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ORIGINAL ARTICLE

The Impact of Mechanical Feedback on Correcting Errors in Overhead Volleyball Serve Performance

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ABSTRACT

Background. It is challenging to master the overhead serve in volleyball because of the several ways of positioning the body correctly when hitting the ball and the toss. This skill is incredibly challenging for novices who experience problems positioning different body parts. **Objectives.** This work aims to apply mechanical feedback to analyze the mistakes likely to occur in overhead volleyball serves and compare it with the usual verbal and visual feedback. **Methods.** This study involved 45 male students from the University of Anbar's College of Physical Education, randomly divided into two groups: one with 25 participants receiving verbal and occasional visual feedback and another with 20 receiving both visual and mechanical feedback. The research measured the kinematic coherence of limb movements and the direction of the serving arm. **Results.** The experimental group demonstrated significantly higher gains in kinematic coherence and serving arm accuracy than the control group. Particular improvements were supported by specific p-values (e.g., $p<0.001$ for kinematic coherence, $p=0.002$ for serving arm accuracy), demonstrating the higher efficiency of mechanical feedback. **Conclusion.** Mechanical feedback improves learning and performance in volleyball overhead serves by enhancing the specificity and timing of feedback regarding player positioning and movement.

KEYWORDS: ***Mechanical Feedback, Verbal Feedback, Visual Feedback, Overhead Serve, Volleyball.***

INTRODUCTION

Assessment is one of the components of sharing knowledge and distinguishing the right and wrong approaches aimed at improving performance (1). Feedback also benefits learners by giving them essential information about their motor performance and how close or far they are from achieving specific goals (2). In addition, feedback increases the accuracy of the responses as well as the effectiveness of learners (3). In sports training, feedback can be visual, verbal, or mechanical, tailored based on the learner's experience, the skills being taught, the delivery method, timing, and frequency of feedback (4). Previous research has established the importance of various types of feedback in learning different elements across all sports (3), highlighting a significant gap in using mechanical feedback for teaching overhead volleyball serves (5-7).

The overhead serve in volleyball is crucial, as it directly impacts scoring and influences the outcome of matches (8). This serve requires precise coordination of the serving arm, free arm, torso, and legs and is particularly challenging for beginners due to the required spatial organization of body segments within a limited time when the ball is in the air (9, 10). From observations and slowed-down video analyses, it has been noted that learners often fail to effectively execute the

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overhead serve due to inaccurate estimation of the optimal ball toss height and disorientation at the ball's peak height, leading to incorrect body positioning and unsuccessful serve execution (11, 12).

To address these learning challenges, we designed an instructional tool that provides mechanical guidance (13, 14). This tool places the ball at an optimum height in the air, giving the learner enough time to reposition his/her body to the position of the ball to execute the serve rightly (15). Furthermore, it allows the learners to practice the skill multiple times within the training sessions as it has a mechanical feedback system that sends the ball back to the same position in the air. Such constant feedback assists the learners in making necessary adjustments to the body position and other parts with every try (16).

Consequently, this study aims to determine whether mechanical feedback is more effective than the frequently utilized verbal and visual feedback in teaching the overhead serves in volleyball to beginner learners. Thus, by examining such feedback channels, the study seeks to establish which is most beneficial in facilitating learning and performance in this critical skill domain.

MATERIALS AND METHODS

Study Design. The present experimental research used a pretest-posttest control group research design to determine the effectiveness of mechanical feedback to verbal and visual feedback in enhancing the overhead volleyball serve among beginners.

Participant Selection. The participants were novice volleyball players from the College of Physical Education, University of Anbar. The selection was intentionally made to focus on players who made mistakes during the overhead serve, as these players would benefit most from the feedback mechanism being currently examined (Figure 1). The volleyball instructor evaluated all beginners and selected 45 learners who constantly committed these mistakes during training. This procedure made it possible to select participants relevant for investigating the effectiveness of feedback interventions in enhancing serve performance.

The inclusion criteria were set to keep participants' physical characteristics homogenized regarding height and weight; this was confirmed by using a SHANGHAI device sourced from Henan, China. The coefficient of variation for these attributes was within the acceptable range of ±1, suggesting that the participants were relatively homogeneous (See Table 1).

Table 1. Statistical Description of Learners' Characteristics (n=45)

Variable	SMA	Median	Standard Deviation	Coefficient of Variation
Age (Years)	19.054	19	0.290	0.558
Length (cm)	171.100	171	0.785	0.382
Weight (kg)	73	74	1.282	0.780

Coefficient of variation acceptable at ±1

Figure 1. Models for analyzing errors in overhead volleyball serve performance.

Participant Selection Criteria.

Inclusion Criteria: Participants included in the study were male learners aged 19-20 years enrolled in the College of Physical Education at the University of Anbar. All the selected participants had casual volleyball playing

experience of less than one year, notably those who displayed poor technique when performing overhead volleyball serves during the screening trials.

Exclusion Criteria: Participants who volunteered for the study were screened if they had practiced volleyball for more than one year, had prior professional coaching or training, or had any physical handicap or injury that could influence how they performed volleyball serves. Also, students who refused to participate or could not be reached within the study period were also omitted.

Search Strategy. The search strategy involved working closely with volleyball trainers at the college, who conducted initial screenings during training sessions to find learners who had difficulties with overhead serves. These sessions were applied to document serve techniques and identify students who frequently displayed improper serve mechanics. The instructors assessed the students based on a list of commonly committed mistakes in volleyball serve techniques, such as ball toss, body stance, and timing of the serve.

Sample Size Estimation. The sample size was determined based on the number of students the instructor noted at the beginning of the semester as having much difficulty with the overhead serve. For the power analysis, G*Power software was employed to ensure that there was 90% power to detect a significant increase in serving accuracy at a 5% significance level.

Randomization and Group Allocation. A list of students was made depending on their registration for the volleyball module. Randomization was achieved by assigning students to either the control or experimental group based on their order in the enrollment list: odd-numbered students became the control group, while the even-numbered ones formed the experimental group.

Feedback Intervention. The intervention was planned into four weekly sessions, each lasting approximately 90 minutes. Each session comprised:

1. Preparatory Section (13 minutes): The first step in this process entailed performing exercises to warm up the body and prepare the participants for volleyball events.

2. Main Section: i) Educational Part (18 minutes): During this segment, the coach explained the cognitive aspects of performing the overhead volleyball serve, including the correct body movements and accurately directing the ball towards a specific target on the ground.

ii) Practical Part (42 minutes): This portion was dedicated to practicing the overhead serve with mechanical feedback interventions:

- Ten minutes of serving were practiced using a mechanical feedback device designed by researchers.
- Seven minutes of serving practiced in front of the net without mechanical feedback.
- Eight minutes of serving again with mechanical feedback.
- Six minutes of serving practiced against a wall, followed by
- Six minutes of serving with mechanical feedback.
- Five minutes of final serving to consolidate the skills learned before the net.

3. Closing Section (17 minutes): The session concluded with recreational games to relax the participants and reduce the intensity of the training session.

These details provide a clear understanding of the intervention's structure and ensure that the educational goals of each phase were met effectively. Mechanical feedback and traditional training methods were designed to maximize learning outcomes by reinforcing correct techniques through repeated practice.

Definition and Specification of Errors. The participants for the study were deliberately chosen by the volleyball instructor based on their frequent exhibition of these significant errors during routine practice sessions. The instructor provided the research team with a list of names of these learners. To ensure unbiased selection and randomization within this identified group, we separated the participants into control and experimental groups based on whether their position in the list was odd or even: individuals listed in odd positions were placed in the control group, and those in even positions were assigned to the experimental group. This method was employed to randomize the allocation and minimize selection bias effectively.

Measurement Variables. Two primary variables were measured:

1. Kinematic Coherence of Active Body Parts: This measure evaluates the coordination of the active body parts involved in the serve—namely, the serving arm, free arm, torso, and legs. The assessment occurs across the three phases of the serve: preparatory, primary, and final. During each phase, judges assign scores ranging from 1 to

3 for each body part based on their movement accuracy and coordination. The cumulative score for each Part serves as an indicator of movement errors for that specific body segment.

2. Targeting Accuracy: This metric assesses the participant's ability to direct the volleyball accurately toward predefined targets within the opponent's court. The court features three nested squares as targets, scoring as follows: hitting the smallest square earns 3 points, the middle square 2 points, and the most significant square 1 point. Each participant performs three attempts to hit the smallest target, and the aggregate score from these attempts represents their precision level in targeting (Figure 2).

These measures are critical in evaluating the effectiveness of the feedback mechanisms employed in our study, as they directly relate to the core skills required for successful volleyball serve execution. I hope this revision provides the necessary clarity on our measurement approach and criteria.

Design of the Mechanical Guidance Tool. The mechanical tool provided continuous feedback, critical for adjusting body position and ensuring the ball's optimal trajectory. It consistently returned the ball to the same point in the air after each serve, allowing for repeated practice and correction (refer to Figure 3 for tool design).

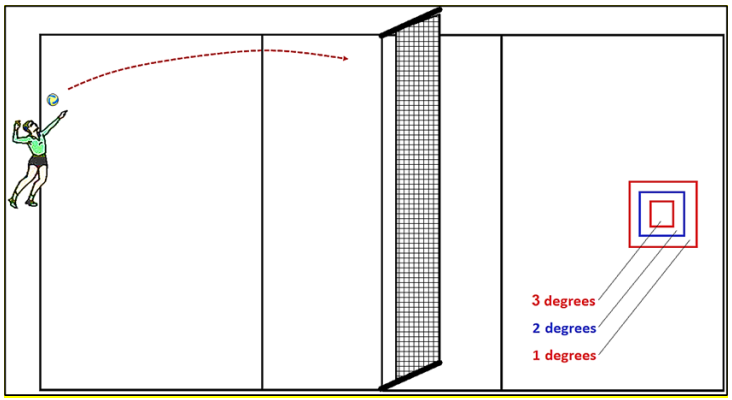

Figure 2. Targeting Accuracy in Volleyball Overhead Serves.

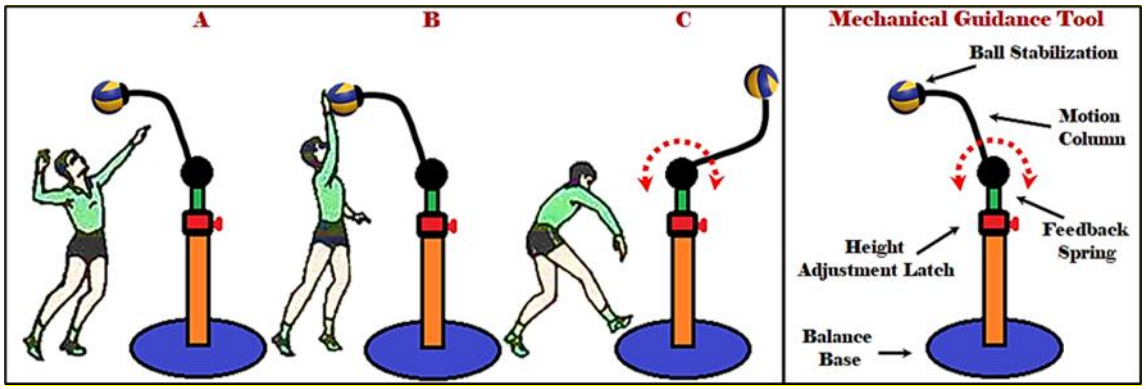

Figure 3. Design of the Mechanical Guidance Tool in Volleyball.

Data Collection Methods. Data were collected using high-speed cameras to capture detailed movements during each serve, and targeted areas were marked on the court to assess accuracy. Pre- and post-tests were administered to gauge improvements in serve technique and accuracy.

Statistical Analysis. Statistical analysis involved the use of IBM SPSS Statistics 25 (17). Descriptive statistics were used to summarize baseline characteristics and changes in serve performance. Paired and independent samples t-tests were employed to analyze between-group improvements and between-group differences. Assumptions of normality and homogeneity of variances were checked before conducting the tests.

Ethical Considerations. The ethical review board of the University of Anbar approved the

study protocol. All participants provided informed consent, understanding their right to withdraw from the study at any time without any consequence. Confidentiality was maintained by anonymizing participant data in all study reports and analyses.

RESULTS

The study demonstrated significant differences between pre-and post-test measurements, indicating a positive impact of feedback mechanisms in rectifying performance errors for both groups, as shown in Table 2 and Table 3. The experimental group showed increased variability in post-test measurements, suggesting mechanical feedback's superior effectiveness (18).

Table 4, the study reveals that all statistical significance values (sig) were below the error threshold (0.05), indicating significant differences in the post-test measurements between the two groups (19). Upon examining the mean values, we observe increased variability in the post-test measurements for the experimental group, suggesting that mechanical feedback is more effective in correcting performance errors than verbal and visual feedback (11, 16).

Table 2. Comparison of Pre- and Post-Test Results for the Control Group

Variables		measuring unit	Pre-test		Post-test		Range	Average deviation	t-test	`sig
			Mean	SD	Mean	SD				
Motor coordination	free arm	3 degrees	1.221	0.487	1.909	0.118	0.288	0.445	3.169	0.000
	Serve arm	3 degrees	0.907	0.297	1.605	0.863	0.418	0.747	2.740	0.000
	the trunk	3 degrees	0.227	0.479	2.324	0.233	0.327	0.748	2.141	0.005
	the two legs	3 degrees	1.400	0.291	2.035	0.472	0.335	0.573	2.863	0.000
Accuracy of the Serve arm		10 degrees	4.782	0.332	6.854	0.371	0.472	0.921	2.510	0.000

Statistically significant at a significance level ≤0.05 with degrees of freedom (25-1=24)

Table 3. Comparison of Pre- and Post-Test Results for the Experimental Group

Variables		measuring unit	Pre-test		Post-test		Range	Average deviation	t-test	`sig
			Mean	SD	Mean	SD				
Motor coordination	free arm	3 degrees	1.105	0.297	2.894	0.234	0.289	0.453	2.780	0.000
	Serve arm	3 degrees	0.935	0.911	2.942	0.751	0.307	0.471	2.840	0.002
	the trunk	3 degrees	0.381	0.310	2.779	0.341	0.398	0.744	2.331	0.000
	the two legs	3 degrees	1.375	0.951	2.749	0.481	0.314	0.504	2.715	0.000
Accuracy of the Serve arm		10 degrees	4.328	0.634	7.989	0.516	0.461	0.842	2.334	0.037

Statistically significant at a significance level ≤0.05 with degrees of freedom (20-1=19)

Table 4. Comparison of Post-Test Results Between Control and Experimental Groups

Variables		measuring unit	control group		experimental group		t-test	`sig
			Mean	SD	Mean	SD		
Motor coordinati	free arm	3 degrees	1.909	0.118	2.894	0.234	5.116	0.000
	Serve arm	3 degrees	1.605	0.863	2.942	0.751	2.473	0.000
	the trunk	3 degrees	2.324	0.233	2.779	0.341	2.333	0.000
	the two legs	3 degrees	2.035	0.472	2.749	0.481	3.141	0.009
Accuracy of the Serve arm		10 degrees	6.854	0.371	7.989	0.516	3.780	0.000

Statistically significant at a significance level ≤0.05 with degrees of freedom (25+20-2=43)

DISCUSSION

From the present research findings, it can be concluded that mechanical feedback facilitates enhancing the volleyball serve's precision and mechanics (20). This kind of feedback gives immediate feedback that helps the players correct their

mistakes, thus using the time efficiently to improve performance and motor learning (21). The ability of the technology to provide accurate feedback to the body positions and serve mechanics made it easier to eradicate significant errors in serve, which is helpful in training for efficient serve in volleyball games (22).

Mechanical feedback systems, as shown in our study, do not replace conventional training and coaching methods; in fact, they enhance these methods by adding the component of mechanical feedback, not limited to the coach's vision or voice, but a substance in their own right (23). This type of feedback is consistent with the recommended motor learning practices, which stress the need to provide prompt and accurate feedback to learners (16). More specifically, mechanical feedback enables a faster internalization of the correct techniques by constantly updating the athletes on their performance (24).

These findings relate to those of Uday and Esam (18), who observed the positive effect of delayed mechanical feedback on athletic performance in the event of a long jump. Thus, these findings indicate the generality of mechanical feedback mechanisms across various sporting disciplines. This supports the notion that such feedback systems can be generalized beyond volleyball to enhance technical skills requiring accurate timing (24).

Additionally, this study adds to the body of knowledge by describing how mechanical feedback can impact motor learning. This way, learners can continuously practice and rehearse, which leads to improved neuromuscular development and increased performance. Such a learning environment is essential for beginners who need much feedback to shape and consolidate their motor plans.

Limitations and Future Research. However, there are certain limitations in the current study which deserve attention. The participants in the study were limited to male college students from one university, and therefore, the results cannot be generalized to other populations. The study was conducted relatively short, so conclusions cannot be made about the long-term retention of skills or the ability to adapt. Subsequent research should try to involve a more diverse population of participants and expand the timeframe of the intervention to investigate whether the results of mechanical feedback are sustainable in the long term.

Furthermore, while some performance measures are scored manually, the inherent subjectivity may skew the results. Future research could improve the validity of the measures by including computer-based systems in quantifying serve efficiency and body movements.

CONCLUSION

The findings of this research prove that mechanical feedback increases the effectiveness of correcting mistakes in volleyball, focusing on position and motor control. Unlike verbal and visual feedback, mechanical feedback is more specific and informative, enabling learners to make more accurate corrections and adjustments to their actions. The study points to the fact that mechanical feedback supports serve technique enhancements in the initial stages and motor skill development by allowing constant practice and feedback corrections.

Based on these advantages, mechanical feedback should be incorporated into training protocols targeting novices, specifically in sports like volleyball, in which accuracy and teamwork are vital components. It can be hypothesized that the advantages of this approach would apply to other sports that intend particular movements and high coordination.

Further studies should extend to measuring the actual impacts of mechanical feedback on skills across various sports and different levels of skill and also compare the effects of combining different forms of feedback, including mechanical feedback, to augment athletic training programs.

APPLICABLE REMARKS

- Functional Notes: Mechanical feedback should be systematically applied in volleyball training programs to improve learners' motor skills and reduce errors.
- Study Population: This approach benefits beginner learners and can be adapted to other sports movements involving specific tools.

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AUTHORS' CONTRIBUTIONS

Study concept and design: Manaf Majid Hassan. Acquisition of data: Omar Ahmed Mosleh. Analysis and interpretation of data: Hameed Hammad Khalaf. Drafting the manuscript: Manaf Majid Hassan. Critical revision of the manuscript for important intellectual content: Hameed Hammad Khalaf. Statistical analysis: Shakir Mahmood Abdullah. Administrative, technical, and material support: Waleed Khalid Hammadi. Study supervision: Manaf

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

FINANCIAL DISCLOSURE

The authors have no competing interests to report.

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ETHICAL CONSIDERATION

This work complied with guidelines set for research among human subjects as recommended by the University of Anbar's Ethics Committee.

ROLE OF THE SPONSOR

This research received no funding and was completed independently by the authors.

ARTIFICIAL INTELLIGENCE (AI) USE

The information was retrieved using ChatGPT, exclusively employed to proofread grammatical errors. Finally, the authors discussed and approved all the material presented in the study and all outcomes.

REFERENCES

1. Shabaan HE, Madkour AA. Impact of video-backed feedback on learning some fencing skills of Physical Education Boys' College in Alexandria. Sci J Phys Educ Sport. 2022;19(19):107.
2. Severo MC, Paul K, Walentowska W, Moors A, Pourtois G. Neurophysiological evidence for evaluative feedback processing depending on goal relevance. NeuroImage. 2020;215:116857. [doi:10.1016/j.neuroimage.2020.116857] [PMID:32304885]
3. Petancevski EL, Inns J, Fransen J, Impellizzeri FM. The effect of augmented feedback on the performance and learning of gross motor and sport-specific skills: A systematic review. Psychol Sport Exerc. 2022;63:1-39. [doi:10.1016/j.psychsport.2022.102277]
4. Hijazi MMK. The effect of visual and verbal feedback on the quality of fencing technique. J Theor Appl Phys Educ Sport Sci. 2020;3(1):11-20. [doi:10.21608/jat.2020.40933.1005]
5. Hamoudi LS. The effect of visual feedback in learning the skill of receiving the serve in volleyball for the deaf and dumb. Sci J Phys Educ Sport Sci. 2017;79(79):411-425.
6. Peeters T, Vleugels J, Garimella R, Truijen S, Saeys W, Verwulgen S. Vibrotactile feedback for correcting aerodynamic position of a cyclist. J Sports Sci. 2020;1-7. [doi:10.1080/02640414.2020.1776814] [PMID:32529942]
7. Hasan MM, Mosleh OA, Hammad F. The impact of the method of teaching the mediator different speed and mental training to teach some of the offensive skills for beginners in handball. Indian J Public Health Res Dev. 2019;10(12):1375-1380. [doi:10.37506/v10/i12/2019/ijphrd/192563]
8. Hussein OM, Ibrahim TT. An educational program using kinematic indicators feedback on learning the three-point shooting skill for junior basketball players. Assiut J Sci Arts Phys Educ. 2016;43(2):274.
9. Al-Battawi KAA. The effect of using the reverse learning strategy on mental alertness and the level of serving performance from the top of the confrontation in volleyball for beginners. Sports Sci J. 2020;33(11):140.
10. Helmy MA. Qualitative analysis to evaluate the performance of the skill of serving directed from above in volleyball during the learning stages as an indicator of learning effectiveness. Sci J Phys Educ Sport Sci. 2016;78(3):233.
11. Hossain T, Noghani MA, Sidaway B, Hejrati B. Investigating the efficacy of a tactile feedback system to increase the gait speed of older adults. Hum Mov Sci. 2023;90:103103. [doi:10.1016/j.humov.2023.103103] [PMID:37257391]
12. Scott SH, Cluff T, Lowrey CR, Takei T. Feedback control during voluntary motor actions. Curr Opin Neurobiol. 2015;33:85-94. [doi:10.1016/j.conb.2015.03.006] [PMID:25827274]
13. Huang VS, Haith A, Mazzoni P, Krakauer JW. Rethinking Motor Learning and Savings in Adaptation Paradigms: Model-Free Memory for Successful Actions Combines with Internal Models. Neuron. 2011;70(4):787-801. [doi:10.1016/j.neuron.2011.04.012] [PMID:21609832]
14. Van Wieringen PCW, Emmen HH, Bootsma RJ, Hoogesteger M, Whiting HTA. The effect of video-feedback on the learning of the tennis service by intermediate players. J Sports Sci. 1989;7(2):153-162. [doi:10.1080/02640418908729833] [PMID:2810468]

15. Guadagnoli M, Holcomb W, Davis M. The efficacy of video feedback for learning the golf swing. J Sports Sci. 2002;20(8):615-622. [doi:10.1080/026404102320183176] [PMID:12190281]
16. Thow JL, Naemi R, Sanders RH. Comparison of modes of feedback on glide performance in swimming. J Sports Sci. 2012;30(1):43-52. [doi:10.1080/02640414.2011.624537] [PMID:22168429]
17. Eom HJ, Schutz RW. Statistical Analyses of Volleyball Team Performance. Res Q Exerc Sport. 1992;63(1):11-18. [doi:10.1080/02701367.1992.10607551] [PMID:1574656]
18. Hasan UC, Hasan EES. Effect of delayed mechanical feedback on long jump performance. Hum Mov. 2022;23(4):140-147. [doi:10.5114/hm.2022.108320]
19. Potdevin F, Vors O, Huchez A, Lamour M, Davids K, Schnitzler C. How can video feedback be used in physical education to support novice learning in gymnastics? Effects on motor learning, self-assessment, and motivation. Phys Educ Sport Pedagogy. 2018;23(6):1-16. [doi:10.1080/17408989.2018.1485138]
20. Boothroyd M, Noble J, Kent M, Komar J, Chow JY. The effectiveness of video feedback on cognitive performance: A review of evidence from neurophysiological, kinematic and sporting domains. Int J Psychophysiol. 2017;114:1-11.
21. Baudry L, Leroy D, Thouvarecq R, Chollet D. Auditory concurrent feedback benefits on the circle performed in gymnastics. J Sports Sci. 2006;24(2):149-156. [doi:10.1080/02640410500130979] [PMID:16368624]
22. Silva LC, Pereira-Monfredini CF, Teixeira LA. Improved children's motor learning of the basketball free shooting pattern by associating subjective error estimation and extrinsic feedback. J Sports Sci. 2016;35(18):1825-1830. [doi:10.1080/02640414.2016.1239025] [PMID:27710197]
23. Nicaise V, Bois JE, Fairclough SJ, Amorose AJ, Cogérino G. Girls' and boys' perceptions of physical education teachers' feedback: Effects on performance and psychological responses. J Sports Sci. 2007;25(8):915-926. [doi:10.1080/02640410600898095] [PMID:17474045]
24. Hassan MM, Khalaf HH, Mosleh OA. Impact of Instant Visual Guidance via Video Technology on the Correction of Some Offensive Skills Performance Errors in Basketball. Asian Journal of Sports Medicine. 2023;14(4). [doi:10.5812/asjsm-135841]