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SYSTEMATIC LITERATURE REVIEW: THE USE OF TECHNOLOGY-BASED AND NON-TECHNOLOGY-BASED TENNIS LEARNING AIDS IN HITTING MOTION SKILLS

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Abstract

This study aims to identify the effectiveness of using tennis learning aids in improving tennis stroke skills at the beginner level. The research method used is a Systematic Literature Review with an Agile SLR approach through searching national and international scientific articles in the period 2019–2025. Of the 74 identified articles, 17 articles were deemed eligible for analysis. The results showed that 71% of the articles discussed the use of technology-based aids such as interactive multimedia, automatic ball throwing machines, artificial intelligence-based robots, and motion sensors, which have been proven to increase training efficiency, provide rapid feedback, and enrich learning innovation. Meanwhile, 29% of the articles emphasized non-technological aids in the form of simple equipment modifications such as low-compression balls, scaled rackets, and mini courts that effectively support basic training, reduce the risk of injury, and facilitate technique adaptation for beginners. The conclusion of this study confirms that there are two types of tennis learning aids at the beginner level to improve stroke skills: both technological and non-technological learning aids are considered effective in improving tennis stroke skills, especially at the beginner level. Therefore, integrating both is an ideal strategy to improve stroke skills for beginners..

Keywords: Tennis, training aids, Technology and NonTechnology

INTRODUCTION

Tennis is now one of the sports with international and national popularity. This development has attracted young people of all classes and age groups, not only for professional and competitive sports but also as a fun and relaxing activity that offers health and social benefits. This increasing popularity has sparked an exponential expansion in the tennis establishment which, in turn, has encouraged the creation of tournaments and competitions, even for amateur and beginner levels. In Indonesia, especially in the city of Bandung in West Java, there are various competitions organized among communities at various levels of tennis, including the Beginner and Beginner

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categories, to further increase this increased interest. The community's tremendous interest in attendance, in addition to the numerous searches for places to study shows a high demand for tennis training. Many of the matches played stimulate people to join groups and look for a place to practice tennis. Tennis is also difficult in the game of tennis compared to many similar sports where it involves mastering a complex and often technical approach to tennis. Newcomers have difficulty with standard equipment and basic techniques in handling tools as well as learning basic stroke skills including forehand, backhand, and serve, as well as motor adaptation [Moussa et al., 2023]. Such challenges can often lead to frustration, demotivation, and an increased risk of injury. The difference between the high interest in learning tennis versus the challenges and concerns of novice tennis players suggests the need for innovation and adaptation in the use of training aids that facilitate novice tennis players for technical and tactical improvement, using technology in the case of some players but non-technology for others (Nur Rahman et al., 2024; Juditya et al., t.t.). Non-tech assistive devices mean that they include customized items such as tennis balls or customized rackets, which, in our estimation, make it easier for novice players to customize equipment according to their physical abilities and what they already know. These tools, when used together, offer simplicity and high opportunities to collect balls and have fun playing tennis for this type of beginner player [Muñoz-Martínez et al., 2024], and will prevent injuries in young players [Moussa et al., 2023]. Instead, new input through technological tools such as motion sensors, video feedback, and machine learning can give first-time users new ways to improve the quality of their actions. Indeed, it has been found that the use of motion sensors has accuracy for stroke classification in the range of 99%, which helps facilitate trainers to capture and assess strokes that still need to be improved [Ebner & Findling, 2025].

Several research articles have investigated sports and training aids including (Sidik et al., 2023) on ball strap aids to improve forehand drive skills in tennis, (FransDevin Tarigan, n.d., 2021) on aids to improve forehand accuracy, (Fauzan et al., 2024) for tennis groundstroke training aids (for beginner athletes), (Penalva et al., 2022) to design and validate tennis training aids that will control training content both technically and tactically, (Wang & Zhang, 2021) to monitor human movements in real-time with robots, and (Andel et al., 2024) for the incorporation of virtual reality that would be beneficial for better performance according to the nature of the player and although the effectiveness of technological and non-technological approaches has been supported in intervention studies [García-Manso et al., 2025] unfortunately the synthesis of complete knowledge is still scarce mainly because there is no formal literature review that published that compares and

integrates the roles, effectiveness, and strategic implications of these two types of training aids in improving the hitting skills of beginner tennis players, the aim of this study was to discover the effectiveness of the use of tennis training aids to improve the hitting skills in beginner tennis players through a Systematic Literature Review (SLR). The aim of this study was to provide evidence-based recommendations to coaches on the best adapted and sustainable integration strategies that reconcile changes in physical equipment with the use of advanced technology for the development of basic level performance of tennis players.

METHODS

This study uses qualitative research methodology and Systematic Literature Review (SLR) methodology as part of the Agile SLR method. The aim of this approach is to enable a literature review to be conducted in an iterative, flexible, and adaptive manner with respect to the development of article findings to obtain more comprehensive and up-to-date findings related to the effectiveness of the use of training aids for the sport of tennis. The study has several published data and data points from research journals focusing on the use of training aids in tennis practice, from leading international journals such as Scopus, PubMed, Web of Science, Google Scholar, DOAJ and the nationally accredited journal SINTA 1-6 from 2019–2025 to obtain data in an appropriate and up-to-date manner. The obtained articles are then systematically pulled through a review checklist taking into account the topic's relevance, source credibility, and methodological orientation. The research tool is an article identification sheet and a thematic tabulation structure that summarizes the important aspects found in each article: author, year of publication, research objectives, type of tools used, indicators of effectiveness, and key outcomes. Qualitative descriptive data analysis with a thematic approach is used for data analysis, categorizing articles by research objectives and topics according to the nature of the training aids, including reflective nets, target cones, sensors, modified spheres, or technology-based devices. Then a mapping of the contribution of each tool to contribute to the improvement of technical skills (forehand, backhand, serve, footwork) and the psychological aspects of the athlete is carried out, and then a synthesis of the results of the analysis is made to answer specific research questions and generate strategic recommendations for better tennis training design.

RESULTS AND DISCUSSION

1. Research Results

Therefore, this paper focuses more on effective tennis training tools for beginners or commonly called beginners/newbies/beginners in the tennis community, so the researcher asks two research questions in this research, namely what types of training aids are considered effective in improving stroke skills for beginners. To map the answers to this research question, the author seeks to analyze the article by setting several inclusive criteria first with appropriate research topics. As for this inclusive criterion, the first is the research topic related to the use of tennis training/learning aids, the second article is published in sinta 1-6 accredited journals and or scopus indexed international journals Q1-Q4 and the 2019-2025 publication year. The following is a description of the results of the analysis of articles with inclusive criteria:

Table 1 Article Categorization Results

Yes	Article Title	Year & Sinta/Q	Point 1: Tennis Aids	Point 2: Sinta/Q	Point 3: Year 2019–2025	Results
1	Biomechanical Analysis of Heading Techniques	2021, Sinta 6	X	V	V	X
2	Aerobic & Anaerobic Sports Analysis	2020, Sinta 2	X	V	V	X
3	Applications of Sprint Biomechanics Analysis	2018, –	X	X	X	X
4	Sprint Biomechanics Analysis Application (Kinovea)	2018, –	X	X	X	X
5	CAI Basketball Learning Application	2016, –	X	X	X	X
6	Dissemination of Cricket Training Equipment	2024, –	X	X	V	X
7	The Effectiveness of Silat Cutting Exercises	–, –	X	X	X	X
8	Effectiveness of Beginner	2021, –	X	X	V	X

	Swimming Training Methods					
9	The Effectiveness of Digital Taekwondo Bags	2024, –	X	X	V	X
10	Modification Game Breaststroke Swimming	2021, Sinta 3-4	X	V	V	X
11	Improving Dribbling via Video Feedback Futsal	2022, Sinta 3-4	X	V	V	X
12	Literature Review ROM in Patients	2021, Sinta 2-3	X	V	V	X
13	Goalkeeper Throw Target Game Practice	2020, –	X	X	V	X
14	Silat Reaction Aids	2021, –	X	X	V	X
15	Football Under-Passing Practice	2019, –	X	X	V	X
16	Hand Paddle Swimming	2025, –	X	X	V	X
17	Football Passing Belt	2025, –	X	X	V	X
18	Water Bottle Swimming	2024, –	X	X	V	X
19	Android Goalkeeper Reaction Tool	2023, –	X	X	V	X
20	Volleyball Thrower	2022, –	X	X	V	X
21	Arduino Futsal Ball Thrower	2017, –	X	X	X	X
22	Side Step Test Microcontroller	2024, –	X	X	V	X
23	Volleyball Smash & Setter Tools	2021, –	X	X	V	X
24	Target Shooting Soccer Game Model	2018, Sinta 2	X	V	X	X
25	Floor Gymnastics Assignment Video	2022, –	X	X	V	X
26	Drill vs Game Passing Futsal	2021, –	X	X	V	X
27	IMU Rangefinder	2022, Sinta 2	X	V	V	X

28	SLR Audiovisual PJOK	2025, –	X	X	V	X
29	Learning Video Short-Distance Running	2025, –	X	X	V	X
30	Throw Athletics Feedback Videotapes	2018, –	X	X	X	X
31	Swimming Buoy Board	2024, –	X	X	V	X
32	Video Feedback American Football	2024, Q1	X	V	V	X
33	Video-Based Visual Feedback PE	2022, Q3	X	V	V	X
34	Biomechanics of Petanque Balls	2025, –	X	X	V	X
35	Softball Lamp Reaction Device	2023, –	X	X	V	X
36	Pitcher Machine Badminton	2023, Sinta 4	X	V	V	X
37	Woodball Modifications	–, –	X	X	X	X
38	Batting Drills Cricket	2024, Sinta 4	X	V	V	X
39	Table Tennis Ball Thrower	Repo, –	X	X	X	X
40	Video Feedback Shooting Petanque	2021, –	X	X	V	X
41	Small Ball Modification (SD)	2018, –	X	X	X	X
42	Biomechanical Analysis of Tennis Service	2024, –	X	X	V	X
43	Game-Based Backhand Tennis	2021, Sinta 3	X	V	V	X
44	Groundstroke Training Model	2021, Sinta 3	X	V	V	X
45	Tennis Drive Forehand Exercise Tools	2021, –	V	X	V	X
46	Micro Tennis (Game Modification)	2017, –	V	X	X	X
47	Hexagon Drill Agility Junior Tennis	2023, Sinta 2	X	V	V	X

48	Analysis of Service Motion Ages 13–15	2020, –	X	X	V	X
49	Digital Based Tennis Footwork	2021, Sinta 4	V	V	V	V
50	Interactive Multimedia Tennis Court	2020, Sinta 2	V	V	V	V
51	Audio-Visual Teaching Materials Tennis	2022, Sinta 2	V	V	V	V
52	Smart Tennis YOLO	2025, Sinta 4	V	V	V	V
53	Tennis Groundstroke Tutorial Video	2023, Sinta 4	V	V	V	V
54	Ball Pressure Coordination Exercise Video	2020, Sinta 4	V	V	V	V
55	Arduino Tennis Ball Thrower	2021, Sinta 4	V	V	V	V
56	Beginner Service Aids	2021, –	V	V	V	X
57	Video Ball Feeling Tennis Beginner	2016, Sinta 4	V	V	X	X
58	Low-Compression Ball in Tennis	2024, Q2	V	V	V	V
59	Equipment Modifications Tennis (Review)	2025, Q1	V	V	V	V
60	Grass Court Tennis Short Points	2021, Q2	V	V	V	X
61	Scaling Sports Equipment for Children	2020, Q1	V	V	V	V
62	Video-Based Visual Feedback (PE SLR)	2021, Q3	X	V	V	X
63	Ball Compression & Scaled Courts Tennis	2023, Q4	V	V	V	V
64	Scaling Racket Tennis Serve	2023, Q2	V	V	V	V
65	Tennis Ball Machine Accuracy	2016, Q3	V	V	X	X

66	IMU Validity (ROM Upper Extremity)	2024, Q2	X	V	V	X
67	Grass Court Tennis Short Points (dup)	2021, Q2	X	V	V	X
68	Tennis Robot Return Strategy AI	2023, Q2	V	V	V	V
69	Self-Controlled Video Feedback Tennis	2024, Q2	V	V	V	V
70	Tennis Action Recognition IMU+SVM	2024, Q4	V	V	V	V
71	Tennis Shot Dataset Side/Top View	2024, Q4	V	V	V	V
72	AI in Tennis: Bibliometric Review	2024, Q1	V	V	V	V
73	Validation of Wearables (Tennis)	2022, – (international, not Q)	V	X	V	X
74	Monitoring Sensor Tennis (Validity)	2021, – (international, not Q)	V	X	V	X

Based on table 1, there were 74 studies that had a research focus related to training aids in sports games, but out of the 74 articles there were only 33 articles that talked about the application of field tennis training aids and 17 research articles passed the inclusive criteria. The following are the results of the analysis that has been carried out by the author in the 17 articles:

Table 2 Results of Article Review That Meet the Inclusive Criteria

Yes	Research Title	Author	Year	Data Source	Publication Source	Study Type	Key Findings	RQ Addressed
1	Development of Digital Based Tennis Footwork Instruments (Prabowo et al., n.d.)	Sugiarto Prabowo, et al.	2021	Sinta, GS	Journal of Sports (Sinta 4)	Development & validation	Valid & reliable digital footwork instruments for tennis practice.	Yes
2	Effectiveness & Qualification of Interactive Multimedia Tennis Teaching	Septian Raibowo et al.	2020	Sinta, GS	Journal of Sports Science Media (Sinta 2)	Experiments	Interactive multimedia effectively improves tennis learning outcomes.	Yes

	Materials (Raibowo et al., 2019)							
3	Feasibility of Audio-Visual Teaching Materials to Support Tennis Learning (Raibowo et al., 2022)	Septian Raibowo et al.	2022	Sinta, GS	Journal of Physical Education (Sinta 2)	Experiments	Audio-visual is valid & improves the efficiency of tennis learning.	Yes
4	DC Motor Control on Smart Tennis Practice Equipment (YOLO) (Al'azzah et al., n.d.)	Al'azzah et al., n.d.) et al.	2025	Sinta, GS	Journal of Sports Technology (Sinta 4)	Development	The smart ball thrower with YOLO is effective for a variety of exercises.	Yes
5	Media Video Tutorial Groundstroke Forehand & Backhand (Aksara & Semarayasa, 2023)	Aksara & Semarayasa et al.	2023	Sinta, GS	Journal of Recreational Sports (Sinta 4)	Development & validation	Video tutorials are worth improving groundstroke skills.	Yes
6	Video Coordination Training Model (Ball Pressure) (Irfan Arifianto, 2020)	Irfan Arifianto et al.	2020	Sinta, GS	Journal of Sports (Sinta 4)	Experiments	A valid coordination video model improves junior tennis technique.	Yes
7	Automatic Tennis Ball Thrower (Sukardi et al., 2021)	Santoso et al.	2021	Sinta, GS	Journal of Sports Science Media (Sinta 4)	Development	Automatic ball throwers are effectively used as a variation of tennis practice.	Yes
8	Does Playing Tennis with a Low-Compression Ball Affect Responses? (Kilit et al., 2024)	Fernandez-Fernandez et al.	2024	Scopus	Int. J. Sports Science (Q2)	Experiments	The low-compression ball enhances performance & playing pleasure.	Yes
9	Exploring the Impact	Martin et al.	2025	Scopus	Sports Eng. (Q1)	Scoping Review	Tool modification	Yes

	of Equipment Modifications on Novice Tennis Players (Scoping Review) (Piquer-Piquer et al., 2025)						s improve technique, control & reduce injuries.	
10	Scaling Sports Equipment for Children Promotes Functional Movement Variability (Buszard et al., 2020)	Buszard et al.	2020	Scopus	J. Sports Sciences (Q1)	Experiments	Scaled equipment improves technique & reduces the load on children's joints.	Yes
11	Effect of Ball Compression and Scaled Court Sizes on Tennis Skills (Kachel et al., 2015)	Kachel et al et al.	2023	Scopus	Eur. J. Sport Sci. (Q4)	Experiments	Mini balls & courts effectively improve beginner tennis skills.	Yes
12	There is no rush to upgrade the tennis racket in young intermediate competitive players: The effects of scaling racket on serve biomechanics and performance (Touzard et al., 2023)	Pierre Touzard., et al.	2023	Scopus	J. Biomechanics (Q2)	Experiments	Scalable rackets reduce joint load without degrading service performance.	Yes
13	Return Strategy & Machine Learning Optimization of Tennis Robot (Wang et al., 2022)	Wang Y, et al.	2023	Scopus	Robotics & AI in Sport (Q2)	AI Experiments	AI-based tennis robots effectively optimize return strategies.	Yes

14	Self-Controlled Video Feedback Facilitates Tactical Skills in Tennis (from der Meer et al., 2024)	van der Meer et al.	2024	Scopus	J. Sports Education (Q2)	Experiments	Self-feedback videos improve tennis tactical skills.	Yes
15	Tennis Action Recognition with IMU & SVM (Jinxia Gao, 2024)	Jinxia Gao, et al.	2024	Scopus	Sensors (Q4)	Experiments	IMU+SVM accurately recognizes tennis techniques for exercise evaluation.	Yes
16	Tennis Shot Side-View and Top-View Dataset for Player Analysis (Kalin Guanlun Lai, 2024)	Kalin Guanlun et al.	2024	Scopus	Dates in Letter (Q4)	Dataset	Tennis visual datasets are useful for player performance & strategy analysis.	Yes
17	Transforming Tennis with Artificial Intelligence (Bibliometric Review) (Sampaio et al., 2024)	Sampaio et al	2024	Scopus	Scientometrics (Q1)	Bibliometric Review	The trend of AI in tennis is increasing rapidly, the publication predicts 2034.	Yes

Based on the results of the study in the 17 articles, it was found that each type of training aid used has effectiveness in learning field tennis, especially in the morning for beginners, even in the 17 articles there are various types of tools, both technological and non-technological that are effective to be used in the field tennis learning process for beginners as explained in the table below:

Table 3 Results of Analysis of Types of Field Tennis Training Aids

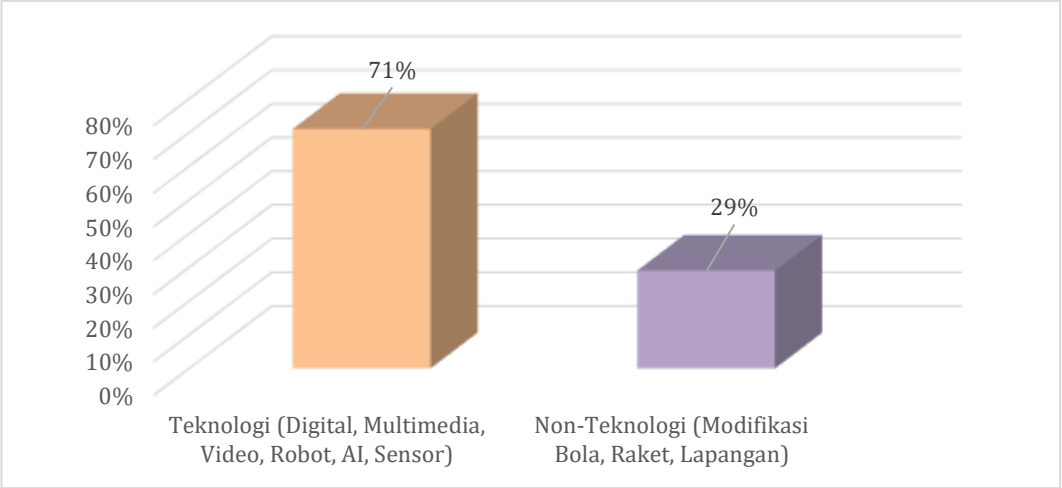
Categories	Yes	Article Title	Year & Sinta/Q	Types of Technology/Modifications	Key Findings
Technology	1	Development of Digital Based Tennis Footwork Instruments	2021, Sinta 4	Digital footwork instruments	Valid (97.5%) & reliable (r=0.998), effective for tennis

				footwork exercises.
2	Effectiveness & Qualification of Interactive Multimedia Tennis Teaching Materials	2020, Sinta 2	Interactive multimedia	Effectively improve the learning outcomes of court tennis.
3	Feasibility of Audio-Visual Teaching Materials Tennis	2022, Sinta 2	Audiovisual media	Valid & improve the efficiency of learning tennis.
4	Smart Tennis YOLO	2025, Sinta 4	Smart Ball Thrower Tool (YOLO)	Able to train in 4 automatic field areas.
5	Media Video Tutorial Groundstroke Forehand & Backhand	2023, Sinta 4	Video tutorials	It is worth improving basic groundstroke skills.
6	Video Coordination Training Model (Ball Pressure)	2020, Sinta 4	Coordination training videos	Valid (91.5%), improved junior tennis coordination.
7	Arduino Mega2560 Based Automatic Tennis Ball Thrower	2021, Sinta 4	Automatic ball throwing machine	Effective as a variation of tennis practice.
8	Tennis Robot Return Strategy AI	2023, Q2	Tennis robot with AI	Optimize the ball return strategy.
9	Self-Controlled Video Feedback in Tennis	2024, Q2	Self-feedback videos	Improve tennis tactical skills.
10	Tennis Action Recognition with IMU & SVM	2024, Q4	Sensor IMU + AI SVM	Accurately recognize tennis techniques for practice evaluation.
11	Tennis Shot Dataset Side/Top View	2024, Q4	Tennis visual dataset	Useful for analysis of player performance & strategy.
12	Transforming Tennis with AI	2024, Q1	AI bibliometrics	Tennis AI trends are increasing, publication

		(Bibliometric Review)			predictions are rising until 2034.
Non-Technology	1	Does Playing Tennis with a Low-Compression Ball Affect Responses?	2024, Q2	Low-compression ball	Improves performance & pleasure of playing recreational tennis.
	2	Equipment Modifications in Novice Tennis (Review)	2025, Q1	Equipment modification (racket/ball)	Improve technique, control, tactics & reduce injuries.
	3	Scaling Sports Equipment for Children	2020, Q1	Child scale equipment	Improves technique & variability of motion, reduces joint load.
	4	Effect of Ball Compression and Scaled Court Sizes on Tennis Skills	2023, Q4	Ball & mini court	Effectively improves beginner forehand, backhand & rally skills.
	5	Scaling Racket on Serve Biomechanics and Performance	2023, Q2	Scaled racket	Reduces joint load without lowering accuracy & service speed.

Table 4 Identification Results of the Use of Tennis Training Aids for Beginners

Yes	**Categories Tools**	**Percentage (%)**
1	Technology (Digital, Multimedia, Video, Robot, AI, Sensors)	71%
2	Non-Technology (Modification of Balls, Rackets, Fields)	29%



Picture of the Level of Use of Field Tennis Aids for Tennis Players at the Beginner Level

Based on the graph above, the use of media or tennis training aids for beginners, especially to improve hitting skills in the field tennis sport, from 17 articles, there are 12 articles (71%) utilizing technology-based aids such as digital instruments, multimedia, audiovisual, video tutorials, automatic ball throwers, AI-based tennis robots, IMU sensors, analysis datasets and as many as 5 articles (29%) show that there are many non-technological aids used in the use of media or training aids in the form of modifications of physical equipment such as low-compression balls, scaled rackets, and mini courts (Table 4). Overall, all articles state that the use of court tennis training aids, both technological and non-technology, provides effectiveness in both aspects of learning, improving technical skills, coordination, game tactics, and reducing the risk of injury.

2. Discussion

According to the above-mentioned findings regarding the identification of learning aids in tennis for beginners, using a systematic review of 17 research articles, it was found that out of the 17 articles, there are two types of learning aids for tennis that beginners can use to improve their hitting skills: technological and non-technological learning aids. Both are considered effective learning aids for beginners because they improve punching skills. As part of all studies conducted as research data sources, technological aids used as research data sources are significantly more than non-technological ones. This reflects the use of technology in various aspects of society at large, in addition to the use of technology learning aids makes it easier to provide direct feedback that can be retested on various occasions. This idea supports biofeedback and motor learning which is supported

by the theory of the information processing paradigm which explains that how a person receives, processes and responds to information received from the surrounding environment to make a decision in doing the movement is in line with the theory of cognitive development from Piaget which explains that learning activities are very closely related to the arrangement of information, perceptual reorganization and internal processes and cognitive theories expressed by Gesalt that all learning activities are carried out utilizing the understanding of relationships, especially relationships that are partial or whole. (Rahyubi, 2012; Rovi Pahliwandari, 2017).

The information provided through the application of technological media in the context of sports is a fairly explicit instruction through data and a clear understanding of movement levels, allowing beginner athletes to match, evaluate, and control the improvement of their performance status, especially in the learning process where in behavioristic theory it is explained that student behavior results from the learning process, especially when there is a proper stimulus process . Currently the use of sports technology can be said to be starting to take over the learning process of Movement, but that does not mean that non-technological learning aids are not needed today. The use of non-technological learning aids, especially modified learning aids is essential to further enable novice tennis players to find more ideal movement solutions on their own based on the feedback obtained from the use of technology. This is consistent with the theory of constraint-based approaches (CBAs) (Liu, 2023; Newcombe et al., 2019). (Park et al., 2020) (Zebua et al., n.d.).

CONCLUSION

The results of the study show that both technology-based and non-technological aids make a significant contribution to improving the quality of court tennis training. Technological tools, such as ball throwers, AI-based robots, motion sensors, and interactive multimedia, have been proven to improve training efficiency, provide fast and accurate feedback, and support innovation in sports skills learning. In addition, the use of technology also has positive implications for the competitiveness and sustainability of athletes' performance through the intensity of innovation. Meanwhile, non-technological aids continue to play an important role, especially in basic coaching. Simple modifications of equipment such as low-compression balls, scaled rackets, or mini-courts, have been shown to be effective in improving basic skills, keeping novice athletes safe,

and reducing the risk of injury. In addition, non-technological factors also help prevent dependence on technology while maintaining psychological aspects, motivation, and training culture that cannot be replaced by digital devices.

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