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Effects of a Structured Ball-Handling Training Program on Selected Fundamental Basketball Skills Among Sport Sciences Students

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ABSTRACT

Background

Fundamental basketball skills require technical and motor abilities developed through training. Ball-handling activities may improve dribbling while supporting offensive skills such as passing and shooting. However, evidence regarding the additional benefits of structured ball-handling programs beyond regular instruction remains limited.

Objective

This study examined whether a structured ball-handling training program improved shooting, passing, and dribbling performance and produced greater gains than regular instruction.

Methods

A quasi-experimental pretest–posttest design with two nonequivalent groups was used. Fifty-six male students enrolled in a Basic Basketball Skills course at the University of Jordan were purposively selected and divided into an experimental group ($n = 28$) and a control group ($n = 28$). The experimental group completed an 18-session ball-handling program over six weeks, with three 50-min sessions per week, in addition to regular instruction; the control group received instruction only. Shooting success rate, successful passes completed in 30 s, and dribbling completion time were assessed pre- and post-intervention. Within-group changes were analyzed using the Wilcoxon signed-rank test, and between-group differences using the Mann–Whitney U test. Effect sizes were calculated using $r = |Z|/\sqrt{N}$.

Results

Both groups improved significantly in shooting, passing, and dribbling ($p < .001$). In the experimental group, shooting success increased from 0.230 ± 0.149 to 0.368 ± 0.090, successful passes from 18.61 ± 2.38 to 23.29 ± 3.33 per 30 s, and dribbling time decreased from 16.16 ± 1.85 to 14.24 ± 2.08 s. At posttest, the experimental group outperformed the control group in shooting ($p = .014$) and passing ($p = .038$), but not dribbling ($p = .171$). However, improvement was significantly greater in the experimental group for shooting ($p = .022$), passing ($p < .001$), and

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dribbling ($p < .001$). Between-group effect sizes were moderate for shooting ($r = .307$), moderate-to-large for passing ($r = .447$), and large for dribbling ($r = .690$).

Conclusions
A structured six-week ball-handling program provided additional benefits beyond regular instruction, producing greater improvements in all three skills. The program particularly benefited shooting and passing, while dribbling showed greater improvement without a significant absolute posttest difference. Structured ball-handling activities may therefore complement regular instruction and support skill development.

Keywords: basketball; ball handling; dribbling; passing; shooting; skill acquisition; motor learning; basketball training

1. Introduction

Basketball is a complex intermittent team sport that requires players to coordinate technical, perceptual, cognitive, and physical capacities while responding continuously to teammates, opponents, the ball, and changing spatial and temporal constraints. Fundamental technical skills such as **dribbling, passing, and shooting** form the basis of offensive performance and must be developed progressively throughout the athlete's developmental pathway. Skill development is therefore not simply the accumulation of repetitions; it involves the acquisition and refinement of coordinated movement solutions under increasingly demanding task and environmental conditions (Schmidt & Lee, 2011; Button et al., 2020; Williams & Hodges, 2023; Runswick et al., 2026).

From a motor-learning perspective, technical proficiency develops through the interaction of the learner, the task, and the environment. Newell's (1986) constraints model proposes that movement coordination emerges from the interaction of organismic, environmental, and task constraints, while ecological-dynamics approaches emphasize that performers learn to regulate movement in relation to information and opportunities for action within the performance environment (Araújo et al., 2006; Davids et al., 2021). Accordingly, basketball practice should provide sufficient repetition to develop movement coordination while also exposing players to appropriate variability, task constraints, and progressively increasing demands. Contemporary skill-acquisition research similarly emphasizes the importance of practice quality, task specificity, challenge, feedback, and the individual characteristics of the learner (Williams & Hodges, 2023; Runswick et al., 2026).

These principles are particularly important during childhood and adolescence, when technical development occurs alongside substantial changes in body size, neuromuscular coordination, strength, speed, and movement control. The **Long-Term Athlete Development (LTAD)** framework was developed to provide a developmentally appropriate pathway through which training and competition can be aligned with the athlete's stage of maturation and long-term participation goals (Balyi & Hamilton, 2004; Balyi et al., 2013). Subsequent research has emphasized that long-term athletic development should promote fundamental movement

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competence, physical literacy, appropriate training exposure, and progressive development rather than premature specialization or excessive emphasis on short-term competitive outcomes (Ford et al., 2011; Lloyd et al., 2015; Moran et al., 2022). Thus, the development of basketball technical skills should be considered within a broader developmental framework rather than as an isolated acquisition of sport-specific techniques.

Within LTAD-oriented development, the progressive acquisition of fundamental and sport-specific motor skills is particularly important. Motor competence during youth is associated with later physical performance and provides a foundation for the development of more complex athletic abilities (Moran et al., 2022). For basketball players, this progression includes increasingly refined control of the ball, coordinated locomotion, changes of direction, passing, receiving, shooting, and the ability to combine these actions under progressively more demanding conditions. Consequently, training programs for young players should provide repeated opportunities to develop fundamental technical abilities while respecting developmental readiness and the progressive nature of skill acquisition (Balyi et al., 2013; Lloyd et al., 2015).

Ball handling and basketball skill acquisition

Ball handling represents an important component of this developmental process because it provides repeated opportunities to manipulate and control the ball through different movement patterns. Ball-handling activities may include stationary manipulation, changes of hand position, dribbling variations, passing and receiving, changes of direction, and combinations of technical actions. These activities can increase players' familiarity with the ball while requiring continuous coordination between hand movements, body position, balance, visual information, and subsequent technical actions.

The importance of structured ball-handling practice is supported by basketball-specific research. Jakovljević et al. (2015) examined three stationary, no-dribble ball-handling drills among 121 male basketball players aged 13–14 years and assessed shooting, passing, and dribbling performance. Their findings indicated that different ball-handling drills were associated with different offensive skills. In particular, the body-circles drill demonstrated significant relationships with shooting, passing, and dribbling, whereas other drills influenced selected skills. These findings suggest that ball-handling practice may have effects extending beyond the immediate manipulation of the ball. More recent research has provided additional evidence for structured ball-control practice. Budiyanto et al. (2023) reported positive effects associated with ball-handling training, while Kunci et al. (2025) found significant improvements in dribbling following varied dribbling exercises. Similarly, Leanita et al. (2025) reported significant improvement in basic dribbling performance following 16 sessions of ball-handling training over four weeks. Although these findings support structured ball-handling practice, differences in intervention design, duration, participant characteristics, and outcome measures make it difficult to establish whether such programs provide benefits beyond regular basketball instruction.

This distinction is important because skill improvement can occur naturally through continued participation in basketball training. Therefore, evidence of improvement within an intervention group alone does not necessarily demonstrate an intervention-specific effect. A controlled design

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comparing structured ball-handling practice with conventional basketball instruction provides stronger evidence regarding the additional contribution of the intervention.

Biomechanics and technical skill development

The development of basketball skills can also be understood from a **biomechanical perspective**. Biomechanics provides a scientific framework for examining how body segments coordinate to produce movement, how forces are generated and transferred through the kinetic chain, and how mechanical characteristics influence technical performance (Winter, 2009; Knudson, 2021). In sports skill development, biomechanical analysis can therefore help identify movement characteristics associated with successful technique and provide objective information that can be translated into training interventions (Robertson et al., 2019).

Basketball shooting provides a particularly clear example. Successful shooting requires coordinated lower- and upper-extremity movement, appropriate joint positioning, force generation, sequencing, balance, and regulation of the ball's release characteristics. Research using biomechanical and image-processing approaches has demonstrated the usefulness of objective movement analysis in basketball. **Saraireh et al. (2019)** developed a biomechanical training model for basketball free throws using image-processing techniques and identified multiple biomechanical variables associated with shooting performance. This type of objective analysis supports the use of biomechanical information to understand and refine technical execution rather than relying exclusively on subjective coaching observation.

Similarly, **Yousef et al. (2020)** examined a proposed training program based on kinetic variables and jump-shot accuracy among basketball beginners and reported improvements in jump-shot performance. Such findings suggest that training programs informed by mechanical characteristics of movement may contribute to the development of basketball shooting technique.

Biomechanical analysis is not limited to laboratory-based measurement. Video-based two-dimensional analysis provides a practical method for examining movement patterns in applied sporting environments. The validity and reliability of software such as Kinovea for obtaining angular and distance measurements from video have been demonstrated, supporting its use for accessible movement analysis when appropriately standardized (Puig-Diví et al., 2019). More broadly, research methods in biomechanics emphasize the importance of appropriate camera positioning, calibration, sampling characteristics, coordinate systems, and measurement procedures when extracting kinematic information from video recordings (Robertson et al., 2019).

This objective approach is particularly relevant to basketball because many technical actions occur rapidly and involve coordinated movement of multiple body segments. Kinematic analysis can provide information concerning joint angles, segment positions, movement displacement, velocity, and timing, whereas kinetic analysis can provide insight into force production and mechanical loading. Together, these approaches can contribute to a more comprehensive understanding of technical skill development (Winter, 2009; Knudson, 2021; Robertson et al., 2019).

Integration of skill acquisition, LTAD, and biomechanics

The combination of **skill-acquisition theory, LTAD principles, and biomechanical analysis** provides a useful conceptual framework for understanding technical development in young basketball players. LTAD establishes the developmental context in which training should progress; motor-learning and skill-acquisition theories explain how movement skills are acquired and

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refined; and biomechanics provides objective information about movement organization and technical execution (Balyi et al., 2013; Button et al., 2020; Knudson, 2021; Lloyd et al., 2015).

From this integrated perspective, ball-handling training can be viewed as more than a collection of isolated exercises. A progressively organized program can provide repeated opportunities for young players to develop coordination, control, and movement adaptability while gradually increasing task complexity. The constraints-led and ecological-dynamics perspectives further suggest that variations in task constraints can encourage performers to explore and stabilize functional movement solutions rather than simply reproduce a single predetermined movement pattern (Davids et al., 2021; Chow et al., 2022).

This theoretical perspective is particularly relevant to basketball because players rarely perform technical skills in complete isolation during actual play. Dribbling may immediately precede passing or shooting; receiving a pass may require an adjustment of body position before a shot; and changes in direction may require simultaneous regulation of the ball and body. Therefore, appropriately designed practice should provide opportunities to coordinate related technical actions while maintaining sufficient repetition to develop consistency.

Evidence for transfer among fundamental basketball skills

Previous empirical research provides evidence that structured practice may influence multiple technical outcomes. Jakovljević et al. (2015) demonstrated that selected stationary ball-handling drills influenced shooting, passing, and dribbling, suggesting potential transfer between related technical skills. More recent studies have demonstrated improvements in dribbling following structured ball-handling or dribbling programs (Kunci et al., 2025; Leanita et al., 2025). At the same time, research based on biomechanical analysis has demonstrated that technical training can influence shooting accuracy when training is informed by movement and kinetic characteristics (Saraireh et al., 2019; Yousef et al., 2020).

The possibility of transfer between skills is consistent with the view that learning involves the development of coordination solutions rather than the isolated memorization of individual movements (Araújo & Davids, 2011; Button et al., 2020). However, transfer should not be assumed automatically. The similarity between practice and performance demands, the organization of the training tasks, the level of challenge, and the learner's existing capabilities may all influence whether improvements in one activity generalize to another (Williams & Hodges, 2023; Orth et al., 2019).

Research gap

Despite increasing interest in basketball skill development, several important gaps remain. First, much of the existing ball-handling literature has concentrated on **dribbling**, whereas fewer studies have simultaneously examined shooting, passing, and dribbling as outcomes of a structured ball-handling intervention. Second, existing studies differ substantially in training duration, exercise selection, participant age, measurement procedures, and experimental design, making comparisons difficult (Budiyanto et al., 2023; Kunci et al., 2025; Leanita et al., 2025). Third, improvements following an intervention cannot be interpreted confidently without considering the improvements that may occur through conventional basketball instruction.

A further gap concerns the integration of technical practice with objective assessment. Although biomechanical studies have examined shooting mechanics and other basketball movement

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characteristics (Saraireh et al., 2019; Yousef et al., 2020), comparatively little research has examined whether a **structured ball-handling program** can produce measurable improvements across several fundamental offensive skills within a controlled educational setting.

The present study therefore addresses this gap by examining whether a structured ball-handling program produces improvements in **shooting, passing, and dribbling beyond those achieved through regular basketball instruction**. The intervention was designed as a progressive supplementary program incorporating ball manipulation, dribbling, passing and receiving, shooting, and combined technical activities. Performance was assessed using standardized measures of shooting success, successful passing, and dribbling completion time.

Based on the theoretical foundations of skill acquisition, developmental training, and biomechanically informed technical practice, and on previous empirical evidence concerning basketball ball handling and technical performance (Balyi et al., 2013; Jakovljević et al., 2015; Williams & Hodges, 2023; Kunci et al., 2025; Leanita et al., 2025; Runswick et al., 2026), it was hypothesized that participants undertaking the structured ball-handling program would demonstrate greater improvements in shooting, passing, and dribbling than participants receiving regular basketball instruction.

Purpose and Research Hypotheses

The purpose of this study was to **determine whether a structured ball-handling training program produces greater improvements in fundamental basketball skills than regular basketball instruction among young basketball players**.

Specifically, the study examined whether the program:

1. improved shooting success rate from pretest to posttest;
2. improved the number of successful passes completed within 30 s;
3. reduced dribbling completion time; and
4. produced greater improvements in these three skills than regular basketball instruction.

Research Hypotheses

Based on the theoretical and empirical literature, the following hypotheses were formulated:

H1. Participants who undertake the structured ball-handling training program will demonstrate significant improvements in shooting success rate, successful passing performance, and dribbling completion time from pretest to posttest.

H2. The experimental group will demonstrate significantly greater **posttest performance** in shooting, passing, and dribbling than the control group receiving regular basketball instruction.

H3. The experimental group will demonstrate significantly greater **pretest-to-posttest improvement** in shooting, passing, and dribbling than the control group.

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2. Methods

2.1 Study Design

A **quasi-experimental pretest–posttest design with an experimental group and a control group** was used to examine the effect of a structured ball-handling training program on selected fundamental basketball skills. The original study describes the design as experimental; however, because the participants were selected purposively and the available documentation does not establish random allocation, the revised manuscript uses the more precise term *quasi-experimental*. The study compared changes within each group and differences between groups following the intervention.

The independent variable was a structured educational program based on ball-handling exercises, whereas the dependent variables were shooting success rate, successful passing performance, and dribbling performance.

The overall experimental design, group allocation, intervention structure, assessment points, and data-analysis procedures are presented in Figure 1.

As shown in **Figure 1**, both groups completed pretest and posttest assessments of shooting, passing, and dribbling, while only the experimental group received the structured ball-handling program in addition to regular basketball instruction.

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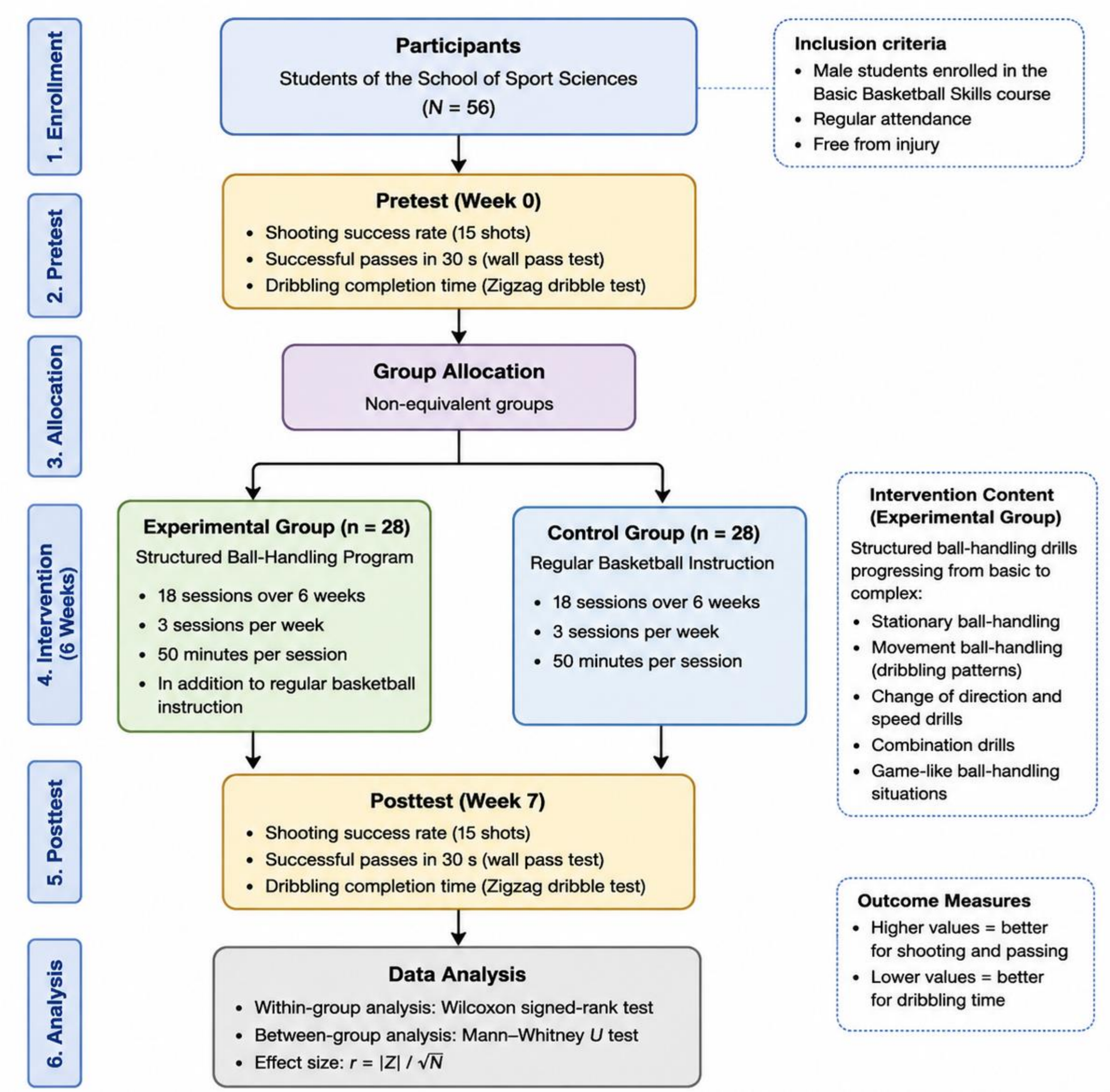

Figure 1 : *Experimental design and participant flow of the study.*

Note. N = total sample size; n = group sample size. The experimental group participated in the structured ball-handling program in addition to regular basketball instruction, whereas the control group received regular basketball instruction only.

2.2 Participants

The study population consisted of **162 students enrolled in the Basic Basketball Skills course at the School of Sport Sciences during the second semester of the 2023/2024 academic year**.

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A purposive sample of **56 students (35% of the population)** was selected and divided into an experimental group (n = 28) and a control group (n = 28).
The experimental group participated in the structured ball-handling program, whereas the control group received the regular instructional program. The two groups were compared at pretest using the Mann–Whitney U test to assess baseline differences in the three outcome measures. No statistically significant baseline differences were identified.
Important methodological correction: I have deliberately not stated participant age, sex, or playing experience because these characteristics are not adequately documented in the source material we have. We should add them only if you have the information.

2.3 Ethical and Administrative Procedures

Formal administrative approval to conduct the study was obtained from the **Deanship of the School of Sport Sciences at the University of Jordan**.
The current manuscript does **not document institutional ethics committee approval, written informed consent, or an ethics approval number**. Therefore, I will not add such information without evidence.
This needs to be checked before submission. If the University of Jordan approval included research ethics approval, we should add the appropriate committee name and approval number.

2.4 Intervention Program

2.4.1 Development of the program

The educational program was developed after reviewing literature and previous studies related to ball-handling training and conventional instruction in basketball, followed by consultation with specialists in physical education and basketball. The initial program was subsequently submitted to **six experts** with relevant expertise in physical education and basketball for evaluation of its content and suitability for the intended purpose. Their recommendations concerning additions, deletions, modifications, and other aspects of the program were incorporated into the final version. The program consisted of **18 instructional sessions delivered over six instructional weeks**, with **three sessions per week**.

Each session lasted **50 min** and consisted of:

- **Warm-up:** 5 min
- **Preparatory/simple ball exercises:** 15 min
- **Instruction/demonstration:** 5 min
- **Practical application:** 20 min
- **Closing activity:** 5 min

The session structure is documented consistently throughout the six-week program.

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2.4.2 Content and progression of the intervention

The program progressed from basic ball familiarity and control exercises toward more complex basketball-specific skills. The intervention was implemented over **six consecutive instructional weeks**, with three 50-min sessions conducted per week, for a total of **18 sessions (900 min)**. The program progressed systematically from basic ball familiarization and control exercises to more complex dribbling, passing, shooting, and integrated basketball-skill activities.

Training principles

The program incorporated several instructional procedures throughout the sessions, including:

- demonstration of the desired movement,
- video demonstrations of selected skills,
- immediate correction of technical errors,
- continuous observation and performance reinforcement,
- feedback following each training bout,
- progressive complexity of exercises, and
- instructions designed to reduce visual dependence during dribbling.

The source specifically states that participants were instructed **not to look at the ball or the floor while dribbling**.
This component is important enough that I recommend retaining it in the final Methods because it distinguishes the intervention from ordinary repetitive basketball practice.

2.5 Control Condition

Participants in the control group received the **regular basketball instructional program** during the same six-week period. The original manuscript indicates that conventional instruction included explanation, demonstration of correct technique, practical practice, repetition, and feedback.
This is important because the control group was **not a no-treatment group**. Both groups therefore received basketball instruction, with the principal distinction being the addition of the structured ball-handling program for the experimental group.

2.6 Outcome Measures

Three basketball skill outcomes were assessed before and after the intervention.
The original study selected skill tests after reviewing the relevant literature and adopted basketball skill-testing procedures associated with **AAHPERD** for assessment of shooting, passing/receiving, and dribbling.

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2.6.1 Shooting success rate

Shooting performance was expressed as a **success rate**, calculated from the number of successful shots relative to the total number of attempts.
For the statistical analysis, the underlying successful-shot and attempt counts recorded in the Excel dataset were used to derive the exact success proportion rather than relying on the rounded percentage values stored in the spreadsheet.
This is an important improvement over the original manuscript because the Excel file contains the underlying In and Attempts variables.

2.6.2 Passing performance

Passing performance was assessed as the **number of successful passes completed during a 30-s testing period**. The manuscript and dataset consistently report this outcome in terms of the number of successful passes rather than passing velocity.
Therefore, the final manuscript will **not** describe this variable as "passing speed."

2.6.3 Dribbling performance

Dribbling performance was assessed using a timed dribbling test, with performance expressed in **seconds**. Lower completion time represented better performance. This is consistent with the interpretation of the original results, in which reductions from 16.16 to 14.24 s and from 16.36 to 15.16 s were interpreted as improvements.
Accordingly, the final manuscript will refer to this outcome as **dribbling completion time (s)** rather than "dribbling speed."

2.7 Testing Procedure

A pretest was administered to both groups before implementation of the intervention. The participants' performance on the three basketball skill tests was recorded individually on standardized recording forms. Following completion of the six-week instructional period, the same skill tests were administered as posttests and the results were recorded for subsequent analysis.
The same general testing procedures were used for the experimental and control groups to permit comparison of changes over time and differences between groups.

2.8 Equipment

The study used:

- a regulation-size 7 basketball,
- a regulation-height basketball backboard and hoop (3.05 m),
- a whistle,

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- cones,
- a stopwatch,
- data-recording forms, and
- a regulation basketball court.

2.9 Content Validity

Content validity of the educational program was assessed by **six experts** with experience in physical education and basketball. The experts reviewed the initial version of the program for its appropriateness, relevance to the intended objectives, and the need for additions, deletions, or modifications. Their recommendations were incorporated into the final program.

Important distinction

This establishes **content validity of the intervention program**.
It does **not**, by itself, establish the reliability of the three outcome tests.
At present, the source material does not provide a test–retest, inter-rater, or intra-rater reliability coefficient for the shooting, passing, or dribbling measures. We therefore should **not invent reliability coefficients**.

2.10 Statistical Analysis

The original analysis was conducted using **SPSS version 25** and included descriptive statistics, the Wilcoxon signed-rank test, and the Mann–Whitney *U* test.
For the revised analysis, the statistical procedures will be specified as follows:

Descriptive statistics

Means and standard deviations were calculated for each outcome at pretest and posttest.

Within-group comparisons

The **Wilcoxon signed-rank test** was used to compare pretest and posttest performance within each group because the distributional assumptions for parametric paired analyses were not consistently satisfied.

Between-group comparisons

The **Mann–Whitney *U* test** was used to compare:

1. experimental and control groups at baseline;
2. experimental and control groups at posttest; and
3. the magnitude of pretest-to-posttest improvement between groups.

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Change scores
For shooting and passing:
Change = Posttest − Pretest
For dribbling:
Change = Pretest − Posttest
because a reduction in completion time represents improved performance.

Effect sizes
Effect sizes will be reported alongside the inferential tests in the revised Results section to provide an estimate of the magnitude of the observed differences, rather than relying solely on *p* values.

Significance level

The statistical significance threshold was set at:

α = .05

3. Results
The statistical analysis was conducted using the participant-level data from the Excel dataset. The three outcomes were **shooting success rate**, **successful passes completed in 30 s**, and **dribbling completion time**. Because lower dribbling time indicates better performance, reductions in dribbling time were interpreted as improvements.

3.1 Baseline Comparison Between Groups
Before examining the intervention effects, the experimental and control groups were compared at pretest using the Mann–Whitney *U* test. No statistically significant differences were found between the groups for any of the three outcomes (Table 1). The original dataset reports *p* values of .961 for shooting, .766 for passing, and .844 for dribbling.

Table 1: Pretest Comparison of Basketball Skill Performance Between the Experimental and Control Groups

Outcome	Experimental, M (SD)	Control, M (SD)	*U*	*p*
Shooting success rate	0.230 (0.149)	0.225 (0.132)	395.50	.961
Successful passes/30 s	18.61 (2.38)	18.86 (3.27)	373.50	.766
Dribbling completion time (s)	16.16 (1.85)	16.36 (2.23)	379.50	.844

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Note. *U* = Mann–Whitney *U*. *p* values are two-tailed. None of the baseline comparisons was statistically significant at α = .05.
These findings indicate that the two groups were comparable in the measured basketball skills before the intervention.

3.2 Pretest–Posttest Changes in the Experimental Group

The Wilcoxon signed-rank test revealed statistically significant improvements in all three outcomes in the experimental group (Table 2).
Shooting success rate increased from **0.230 ± 0.149** at pretest to **0.368 ± 0.090** at posttest. Successful passes increased from **18.61 ± 2.38** to **23.29 ± 3.33 per 30 s**, while dribbling completion time decreased from **16.16 ± 1.85 s** to **14.24 ± 2.08 s**. All three changes were statistically significant, $p < .001$.

Table 2: Pretest–Posttest Changes in the Experimental Group

Outcome	Pretest, M (SD)	Posttest, M (SD)	*Z*	*p*
Shooting success rate	0.230 (0.149)	0.368 (0.090)	−4.57	< .001
Successful passes/30 s	18.61 (2.38)	23.29 (3.33)	−4.55	< .001
Dribbling completion time (s)	16.16 (1.85)	14.24 (2.08)	−4.62	< .001

Note. *Z* values are from the Wilcoxon signed-rank test. A lower posttest value for dribbling time represents improved performance.

Thus, the experimental group demonstrated significant pretest-to-posttest improvement across all three measured basketball skills.

3.3 Pretest–Posttest Changes in the Control Group

The control group also demonstrated statistically significant improvements in all three outcomes (Table 3).
Shooting success rate increased from **0.225 ± 0.132** to **0.305 ± 0.084**, while successful passes increased from **18.86 ± 3.27** to **21.46 ± 2.60 per 30 s**. Dribbling completion time decreased from **16.36 ± 2.23 s** to **15.16 ± 2.28 s**. All three changes were statistically significant, $p < .001$.

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Table 3: Pretest–Posttest Changes in the Control Group

Outcome	Pretest, M (SD)	Posttest, M (SD)	*Z*	*p*
Shooting success rate	0.225 (0.132)	0.305 (0.084)	−3.94	< .001
Successful passes/30 s	18.86 (3.27)	21.46 (2.60)	−4.49	< .001
Dribbling completion time (s)	16.36 (2.23)	15.16 (2.28)	−4.62	< .001

Note. *Z* values are from the Wilcoxon signed-rank test. A reduction in dribbling completion time represents improved performance.

This finding is important: **regular basketball instruction also produced significant skill development**. Therefore, the effect of the experimental program should be evaluated primarily through the between-group comparisons rather than by considering improvement within the experimental group alone.

3.4 Posttest Comparison Between Groups

The Mann–Whitney *U* test was subsequently used to compare the two groups at posttest (Table 4). The experimental group demonstrated significantly higher shooting success than the control group, **0.368 ± 0.090 versus 0.305 ± 0.084, U = 542.00, p = .014**.
Similarly, the experimental group completed significantly more successful passes in 30 s than the control group, **23.29 ± 3.33 versus 21.46 ± 2.60, U = 518.00, p = .038**.
For dribbling, although the experimental group had a lower mean completion time (**14.24 ± 2.00 s**) than the control group (**15.16 ± 2.28 s**), the difference was **not statistically significant**, U = 308.00, p = .171.

Table 4 : Posttest Comparison of Basketball Skill Performance Between Groups

Outcome	Experimental, M (SD)	Control, M (SD)	*U*	*p*
Shooting success rate	0.368 (0.090)	0.305 (0.084)	542.00	.014
Successful passes/30 s	23.29 (3.33)	21.46 (2.60)	518.00	.038
Dribbling completion time (s)	14.24 (2.00)	15.16 (2.28)	308.00	.171

Note. *U* = Mann–Whitney *U*. *p* values are two-tailed. For dribbling, the lower mean indicates better performance.

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Interpretation

The posttest analysis therefore demonstrated a significant advantage for the experimental group in:

- **shooting**, and
- **passing**,

but **not in dribbling**.

This is an important result that must remain explicit in the final manuscript.

3.5 Comparison of Magnitude of Improvement

To determine whether the experimental program produced greater improvement than regular instruction, individual change scores were calculated for each participant. For shooting and passing, improvement was calculated as posttest minus pretest. For dribbling, improvement was calculated as pretest minus posttest because lower completion time represents better performance.

The experimental group demonstrated significantly greater improvement than the control group in all three outcomes (Table 5). The mean improvement was **0.139 ± 0.110 versus 0.080 ± 0.098** for shooting, **4.68 ± 2.48 versus 2.61 ± 1.89** for passing, and **1.92 ± 0.42 versus 1.20 ± 0.37 s** for dribbling.

Table 5: Between-Group Comparison of Pretest–Posttest Improvement

Outcome	Experimental, M (SD)	Control, M (SD)	*U*	*p*
Shooting success rate	0.139 (0.110)	0.080 (0.098)	251.50	.022
Successful passes/30 s	4.68 (2.48)	2.61 (1.89)	187.50	< .001
Dribbling improvement (s)	1.92 (0.42)	1.20 (0.37)	76.50	< .001

Note. For shooting and passing, positive values indicate increases from pretest to posttest. For dribbling, positive values indicate reductions in completion time.

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3.6 Effect Sizes

The effect-size analysis showed that the observed changes were not only statistically significant but also generally substantial in magnitude.

Table 6: Effect Sizes for Within- and Between-Group Comparisons

Comparison	Outcome	*r*	Interpretation
Experimental pre–post	Shooting	.864	Large
Experimental pre–post	Passing	.860	Large
Experimental pre–post	Dribbling	.874	Large
Control pre–post	Shooting	.745	Large
Control pre–post	Passing	.849	Large
Control pre–post	Dribbling	.874	Large
Posttest: Experimental vs. Control	Shooting	.328	Moderate
Posttest: Experimental vs. Control	Passing	.275	Small–moderate
Posttest: Experimental vs. Control	Dribbling	.184	Small
Change scores: Experimental vs. Control	Shooting	.307	Moderate
Change scores: Experimental vs. Control	Passing	.447	Moderate–large
Change scores: Experimental vs. Control	Dribbling	.690	Large

Note. Effect sizes for the Wilcoxon signed-rank and Mann–Whitney *U* tests were calculated as $r = |Z|/\sqrt{N}$. Following conventional guidelines, approximately .10, .30, and .50 represent small, moderate, and large effects, respectively. The magnitude of *r* should be interpreted together with the direction and practical meaning of the outcome.

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Interpretation

The within-group effect sizes were large for all three skills in both groups. This indicates that **both regular basketball instruction and the structured ball-handling program were associated with substantial pretest-to-posttest changes**.

The more informative comparison, however, is the difference in improvement between groups. The experimental program produced a **moderate effect for shooting (*r* = .307), a moderate-to-large effect for passing (*r* = .447), and a large effect for dribbling (*r* = .690)**.

This strengthens an important conclusion from the Results: although the experimental group did not differ significantly from the control group in **absolute posttest dribbling time**, the experimental group demonstrated a **substantially greater improvement from baseline**.

3.7 Summary of Results

Overall, both groups demonstrated significant improvements in shooting, passing, and dribbling following the instructional period. However, the **magnitude of improvement was significantly greater in the experimental group for all three outcomes**.

At posttest, the experimental group performed significantly better than the control group in **shooting and passing**, whereas the between-group difference in **dribbling completion time was not statistically significant**.

This distinction is important because it indicates that the intervention's effect on dribbling is more clearly demonstrated by the **greater change from baseline** than by the absolute posttest comparison.

Hypothesis status

Hypothesis	Outcome
H1: Experimental group improves in all three skills	**Supported**
H2: Experimental group superior at posttest in all three skills	**Partially supported** — shooting and passing only
H3: Experimental group shows greater improvement in all three skills	**Supported**

5. Discussion

The purpose of this study was to examine whether a structured ball-handling training program could improve three fundamental basketball skills—shooting, passing, and dribbling—beyond the improvements achieved through regular basketball instruction. The results demonstrated

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significant changes in the experimental group across the assessed technical outcomes, while the magnitude and pattern of improvement differed among shooting, passing, and dribbling. The between-group findings and effect-size estimates further indicate that the structured program provided an additional training stimulus beyond conventional instruction. These findings support the view that systematically organized technical practice can contribute to the development of fundamental basketball skills when training content is aligned with the characteristics of the skills being developed (Jakovljević et al., 2015; Williams & Hodges, 2023; Runswick et al., 2026).

5.1 Effect of the program on shooting performance

The improvement in shooting performance observed following the structured ball-handling program is important because shooting represents a complex technical action requiring coordinated control of the ball, body alignment, force production, timing, balance, and release mechanics. Although the intervention was not limited to shooting practice, repeated ball manipulation and integrated technical activities may have provided additional opportunities to refine coordination between the hands, upper extremities, trunk, and lower extremities.

The present findings are consistent with previous basketball research demonstrating that structured technical training can influence shooting accuracy. Yousef et al. (2020) reported improvements in jump-shot accuracy following a training program based on kinetic variables, suggesting that systematic training directed toward the mechanical characteristics of shooting can produce measurable technical adaptations. Similarly, Saraireh et al. (2019) demonstrated the usefulness of image-processing and biomechanical analysis for identifying movement variables associated with successful free-throw performance. Together, these findings suggest that improvements in shooting should be understood not simply as the result of repeated attempts, but as an outcome of developing coordinated movement patterns and controlling the mechanical characteristics of the shooting action.

The current findings can also be interpreted within the broader motor-learning framework. Schmidt and Lee (2011) and Button et al. (2020) emphasize that motor skill learning involves the development and stabilization of coordinated movement solutions through practice. From this perspective, repeated ball-handling activities may indirectly support shooting by improving ball control, hand positioning, timing, and coordination, which are subsequently incorporated into the shooting action.

However, the transfer from ball handling to shooting should not be interpreted as automatic. The degree of transfer depends on the similarity between the practiced coordination demands and those required during the criterion skill (Williams & Hodges, 2023). The improvement observed in the present study may therefore reflect the fact that the intervention included not only isolated ball manipulation but also progressive activities combining ball control with shooting-related actions.

5.2 Effect of the program on passing performance

Passing also improved following the intervention, supporting the hypothesis that structured ball-handling practice can influence technical skills beyond dribbling. Passing requires accurate control of direction and force, appropriate hand positioning, timing, and coordination between the ball and body. The present finding is particularly consistent with Jakovljević et al. (2015), who reported

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significant effects of selected stationary ball-handling drills on passing performance among young basketball players.

One possible explanation is that repeated manipulation of the ball increased familiarity with its weight, trajectory, and required force regulation. The intervention also provided repeated opportunities to coordinate hand movements with body position and movement direction. These characteristics may have contributed to more consistent execution during the passing test.

The finding is also compatible with contemporary skill-acquisition theory. Effective practice does not necessarily require that every practice activity reproduce the final performance exactly; rather, appropriately related tasks can develop underlying coordination patterns that subsequently support performance in related skills (Araújo & Davids, 2011; Davids et al., 2021). Thus, the present results provide some evidence for transfer between related technical actions.

Nevertheless, the magnitude of improvement should be interpreted in relation to the actual structure of the intervention. If passing activities constituted a substantial component of the program, the improvement may represent both direct practice effects and indirect benefits arising from improved ball control. Future research should therefore manipulate the proportion of direct versus indirect practice to determine which component contributes most strongly to passing development.

5.3 Effect of the program on dribbling performance

The improvement in dribbling performance provides the most direct evidence supporting the effectiveness of the intervention because dribbling is closely related to the content of ball-handling training. The result is consistent with recent intervention studies. Leanita et al. (2025) reported significant improvement in dribbling following a structured ball-handling program, while Kunci et al. (2025) similarly reported improvements following varied dribbling exercises. These findings reinforce the proposition that systematic exposure to different ball-control tasks can improve players' ability to manipulate the ball while moving.

The findings are also compatible with Jakovljević et al. (2015), who demonstrated that selected stationary ball-handling drills influenced dribbling performance. Importantly, however, their results showed that different drills produced different patterns of influence across shooting, passing, and dribbling. This supports the idea that **exercise content matters** and that the effectiveness of a ball-handling program cannot be attributed simply to the amount of practice.

From a motor-learning perspective, repeated changes in hand position, movement direction, speed, and coordination may encourage the development of more adaptable movement solutions. Newell's (1986) constraints model provides a useful explanation: altering task constraints can encourage performers to reorganize their coordination patterns in response to changing movement demands. Similarly, ecological-dynamics approaches emphasize that skill emerges through the interaction of performer, task, and environmental constraints (Araújo et al., 2006; Davids et al., 2021).

This interpretation is particularly relevant to basketball because effective dribbling during actual play requires more than maintaining control of the ball. Players must change speed and direction, protect the ball, maintain balance, and respond to opponents while simultaneously perceiving

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opportunities for action. The FIBA coaching framework likewise emphasizes controlling the ball at different speeds, using both hands, maintaining balance, and keeping the eyes up as important components of competent dribbling.

5.4 Why the three skills may have responded differently

Although all three technical outcomes improved, differences in the magnitude of improvement are theoretically meaningful. Shooting, passing, and dribbling share some underlying coordination requirements but also impose distinct task constraints. Dribbling requires continuous ball control during movement; passing requires accurate force and directional regulation toward a target; and shooting requires precise spatial and temporal control of the release action.

Consequently, a common ball-handling intervention may not produce identical adaptations across all three skills. The finding that the intervention affected multiple outcomes nevertheless supports the idea that related technical skills can share transferable coordination components. This is consistent with the concept of **skill transfer**, although the degree of transfer is expected to depend on the functional similarity between the practiced and tested actions (Schmidt & Lee, 2011; Williams & Hodges, 2023).

The present findings also reinforce the importance of practice design. Williams and Hodges (2023) argue that effective practice should be purposeful, appropriately challenging, and sufficiently specific to the intended learning outcome. Runswick et al. (2026) similarly identified practice design and individualized skill development as central components of effective skill acquisition. Therefore, the present results may reflect not simply the presence of additional practice but the structured organization and progression of the additional practice.

5.5 Relationship with LTAD and youth basketball development

The findings have particular relevance to long-term athlete development. Fundamental technical skills developed during youth provide an important foundation for later sport-specific performance. LTAD frameworks emphasize progressive development and appropriately structured training rather than an exclusive focus on immediate competitive outcomes (Balyi et al., 2013; Ford et al., 2011; Lloyd et al., 2015).

The present intervention provides a practical example of how additional technical practice can be integrated into youth basketball development. Rather than treating ball handling, passing, and shooting as completely independent skills, the program provided opportunities to develop related technical components progressively. Such an approach is compatible with contemporary developmental perspectives emphasizing the integration of fundamental movement competence, sport-specific skill development, and progressively more demanding practice environments (Moran et al., 2022).

Importantly, recent evidence from **Ashkanani et al. (2026)** strengthens this interpretation. Their study of basketball coaches specifically examined biomechanics literacy in relation to LTAD and coaching practice and highlighted the importance of coaches' biomechanical knowledge for athlete development. This is directly relevant to the present findings because a structured technical

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program benefits from coaches being able to understand not only *what* skill should be practiced but also the movement and biomechanical characteristics underlying effective execution.

5.6 Biomechanical interpretation and practical implications

Although the present study primarily evaluated performance outcomes rather than detailed kinematic variables, the findings can be interpreted within a biomechanical framework. Basketball technique is ultimately expressed through coordinated segmental motion, force production, balance, and timing. Biomechanical analysis can therefore provide a useful bridge between observed performance outcomes and the movement mechanisms responsible for those outcomes (Winter, 2009; Knudson, 2021; Robertson et al., 2019).

Previous work by Saraireh et al. (2019) illustrates how image-processing methods can identify biomechanical variables associated with successful basketball shooting, while Yousef et al. (2020) demonstrated that training based on kinetic characteristics can influence jump-shot accuracy. These studies suggest that future research should move beyond measuring whether a ball-handling program improves performance and examine **how** the movement pattern changes.

For example, future studies could investigate whether improvements in shooting are accompanied by changes in release angle, trunk position, elbow and wrist motion, or lower-extremity contribution. Similarly, changes in dribbling could be examined through movement velocity, center-of-mass displacement, trunk inclination, or hand-ball coordination. Two-dimensional video analysis provides a practical possibility for such investigations when laboratory-based motion capture is unavailable, provided that camera placement, calibration, sampling frequency, and measurement procedures are appropriately standardized (Puig-Diví et al., 2019; Robertson et al., 2019).

5.7 Theoretical and practical significance

The principal theoretical contribution of the present study is that it provides evidence that a structured ball-handling program can influence **multiple related basketball skills**, rather than producing an improvement restricted to dribbling. This finding supports a broader view of technical development in which related movement skills can interact and potentially transfer when practice is appropriately structured.

Practically, the findings suggest that basketball instructors can incorporate structured ball-handling activities as a supplementary component of regular instruction rather than treating ball handling as an isolated skill. Coaches may particularly benefit from progressing from simple manipulation tasks toward more complex activities involving changes of direction, passing, receiving, shooting, and combined actions. Such progression is consistent with skill-acquisition principles and the developmental logic of LTAD (Balyi et al., 2013; Williams & Hodges, 2023; Runswick et al., 2026).

The findings also reinforce the potential value of biomechanical literacy among basketball coaches. As emphasized by Ashkanani et al. (2026), understanding biomechanical principles can strengthen coaching practice and contribute to more informed athlete development. In this context,

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coaches may use objective performance measures and, where possible, video-based biomechanical assessment to identify technical deficiencies and individualize training.

5.8 Limitations and directions for future research

Several limitations should be considered. First, the intervention duration was relatively short, and therefore the extent to which the observed improvements would be retained over longer periods remains unknown. Second, the study assessed technical performance through selected field-based tests; these tests provide useful objective measures but may not fully reproduce the perceptual and decision-making demands of competitive basketball. Third, the present study did not directly measure kinematic or kinetic changes, so the biomechanical mechanisms underlying the observed performance improvements cannot be established.

Future studies should therefore investigate whether improvements are retained after a detraining period and whether they transfer to more representative game situations. Research should also examine the relationship between performance changes and biomechanical variables using synchronized video analysis or three-dimensional motion capture. Finally, studies could compare different ball-handling program structures, training frequencies, and levels of task variability to identify the optimal dose and organization of technical practice.

5.9 Overall interpretation

Taken together, the findings indicate that the structured ball-handling program provided an effective supplementary stimulus for the development of fundamental basketball skills. The improvements observed across shooting, passing, and dribbling are consistent with previous basketball intervention research and with contemporary theories of skill acquisition and developmental training. The findings further suggest that the benefits of ball-handling practice may extend beyond direct dribbling proficiency when training is progressively organized and incorporates related technical actions.

The study therefore supports an integrated approach in which **skill acquisition, LTAD principles, basketball pedagogy, and biomechanical understanding** inform the design and evaluation of youth basketball training. Further research combining controlled interventions with objective biomechanical measurements is warranted to determine the movement mechanisms responsible for these improvements and to establish how long they persist.

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