1,2). Moreover, presenting observational models to learners through different mediums such as videos of skilled performers, self-learning videos, animations, and highlighting key points has been proven beneficial. While experimental studies indicate that observational modeling combined with physical training yields better results than pure physical training in terms of learning and performance, the impact on motor skill performance surpasses the actual skill acquisition. Continuous and discrete motor skills have shown to benefit more from observational learning compared to other types of skills (3-5).

Moreover, the impact of observational modeling on adult skill performance is significantly higher compared to children, whereas its influence on task goal achievement is minimal in adults but notable in children (2,6). These results indicate that younger learners exhibit a stronger drive to reach motor skill outcomes in contrast to adults, who prioritize adaptation. The interplay between performance dynamics and task dynamics highlights developmental disparities in the efficacy of observational learning. Conversely, the guidelines proposed for modifying training conditions stem from studies utilizing basic laboratory tasks, raising doubts about their applicability to intricate motor skills in real-world settings, such as those required in various sports (6-8). This debate on the varying effectiveness of observational learning for motor skills of different complexities has been supported by multiple research endeavors. Given these considerations, including developmental discrepancies and variations in modeling effectiveness for simple versus complex movement skills, the question arises: what is the optimal modeling approach for teaching handball skills to novice female players?

Various studies have explored the impact of observational modeling on the learning and execution of sports skills in different fields such as basketball, badminton, tennis, shooting, gymnastics, and judo (9-11). The results of these studies vary due to differences in intervention features, sample populations, and specific sports skills. For instance, it has been found that a combination of modeling and feedback, followed by self-modeling with or without feedback, enhanced the acquisition and retention of badminton long serve. On the other hand, it has been discovered that different modeling methods had similar effectiveness in learning judo skills, despite positive outcomes from all interventions (5,8,9,11,12). Conversely, there have been limited studies examining the impact of modeling type in conjunction with different training setups (blocked and random training). Also, it was found that variable training was more effective than fixed training in observational learning. However, a study showed no significant difference between blocked and random conditions. Other studies showed that the random observation training outperformed the blocked and random physical training in retention and transfer tests (10,13).

A study found no significant difference between the physical training and observation groups that practiced in a blocked and random manner (5). Also, it has been demonstrated that the random combined exercise group outperformed the blocked and random physical and observational exercise groups, even in the transfer test (7). A study examined the interactive effect of contextual interference (blocked/random) and type of training (observational/physical/combined) on learning badminton skills. The results indicated that in the stages of delayed retention and transfer, combined and random physical training resulted in superior learning outcomes compared to other interventions (12). Furthermore, a study explored the impact of contextual interference with observational learning on basketball skills in 10-11-year-old beginner students. Five types of interventions were investigated, including blocked physical training, observational training, blocked serial physical exercise, serial observational exercise, and no intervention. Observational modeling was utilized through live peer performance demonstrations. The findings from this study indicated that the block and chain observation exercise proved to be successful in enhancing the execution of skills in both form and outcome (14-16). Comparisons between different groups further supported the effectiveness of chain observation training in improving dribbling control execution compared to blocking formation. Nevertheless, the impact of contextual interference on the execution of two-handed chest passes and observation dribbles did not seem evident. Based on the data at hand, it seems that a combination of skilled modeling and varied physical training could result in enhanced learning and performance. Nonetheless, the presence of contradictory evidence emphasizes the necessity for further research in this area.

Based on the information provided, it can be inferred that observational modeling combined with physical training involving contextual interference can impact the acquisition and execution of complex sports movement skills. The influence of this combination varies across different age groups. The study aimed to investigate how different types of modeling (live demonstration by a skilled individual, video demonstration, self-learning video) interact with various training arrangements (blocked and random) in terms of skill acquisition, retention, and transfer. The effectiveness of handball (passing, shooting, dribbling) was specifically examined in novice female athletes aged 12 to 16.

2. Methods

2.1. Design

The current study utilized a semi-experimental research method. The research design is depicted in Figure 1, where A represents the independent variable of the experimental protocol type (A1 to A6), G represents the group type (G1 to G6), R represents random assignment, and O represents the measurement of dependent variables at different times. These measurements consist of pre-test (O1 to O6), acquisition test (O7 to O12), retention (O13 to O18), and transfer (O19 to O24). The study included six types of experimental protocols and groups, each corresponding to a specific research group.

1. Modeling a skilled person with blocked practice
2. Modeling a skilled person with random practice
3. Video modelling of a skilled person with blocked exercises
4. video modeling of a skilled person with random practice
5. One's own video modelling with blocked exercises
6. One's own video modelling with random practice

Table 1. Research Design.

Attribution	Groups	Pre-Test	Experimental Protocol	Acquisition-Test	Retention-Test	Transfer-Test
R	G1	O1	A1	O7	O13	O19
R	G2	O2	A2	O8	O14	O20
R	G3	O3	A3	O9	O15	O21
R	G4	O4	A4	O10	O16	O22
R	G5	O5	A5	O11	O17	O23
R	G6	O6	A6	O12	O18	O24

2.2. Participants

The study included 90 right-handed adolescent girls aged between 12 and 16, divided into six groups of 15 individuals each. These participants were chosen from a pool of 200 female students in the first year of secondary school. While all the girls had received handball training at school, none of them had prior experience in team training at various competitive levels or championship competitions.

2.3. The experimental procedure

Initially, the essential preparatory sessions for acquiring handball skills and conducting the required tests were delivered across three sessions, during which participants were instructed to adhere to the provided guidelines for all training and testing activities. Subsequently, the pre-test measurements were conducted in a distinct session, after which participants were assigned at random to one of six experimental research groups. These groups were required to attend the research location as per the specified timetable and to avoid any absences.

After completing a 10-minute warm-up consisting of light running, joint rotations, and stretching, the participants proceeded to observe the pattern during three rounds, with three attempts for each skill, before practicing the skills with five attempts for each skill. The sequence of skills in modeling and physical training in blocked conditions was fixed (pass, shoot, and dribble), while in modeling and physical training in random conditions, the sequence was altered to ensure that no skill was repeated twice in a row. Table 1 displays the sequence of skills in modeling and practice in random conditions. The training distance was set at 15 meters for passing skills, 9 meters for shooting skills, and 30 meters for dribbling skills. In total, 15 shots, 15 passes, 15 dribbles, and a combined total of 45 attempts were performed in each session. Over the course of eight sessions during the three-week acquisition period, a total of 360 attempts were made for the three skills. To model the skilled person, the performance of six skilled players (one player for each group, all members of the club's handball team) was utilized, allowing the participants to observe the skilled person's performance from a side angle. For video modeling, the J.E. camera model 1035 with 10-megapixel imaging quality made in China was used to capture the performance of the skilled person and the participant himself, with the videos being displayed on a 21-inch Sanam TV made in Iran. All videos were filmed from a side angle and at a distance of 10 meters from the performer. Each training session concluded with five minutes of body cooling.

The evaluation test took place during the final session of the course. Following a 72-hour gap from the conclusion of the evaluation session, the retention and transfer assessments were carried out. Throughout all training sessions and evaluations, a standard spherical leather ball, size two, with a circumference ranging from 54 to 56 cm and weighing between 325 to 375 grams (size 25 according to the regulations of the World Handball Federation for women and young girls over 14 years old) was utilized. Additionally, the participants' performance in executing skills was monitored and documented by two handball-savvy observers (one for observation and one for recording) using the designated forms (appendix one). A Citizen model D.X. 9116 chronometer manufactured in Japan was employed to measure the time taken to complete the dribbling skill.

Table 2. Sequence of Skills in Random Exercises.

Sequence	The Sequence of Skills in Modeling	The Sequence of Skills in Practice
First	Run 1: Pass, Shoot, Dribble Run 2: Shoot, Pass, Dribble Run 3: Dribble, Shoot, Pass	Run 1: Pass, Shoot, Dribble Run 2: Shoot, Dribble, Pass Run 3: Dribble, Pass, Shoot Run 4: Pass, Shoot, Dribble Run 5: Shoot, Pass, Dribble
Second	Run 1: Shoot, Pass, Dribble Run 2: Pass, Dribble, Shoot Run 3: Dribble, Shoot, Pass	Run 1: Pass, Dribble, Shoot Run 2: Dribble, Shoot, Pass Run 3: Shoot, Pass, Dribble Run 4: Pass, Dribble, Shoot Run 5: Dribble, Shoot, Pass
Third	Run 1: Shoot, Pass, Dribble Run 2: Pass, Dribble, Shoot Run 3: Dribble, Shoot, Pass	Run 1: Shoot, Pass, Dribble Run 2: Pass, Dribble, Shoot Run 3: Dribble, Shoot, Pass Run 4: Shoot, Pass, Dribble Run 5: Pass, Dribble, Shoot

2.4. Measurements

The current study assessed the participants' performance in passing, shooting, and dribbling skills across four time periods: pre-test (before the acquisition period), acquisition test (last session of the acquisition period), retention tests, and Transfer (72 hours after the end of the acquisition session). Standard handball tests were used to measure and record their performance. Furthermore, the participants' performance during eight skill acquisition sessions was also evaluated.

The objective of this assessment is to evaluate the accuracy of the performer's overhead pass skill and targeting ability, as developed by Zain (1981). In this evaluation, a line is marked 15 meters away from the wall for the ball to be passed on the ground, with three circles of 150, 95, and 45 cm respectively drawn on the wall. Participants are positioned behind the line in a comfortable stance to pass the ball towards the designated target on the wall with maximum velocity over 10 attempts. The passes are made with the dominant hand from above the head. A designated individual meticulously records the location where the passes make contact. Scoring is based on hitting the ball within the circles, with 3 points for the smallest circle, 2 points for the medium circle, and 1 point for the largest circle. The scoring range for this test is from zero to a maximum of 30 points.

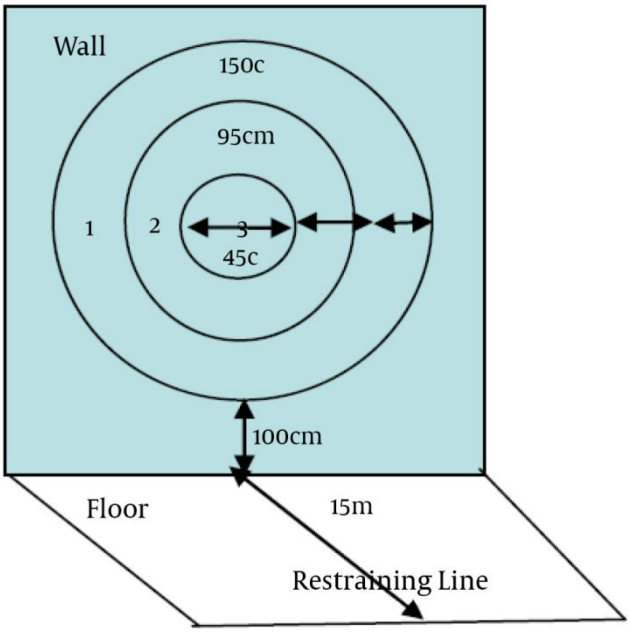

Figure 1. Overhead Pass Skill Test (Zinn, 1981).

The 9-meter forward free throw skill test aims to evaluate the player's precision in free throw skill and the ability to execute shots with a high likelihood of scoring a goal. Zain (1981) developed this test. In this assessment, a line is marked 9 meters away from the wall for the free throw on the ground. A rectangle measuring 200 cm in height and 300 cm in length is drawn on the wall, with the bottom part touching the ground. Participants stand behind the line in a comfortable position to perform the free throw, shooting the ball at maximum speed for 10 attempts (five standing and five jumping). The ball is aimed towards specific areas on the wall. Scoring is based on hitting different zones, with 1 point for the central area, 2 points for the upper-central area, 3 points for the lower-side areas, and 4 points for the upper-side areas. A designated person records the accuracy of the shots. Scores range from zero to a maximum of 40 in this test.

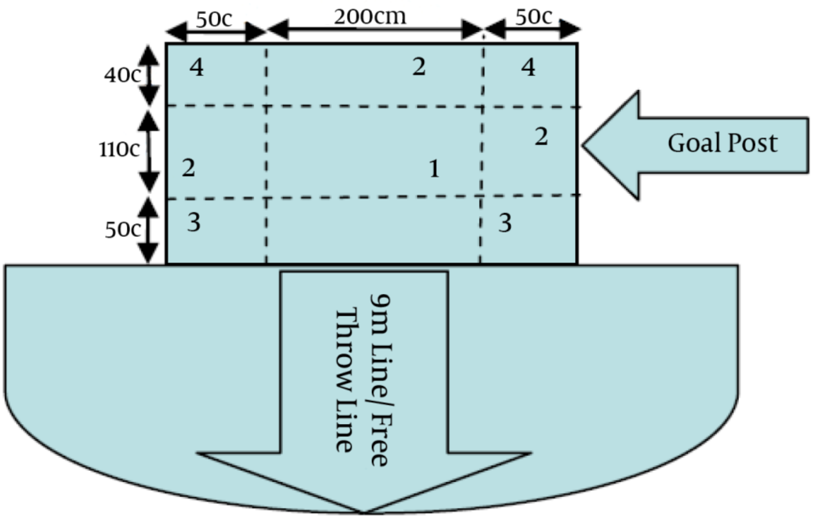

Figure 2. 9-Meter Forward Free Throw Skill Test (Zinn, 1981).

The 30-meter dribbling test assesses the player's speed while dribbling. The participant starts in a comfortable position behind the starting line with the ball in hand. Upon the examiner's signal, they dribble at maximum speed along the straight path. The time taken to complete the test indicates the speed of execution in dribbling. If errors are made during the test, it will be repeated (Lidor et al., 2005).

It is important to note that the distance used for the pre-test, acquisition, and retention test was 15 meters for passing skill, 9 meters for shooting skill, and 30 meters for dribbling skill. However, the distance and angle for the transfer test were altered, with the distance set at 16 meters for the pass skill test, 9 meters for the shot skill test, and a change in the throwing angle (from the left and right of the goal), and 35 meters for the dribbling skills test. Additionally, the number of attempts for the pre-test and acquisition tests was 15 attempts, and 10 attempts for the retention and transfer tests. Due to the varying number of attempts at different stages of measurement, it was necessary to normalize the participants' performance in the tests in relation to the number of attempts. Therefore, the final grade for all tests was calculated and recorded by dividing the total score/record obtained in each stage by the number of attempts. Each measurement session began with a 10-minute warm-up (smooth running, joint rotation, and stretching) and performing skills to prepare (three attempts for each skill), and concluded with a five-minute cool-down.

2.5. Data analysis

The data analysis procedure involved the utilization of various statistical tests. The Shapiro-Wilk test was employed to assess the normality of data distribution, particularly when the number of observations in each distribution was less than 50 cases. Levine's test was conducted to examine the homogeneity of variance among the groups being compared. Additionally, Macholi's sphericity test was utilized to evaluate the sphericity of the data, assuming the implementation of a time series design. In cases where non-sphericity was detected, the Greenhouse-Geisser correction (epsilon ε) was applied to adjust the degrees of freedom. Furthermore, the analysis of variance with repeated measures (RM-ANOVA) was carried out to investigate the impact of six interventions on the acquisition, retention, and transfer of handball skills across four measurement stages. Subsequently, paired t-tests with Bonferroni's correction were conducted for post hoc intra-group comparisons if the main effect was deemed significant. Moreover, a two-way analysis of variance (ANOVA) was performed to assess the influence of different types of modelling and contextual interference on learning outcomes. Fisher's least significant difference (LSD) test and Duncan's multiple range test were employed for post hoc intergroup comparisons in cases where the main effect of intergroup factors was statistically significant. All analyses were conducted at a 95% confidence level using the Statistical Package for Social Sciences (SPSS) version 22.

3. Results

The Shapiro-Wilk test results indicated that the data distribution for all variables was found to be normal ($P<0.05$), while Levin's test results confirmed the homogeneity of variance for the variables ($P<0.05$). Table 3 displays the findings from the analysis of the impact of modeling type and contextual interference on passing skill execution. In the pre-test phase, the main effect of modeling type ($F_{2,84}$=2.864, p=0.063, η^2= 0.064), the main effect of contextual interference type ($F_{1,84}$=1.439, p=0.234, η^2= 0.017), and the interactive effect of modeling type and contextual interference ($F_{2,84}$=0.202, p=0.818, η^2= 0.005) were not statistically significant on pass skill performance. This indicates that pass skill performance was consistent across the six experimental groups during the pre-test phase. In the acquisition test, while the main effects of modelling type ($F_{2,84}$=0.895, p=0.412, η^2= 0.021) and contextual interference type ($F_{1,84}$=2.744, p=0.101, η^2= 0.032) were not statistically significant, the interactive effect of modeling type and contextual interference on passing skill implementation level was statistically significant ($F_{2,84}$=4.842, p=0.010, η^2= 0.103). Specifically, Duncan's multi-domain post hoc test results revealed that pass skill performance in the acquisition test was significantly higher in the self-random video modeling group (M = 2.44) compared to the skillful person-random modeling group (M = 2.24), blocked person's own video modeling group (M = 2.17), and skillful-random person video modeling group (M = 2.40) compared to the self-blocked self-video modelling group (M = 2.18). The differences were not statistically significant in some cases ($p>0.05$). In the retention test, the main effect of the type of modeling ($F_{2,84}$=9.22, p=0.001, η^2= 0.18), the main effect of the contextual interference type ($F_{1,84}$=3.89, p=0.05, η^2= 0.044) and the interactive effect of modelling type and contextual interference ($F_{2,84}$=5.323, p=0.007, η^2= 0.112) on the level of pass skill performance was statistically significant. The significance of the main effect of modeling type indicates that the level of pass skill performance, regardless of the type of contextual interference, in three groups of skilled person modeling (M = 1.63), skilled person video modeling (M = 1.91) and modeling of one's own video (M = 1.81) are statistically different. The LSD post-hoc test revealed that the level of pass skill implementation in the expert video modeling ($p < 0.001$) and individual video modeling ($p = 0.007$) groups was significantly higher than the expert modeling group, but there is no significant difference between the video modeling groups of the skilled person and the video of the person himself ($p < 0.05$). Additionally, the significance of the main effect of the type of contextual interference indicates that the level of performance of pass skill in the retention test, regardless of the type of modeling, in the blocked training group (M = 1.84) is significantly higher than the random group (M = 1.73). The interactive effect of the type of modelling and contextual interaction highlights a significant difference in passing skill levels among groups in the retention test. Duncan's test results indicated that the skilled-random modeling group had notably lower passing skill performance in the retention test compared to other groups ($p \geq 0.05$). Conversely, no statistically significant differences were observed in other instances ($p<0.05$). Regarding the transfer test, the main effect of modelling type ($F_{2,84}$=2.473, p=0.09, η^2= 0.056), the main effect of contextual interference type ($F_{1,84}$=0.788, p=0.377, η^2= 0.009), and the interactive effect of modelling type and contextual interference ($F_{2,84}$=0.9, p=0.41, η^2= 0.021) on pass skill implementation were not statistically significant. This suggests that pass skill execution levels in the transfer test were consistent across all six experimental groups.

Table 3. The Results of the Analysis of the Effect of the Type of Modeling and Contextual Interference on the Execution of the Pass Skill

Phase	Source of Change	SS	df	MS	F	P-Value	η^2
Pre-test	Pattern Type	0.493	2	0.247	2.864	0.063	0.064
	Interference Type	0.124	1	0.124	1.439	0.234	0.017
	Interference Modelling	0.035	2	0.017	0.202	0.818	0.005
	Error	7.238	84	0.086			
	Modified Total	7.890	89				
Acquisition-test	Pattern Type	0.090	2	0.045	0.895	0.412	0.021
	Interference Type	0.138	1	0.138	2.744	0.101	0.032
	Interference Modelling	0.489	2	0.244	4.842	0.010	0.103
	Error	4.239	84	0.050			
	Modified Total	4.957	89				
Retention-test	Pattern Type	1.214	2	0.607	9.220	<0.001	0.180
	Interference Type	0.256	1	0.256	3.890	0.05	0.044
	Interference Modelling	0.701	2	0.350	5.323	0.007	0.112
	Error	5.528	84	0.066			
	Modified Total	7.698	89				
Transfer-test	Pattern Type	0.587	2	0.293	2.473	0.090	0.056
	Interference Type	0.093	1	0.093	0.788	0.377	0.009
	Interference Modelling	0.214	2	0.107	0.900	0.410	0.021
	Error	9.967	84	0.119			
	Modified Total	10.861	89				

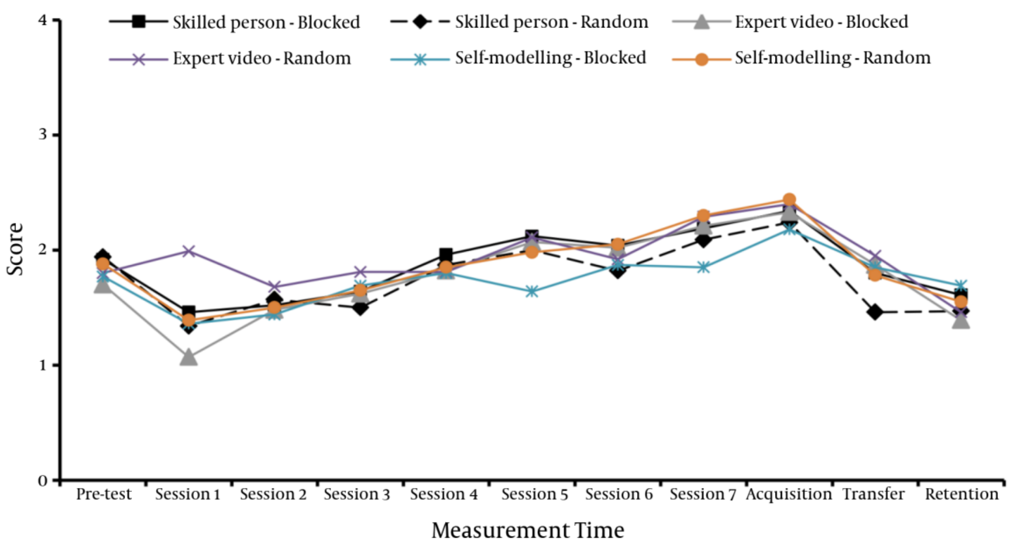

Figure 3. The Average Scores of Handball Pass Skill Execution by Groups at Different Stages of Measurement.

Table 4 presents the findings of the analysis on the impact of modeling type and contextual interference on the performance of shooting skills. In the pre-test phase, despite the significant main effects of modeling type ($F_{2,84}$=4.280, p=0.017, η^2= 0.092) and contextual interference type ($F_{1,84}$=4.603, p=0.035, η^2= 0.052), the interactive effect of modeling type and contextual interference on shooting skill performance was not statistically significant ($F_{2,84}$=1.078, p=0.345, η^2= 0.025). This indicates that the execution level of shooting skills was similar across the six experimental groups in the pre-test phase. In the acquisition test, the main effect of modeling type ($F_{2,84}$=13.927, p<0.001, η^2= 0.249), the main effect of contextual interference type ($F_{1,84}$=10.659, p=0.002, η^2= 0.113), and the interactive effect of modeling type and contextual interference ($F_{2,84}$=3.249, p=0.044, η^2= 0.072) on shooting skill performance were statistically significant. The significance of the main effect of modeling type suggests that the execution level of shooting skills differed statistically among the three groups: expert modeling (M = 3.45), expert video modeling (M = 3.04), and individual video modeling (M = 3.22). The LSD post hoc analysis revealed that the shooting skill performance level in the acquisition test was significantly higher in the expert modeling group compared to the expert video modeling groups (p < 0.001) and individual's own video modeling (p = 0.005). Additionally, the shooting skill performance level in the self-modeling video group was notably higher than the skilled person's video modeling group (p = 0.02). Moreover, the main effect of the type of contextual interference indicated that the execution level of shooting skill in the acquisition test, irrespective of the modeling type, was significantly higher in the blocked training group (M = 3.34) compared to the random group (M = 3.13). Furthermore, the interactive effect of the type of modelling and contextual interaction suggested that at least one group's shooting skill execution level in the acquisition test was significantly different from the other groups. Duncan's multi-domain test results demonstrated that the shooting skill execution level in the acquisition test was significantly lower in the expert-random video modeling group compared to other groups (p ≥ 0.05). Additionally, the performance level in the expert-blocked video modeling group was significantly higher than the expert-random video modeling group, skilled-random video modeling group, and individual-random video modeling group (p ≥ 0.05). In all other instances, the differences were not statistically significant (p < 0.05). The retention test results indicated that the type of modeling ($F_{2,84}$=0.127, p=0.881,

η^2= 0.003), contextual interference type ($F_{1,84}$=2.422, p=0.123, η^2= 0.028), and the interactive effect of modelling type and contextual interference ($F_{2,84}$=0.851, p=0.431, η^2= 0.020) did not have a significant impact on shooting skill performance. However, in the transfer test, the modeling type ($F_{2,84}$=3.242, p=0.044, η^2= 0.072) had a statistically significant effect on shooting skill execution, while the contextual interference type ($F_{1,84}$=0.564, p=0.455, η^2= 0.007) and the interactive effect of modeling type and contextual interference ($F_{2,84}$=1.703, p=0.188, η^2= 0.0.39) did not show statistical significance. Specifically, the execution of the shooting skill in the transfer test varied significantly between the expert modeling (M = 2.87), expert video modeling (M = 2.56), and modeling one's own video (M = 2.563) groups. The LSD post-hoc test revealed that the expert modeling group had significantly higher performance levels compared to the expert video modeling (p = 0.029) and individual's own video modeling (p = 0.981) groups.

Table 4. The results of the analysis of the effect of the type of modelling and contextual interference on the execution of the shooting skill..

Phase	Source Of Change	SS	df	MS	F	P-Value	η^2
Pre-test	Pattern Type	1.768	2	0.884	4.280	0.017	0.092
	Interference Type	0.951	1	0.951	4.603	0.035	0.052
	Interference Modelling	0.445	2	0.223	1.078	0.345	0.025
	Error	17.351	84	0.207			
	Modified Total	20.515	89				
Acquisition-test	Pattern Type	2.571	2	1.285	13.927	<0.001	0.249
	Interference Type	0.984	1	0.984	10.659	0.002	0.113
	Interference Modelling	0.600	2	0.300	3.249	0.044	0.072
	Error	7.753	84	0.092			
	Modified Total	11.908	89				
Retention-test	Pattern Type	0.045	2	0.022	0.127	0.881	0.003
	Interference Type	0.427	1	0.427	2.422	0.123	0.028
	Interference Modelling	0.300	2	0.150	0.851	0.431	0.020
	Error	14.812	84	0.176			
	Modified Total	15.584	89				
Transfer-test	Pattern Type	1.943	2	0.971	3.242	0.044	0.072
	Interference Type	0.169	1	0.169	0.564	0.455	0.007
	Interference Modelling	1.021	2	0.510	1.703	0.188	0.039
	Error	25.171	84	0.300			
	Modified Total	28.303	89				

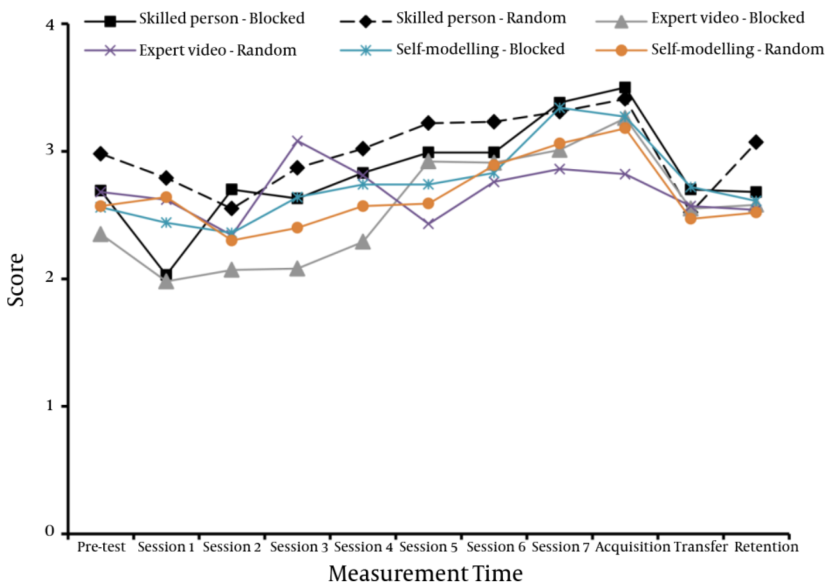

Figure 4. The average scores of handballs shooting skill execution by groups at different stages of measurement.

Table 5 presents the findings from the analysis conducted on the impact of modelling type and contextual interference on dribbling skills performance. In the pre-test phase, the main effects of modelling type ($F_{2,84}$=0.225, p=0.779, η^2= 0.005), contextual interference type ($F_{1,84}$=0.01, p=0.920, η^2= 0.001), and the interaction between modelling type and contextual interference ($F_{2,84}$=0.955, p=0.391, η^2= 0.022) were not statistically significant. This indicates that the performance time for dribbling skills was consistent across the six experimental groups in the pre-test phase.

In the acquisition test, although the main effects of modelling type ($F_{2,84}$=14.159, p<0.001, η^2= 0.252) and contextual interference type ($F_{1,84}$=137.871, p < 0.621, η^2= 0.621) were significant, the interactive effect of modeling type and contextual interference on dribbling skill performance time was not statistically significant ($F_{2,84}$=2.125, p=0.126, η^2= 0.048). The main effect of modeling type showed that the execution time for dribbling skills varied significantly among the expert modeling group (M = 5.79), expert video modeling group (M = 6.25), and individual video modeling group (M = 5.77), regardless of the contextual interference type. The LSD post hoc analysis revealed that the skilled person's video modeling group had a significantly longer dribbling skill execution time in the acquisition test compared to both the skilled person's modeling group and the individual's own video modeling group (p < 0.001). However, there was no significant difference in execution time between the skilled person's modeling group and the individual's own video modeling group (p < 0.05). The main effect of contextual interference type indicated that the execution time of the dribbling skill in the acquisition test was significantly higher in the blocked training group (M = 6.42) compared to the random group (M = 5.449). Nonetheless, the lack of significance in the interaction effect of modelling type and contextual interference suggested that the execution time of the dribbling skill in the acquisition test was consistent across all six experimental groups.

In the retention test, neither the main effect of modelling type ($F_{2,84}$=0.394, p=0.254, η^2= 0.032) nor the interactive effect of modelling type and contextual interference ($F_{2,84}$=0.907, p=0.408, η^2= 0.021) had a statistically significant impact on the dribbling skill execution time. However, the main effect of contextual interference type on the execution time in the retention test was statistically significant ($F_{1,84}$=13.062, p=0.001, η^2= 0.135), indicating that the execution time was significantly longer in the blocked training group (M = 6.28) compared to the random group (M = 5.60).

The transfer test revealed significant main effects of modelling type ($F_{2,84}$=14.161, p<0.001, η^2= 0.254) and contextual interference type ($F_{1,84}$=137.548, p<0.001, η^2= 0.619) on dribbling skill performance time. However, the interaction effect of modelling type and contextual interference was not statistically significant ($F_{2,84}$=2.122, p=0.128, η^2= 0.046). The main effect of modeling type was found to be significant, indicating that the dribbling skill performance time differed statistically among the expert modeling group (M = 6.75), expert video modeling group (M = 7.29), and modeling one's own video group (M = 6.73) in the transfer test, regardless of contextual interference type. The LSD post hoc test revealed that the dribbling skill execution time was significantly higher in the expert video modeling group compared to the expert modeling group (p < 0.001) and the individual's own video modeling group (p < 0.001). There was no significant difference in execution time between the expert modeling group and the individual's own video modeling group (p = 0.838). The main effect of contextual interference type was also significant, with the blocked training group (M = 7.49) showing significantly higher execution time compared to the random group (M = 6.36). The non-significant interaction effect between modeling type and contextual interference suggests that the dribbling skill execution time was consistent across all six experimental groups in the transfer test.

Table 5. The Results of the Analysis of the Effect of the Type of Modelling and Contextual Interference on the Execution of Dribbling Skills.

Phase	Source of Change	SS	df	MS	F	P-Value	η^2
Pre-test	Pattern type	0.334	2	0.167	0.225	0.799	0.005
	Interference type	0.007	1	0.007	0.010	0.920	0.001
	Interference modelling	1.413	2	0.707	0.951	0.391	0.022
	Error	62.439	84	0.743			
	Modified Total	64.194	89				
Acquisition-test	Pattern type	4.358	2	2.179	14.159	<0.001	0.252
	Interference type	21.219	1	21.219	137.871	<0.001	0.621
	Interference modelling	0.654	2	0.327	2.125	0.126	0.048
	Error	12.928	84	0.154			
	Modified Total	39.159	89				
Retention-test	Pattern type	2.174	2	1.087	1.394	0.254	0.032
	Interference type	10.188	1	١٠/١٨٨	10.188	0.001	0.135
	Interference modelling	1.415	2	0.708	0.907	0.408	0.021
	Error	65.514	84	0.780			
	Modified Total	79.291	89				
Transfer-test	Pattern type	5.953	2	2.977	14.161	<0.001	0.254
	Interference type	28.911	1	28.911	137.548	<0.001	0.619
	Interference modelling	0.892	2	0.446	2.122	0.128	0.046
	Error	17.656	84	0.210			
	Modified Total	53.412	89				

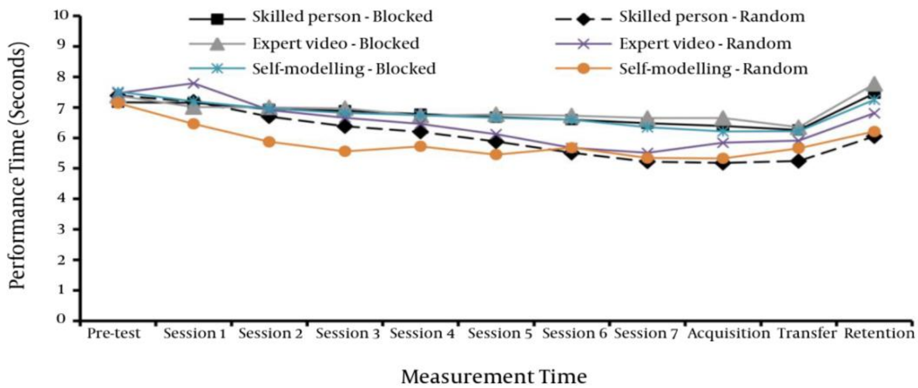

Figure 5. Average Execution Time of Handball Dribbling Skills by Groups at Different Stages of Measurement.

4. Discussion

The objective of the current research was to assess the impact of three observational learning models incorporating contextual interference on the acquisition and execution of handball passing, shooting, and dribbling skills. To achieve this goal, the proficiency of the participants was evaluated at four different points: initial assessment, skill acquisition test, retention, and transfer.

The current study's results on the impact of self-modeling with blocked and random practice indicate that the performance level of passing and shooting skills increased from the pre-test to acquisition, and then decreased from acquisition to retention and transfer. However, the execution time for dribbling decreased from pre-test to acquisition, remained constant from acquisition to retention, and increased from acquisition to transfer. These findings suggest that self-modeling was effective for acquiring handball skills in both practice conditions, but only effective for learning the dribble skill during the acquisition period. The increase in execution time for dribbling from acquisition to transfer was due to the longer distance in the transfer test. These results are consistent with previous research on the positive impact of self-modeling on various skills, indicating its effectiveness in acquiring handball skills and memorizing and transferring dribbling skills (4,7,17,18). However, the current research did not find a positive impact of self-modeling on the retention and transfer of passing and shooting skills, aligning with previous studies. It has been demonstrated that self-observation does not influence the learning, retention, and transfer of tennis forehand accuracy. The discrepancies in research outcomes could be attributed to variations in self-modeling interventions, the specific sports skills under investigation, and the methods used to assess the acquisition and application of these skills. Experts have supported the use of self-modeling based on studies suggesting that utilizing a model that the observer can relate to has the greatest impact on learning. Therefore, it is argued that specialized forms of modeling such as "self-observation," "positive self-monitoring self-modeling," and "anticipatory self-modeling" may bear the closest resemblance to the individual. In self-observation, the learner reviews their previous performance without any alterations to the footage (19,20). In positive self-monitoring self-modeling, the individual simply observes their successful behavior executed at peak performance, allowing the instructor to assess the learner's practice attempts and select the best one that closely mirrors the optimal skill level, discarding incorrect choices and skill attempts from the video. In this approach, the learner selects and watches the best performances from a variety of existing performances. Anticipatory self-modeling involves observing the successful execution of a future skill that has not yet been achieved. The desired skill is broken down into stages, and the best stage of each skill is chosen (17,18,21,22). By segmenting the video, the learner's performance is juxtaposed to create a recorded clip of the correct and skillful performance. This method creates an image of future performance by modifying existing skills. Positive self-monitoring, also known as "constructive self-modeling," reinforces behavior that has already been achieved, while "reconstructive self-modeling" restores behavior that has not been acquired before but is likely to be acquired in the future. Some researchers argue that focusing on the negative aspects of performance through self-observation may have negative consequences on skill learning. Nevertheless, self-observation can prove to be a more effective technique compared to positive self-examination interventions. This is because learners can assess their skill implementation, identify errors, and work towards rectifying them in future performances, thereby enhancing cognition and processing ability. Overall, the evidence from current research suggests that self-modeling is beneficial for the performance and learning of certain handball skills in teenage girls (23,24).

The current study's results on the impact of live and video performance modeling of a skilled individual with blocked and random practice yielded nearly identical evidence. The findings revealed that the proficiency in two or three passing and shooting skills increased from the pre-test phase to acquisition, then decreased from acquisition to retention, and from acquisition to transfer. However, the performance level of dribbling skills decreased from the pre-test phase to acquisition due to modeling the live performance of a skilled individual with blocked and random practice, and remained constant from acquisition to retention, and increased from acquisition to transfer. These results suggest that modeling through the live performance of a skilled individual was effective in acquiring handball skills in both blocked and random practice conditions, but only effective in learning the dribble skill during the eight sessions of the acquisition period. It is important to note that the increase in the execution time of the dribbling skill from acquisition to transfer was due to the longer distance in the transfer test. Additionally, the findings on the video modeling effect of a skilled individual with blocked practice indicated that the proficiency in two or three passing and shooting skills increased from the pre-test phase to acquisition, and decreased from acquisition to retention, and from acquisition to transfer. The outcomes of the skilled individual's video modeling with random practice varied between pass and shoot skills. In pass skill, the pattern of blocked practice was replicated, leading to an increase in performance level from pre-test to acquisition, and a decrease from acquisition to transfer. Conversely, shooting skills did not show significant changes. Dribbling skill performance decreased from pre-test to acquisition due to the skilled person's video modeling with both blocked and random practice, but remained constant from acquisition to retention, and increased from acquisition to transfer. These findings indicate that the skilled person's video modeling, under both blocked and random training conditions (excluding shooting skills), was effective in acquiring handball skills, particularly in learning dribbling skills over the eight-session acquisition period.

In the comparison of modeling types' effectiveness, it was found that the type of modeling significantly impacted the acquisition of shooting and dribbling skills. Expert live performance model outperformed video presentation groups (expert and self-impersonation) in shooting skills acquisition, while live performance of expert model and self-modeling were both superior to video modeling by expert in dribbling skills acquisition. During the acquisition phase, live performance of the skilled model and self-modeling were more effective than video presentation of the skilled model. Moreover, during the retention and transfer stages, modeling type significantly influenced the retention of passing skills and the transfer of shooting and dribbling skills. In the retention test, video presentation groups (expert and individual) were similar to expert live performance model, while in the transfer test for shooting skills, expert live performance model outperformed video presentation groups (expert and self). In dribbling skills transfer test, expert live performance model and self-modeling were superior to video presentation of expert model. Generally speaking, it can be observed that during the retention and transfer phases, the live demonstration of expert model and self-modeling proved to be more effective compared to the video demonstration of expert model. Overall, the results suggest that the most effective way to acquire handball skills is through observing expert model live, while the least effective method is through video presentation of expert model. These findings align with existing research in the field. Some studies have shown significant variations in the effectiveness of modeling interventions (25-27). For instance, a study conducted a study on badminton long serve skills in adult women, comparing six different interventions (self-modeling without feedback, self-modeling with feedback, skilled model without feedback, skilled model with feedback, mixed model without feedback, and combined model with feedback). The results indicated that combined modeling with feedback resulted in better skill acquisition and retention. Additionally, self-modeling with or without feedback was more effective than skilled modeling with or without feedback, contradicting the results of the current study. These discrepancies could be attributed to differences in intervention characteristics, types of sports skills, and the age of the participants.

In some other research, there have been no reported differences in the effectiveness of various modeling methods. For instance, a study on the impact of four modeling techniques (observational self-modeling, live expert modeling, video expert modeling, and self-regulation) on the acquisition of judo skills in novice female athletes revealed that all interventions had a positive effect on skill acquisition, with no discernible differences between the groups. Similarly, research on the influence of feedback on self-control performance awareness and the observation of different patterns (skilled, novice, and mixed) on the learning and retention of basketball free throw patterns in beginner female students demonstrated that there were no differences in learning based on the type of pattern observed, although all experimental groups outperformed the control group. Additionally, findings on the impact of role modeling (live model, video model, and self-modeling) on the observational learning of shooting skills in adolescent boys indicated that while all groups showed improvement in performance, there were no differences in the learning, retention, and transfer processes among the four research groups (28,29). Furthermore, in a separate investigation, a study explored the impact of three different observational learning models (live observation of skilled model execution, video observation of skilled model execution, and self-modeling) on the acquisition and learning of archery skills among middle school male students. The findings indicated that while progress was evident in all groups, there was no discernible variance among the four groups in terms of acquisition, retention, and transfer stages. Additionally, a study conducted a study comparing the effects of live performance viewing versus video viewing through six experimental interventions (physical exercise, live performance viewing from a first-person perspective, live performance viewing from a third-person perspective, video performance viewing from a first-person perspective, and video performance viewing from a third-person perspective). The results demonstrated that the observational learning groups outperformed the control group, although no significant differences were noted between the observational groups' performances (25,28,30). The evidence presented in these studies aligns with the current research findings on the efficacy of role modeling in sports skill acquisition, yet discrepancies exist regarding the varying effectiveness of role modeling types. On the contrary, contrasting groups of studies have shown a significant impact of modeling, contradicting the results of the current study. For instance, it has been demonstrated that when examining the influence of observational learning using self-modeling, skilled model, and combined model on the acquisition, retention, and transfer of table tennis forehand skills in young female players, self-modeling and skilled model did not have an effect on acquisition, retention, and transfer of table tennis forehand skills, while combined modeling had a significant impact on learning the table tennis forehand stroke skill (24,25). The discrepancies in research findings are primarily attributed to variations in the characteristics of modeling interventions, sample age, the specific skill being studied, and the assessment methods used. Overall, the current study's results on the effectiveness of the three types of modeling indicate that live demonstration by a skilled model is most effective for acquiring handball skills, whereas video presentation by a skilled model is the least effective. The high efficacy of live modeling by a skilled individual supports the theory of direct visual perception, which suggests that observation can enhance movement production, with coordination aspects such as body and limb movements and skill acquisition being crucial elements acquired through observation. According to Schmitt's schema theory, the initial efforts of an observer to perform a movement are comparable to those of a group without training, but weaker than a group with physical training (1,5,18). This suggests that observation is primarily beneficial for enhancing memory (recall schema) which is crucial for action production. The key is to combine observational and physical practice to maximize the advantages of modeling. During practice, both the observer and the performer engage in processes related to error identification and correction. Some cognitive activities involved in observational exercises are similar to those experienced during physical exercises. However, observation training alone is not as effective as physical or combined training, as observers may not fully undergo all necessary processes provided by physical or combined training. A significant distinction between observational and physical exercises lies in the processing stage of response execution. Observers do not need to engage in processes related to movement execution or sensory feedback. Therefore, it can be concluded that physical and observational training involve different processes in skill acquisition, and combining these two types of training with relevant processes holds great potential for developing similar retention as seen in the combined training group. By integrating these exercises, learners acquire the essential elements for performance akin to both physical and observational exercises (4,7,19,24).

The outcomes of this study on the primary impact of contextual interference (blocked and random training) revealed that contextual interference significantly influenced the development of shooting and dribbling abilities, retention of passing and dribbling skills, and the transfer of dribbling skills. Specifically, blocked training was more effective in enhancing the acquisition of shooting skills and retention of passing skills compared to random training. Conversely, random training proved to be superior to blocked training in enhancing the acquisition, retention, and transfer of dribbling skills. Based on these findings, it can be inferred that the impact of contextual interference was evident only in the learning and execution of dribbling skills, displaying a consistent trend. However, this inference may lack reliability without considering the outcomes of the interaction effect analysis involving modeling type and contextual interference, as the main effects were assessed without factoring in the type of modeling intervention. Further examination of the interactive effect of modelling type and contextual interference indicated that self- modelling-random interventions were most effective in acquiring passing skills, while self- modelling-blocking interventions were least effective. Live performance interventions were most effective in acquiring shooting skills, with skilled-blocking/random pattern and video presentation interventions being equally effective (11,15,19,25). Interestingly, there was no significant difference in the effectiveness of the six interventions in acquiring dribbling skills. Based on the results, it can be concluded that the most effective method for acquiring passing skills is observational training through self-modelling, while the most effective method for acquiring shooting skills is observational training through the live performance of a skilled model. On the other hand, observational training through video modeling by a skilled person was found to be the most effective method for memorizing passing skills. It was also observed that contextual interference only had an effect on the acquisition and retention of pass skills. In fact, accidental self-modelling leads to greater acquisition, while skilled person video modelling leads to greater retention in pass skills.

In the realm of interactive effects of observational modelling and contextual interference, there is a scarcity of reports in the research literature that also demonstrate evidence of heterogeneity. A study delved into the impact of training arrangement (variable and fixed) and type of feedback (modeling/physical) on learning and executing an angular positioning task, yielding notably positive results. Variable training, as opposed to constant training, exhibited an enhancement in observational learning. The benefits of employing contextual interference were also highlighted in several other studies. Also, it was discovered that the group undergoing random observation training outperformed the blocked and random physical training groups in retention and transfer assessments. Furthermore, it has been demonstrated that the group engaging in random combined exercises exhibited superior performance in the transfer test compared to the blocked and random physical and observational exercise groups (17,27,29). A study explored the interactive effect of contextual interference (blocked/random) and type of training (observational/physical/combined) on learning badminton skills, revealing that in the delayed retention and transfer stages, combined and random physical training resulted in more effective learning outcomes when compared to other interventions (13). A study explored the impact of contextual interference on observational learning in 10–11-year-old beginner basketball students. They used various interventions, including blocked physical training and observational training. The study found that observational modeling through live peer demonstrations improved skills implementation. The results indicated that chain observation exercise was more effective in enhancing dribbling control compared to blocked formation (19). However, the effect of contextual interference on two-handed chest pass execution and observation dribble execution was not significant. The findings align with previous studies suggesting that random practice arrangement is beneficial for performance and learning in passing skills. A study explored the impact of modeling live performance and feedback on performance awareness in both blocked and random practice conditions for two experimental tasks. They found that observational learning improved learning in both conditions, but there was no significant difference between the two (21). Similarly, a study found no significant difference between physical training and observation groups in blocked and random practice. These findings align with the present study's results on the effectiveness of blocked and random training in acquiring and memorizing shooting and dribbling skills. In conclusion, it appears that the type and nature of sports skills, as well as the learner's skill level, are crucial factors in determining the effectiveness of blocked and random training in the learning and observational training process. According to the "action plan reconstruction hypothesis", different sports skills involve different movement programs (25,27). The contextual interference effect occurs when tasks involving a generalized motor program are controlled differently. Random training promotes more active processing and reproduction of the action pattern, while blocked training results in less memory activity and reduced learner engagement in learning the action pattern. Therefore, active processing of the action pattern in the random training group leads to improved memory retention. The "expansion hypothesis" highlights the benefits of practicing with a random arrangement, which enhances learning through the interaction of multiple similar tasks. Increased interference in working memory during training promotes thorough and distinct processing, ultimately aiding in retention. In random practice, the learner must reconstruct the action plan for each practice attempt, increasing involvement in the problem-solving process. Conversely, the ineffectiveness of random training can also be considered (13,17,18). Consequently, training with minimal contextual interference (blocked training) fosters a reliance on the training context, hindering the improvement of universal response ability when tasks or training conditions change, unlike contextual interference (random training). Moreover, high contextual interference demands greater attention compared to low contextual interference, potentially yielding positive outcomes in younger age groups, as evidenced in the current study.

4.1. Conclusion

Based on the extent and focus of the current study, it is crucial to highlight that the results pertain to observational training interventions involving live and video demonstrations of a proficient and self-learning model across eight sessions within a three-week timeframe. A total of 120 attempts were made for each skill, resulting in 360 attempts overall for passing, shooting, and dribbling handball among female students aged 12 to 16. These findings can be extrapolated to various age groups, sports skills, and interventions, although outcomes may vary for individuals with differing characteristics.

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Footnotes

Authors' Contribution: Study concept and design: B. J; H. Z. Acquisition of data: H. Z. Analysis and interpretation of data: B. J. Drafting of the manuscript: B. J. Critical revision of the manuscript for important intellectual content: H. Z. Statistical analysis: B. J. Administrative, technical, and material support: B. J; H. Z. Study supervision: B. J.

Conflict of Interests: The researchers confirms that there is no conflict of interests in this study with any participant.

Data Availability: The data that support the findings of this study are openly available upon request from the corresponding author.

Ethical Approval: Approval for this study was obtained from the university. The authors confirms that all steps .The requirements of this study comply with ethical guidelines. Participants were informed about the characteristics of the study and gave written informed consent.

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