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Araştırma Makalesi / Research Article

Effects of an 8-Week Skill-Based Training Program on Anaerobic Performance in Young Basketball Players: A Comparison of U17 and U19 Athletes

Genç Basketbolcularda 8 Haftalık Beceri Tabanlı Antrenmanın Anaerobik Performans Üzerine Etkisi: U17 ve U19 Sporcularının Karşılaştırılması

Hamza Budak[1], Mustafa Karahan[2], Hüseyin Ünlü[3], Büşra Özdek[3]

[1] Department of Coaching Education, Faculty of Sports Sciences, Aksaray University, Aksaray, Türkiye
[2] Department of Coaching Education, Necat Hepkon Faculty of Sports Sciences, Dokuz Eylül University, İzmir, Türkiye
[3] Department of Physical Education and Sports, Faculty of Sports Sciences, Aksaray University, Aksaray, Türkiye

ABSTRACT

Although skill-based training has been shown to improve performance in young athletes, the role of age in the response to such training remains unclear. This study aimed to investigate whether the effects of skill-based basketball training on anaerobic and neuromuscular performance differ according to age group in young male basketball players. A total of 20 amateur male basketball players from the U17 (n=10) and U19 (n=10) age groups voluntarily participated in the study. The athletes completed skill-based basketball training for 8 weeks, 3 days per week, with each session lasting 80 minutes. Before and after the training period, the athletes performed the 20-m sprint, T-test, 6×35-m repeated sprint, and vertical jump tests. In the U17 and U19 groups, mean anaerobic power improved by 6.07% and 5.27%, 20-m sprint performance by 2.25% and 3.13%, change-of-direction performance by 1.76% and 1.79%, vertical jump performance by 3.26% in both groups, and explosive power by 4.39% and 3.81%, respectively. A significant group × time interaction was observed only for change-of-direction performance ($p=0.007$), indicating that the pattern of change differed between the two age groups. No significant group × time interactions were observed for the other performance measures ($p>0.05$). In conclusion, skill-based basketball training was associated with improvements in anaerobic and neuromuscular performance measures in young male basketball players. However, except for change-of-direction performance, the training responses did not differ between the U17 and U19 groups.

Keywords: Anaerobic power, change of direction, vertical jump, sprint.

ÖZET

Beceri tabanlı antrenmanların genç sporcularda performansı geliştirdiği bilinmekle birlikte, yaşın bu antrenmanlara verilen yanıt üzerindeki rolü net değildir. Bu çalışmanın amacı, beceri tabanlı basketbol antrenmanının genç erkek basketbolcuların anaerobik ve nöromüsküler performansları üzerindeki etkilerinin yaş gruplarına göre farklılık gösterip göstermediğini incelemektir. Çalışmaya U17 (n=10) ve U19 (n=10) gruplarında yer alan toplam 20 amatör erkek basketbolcu gönüllü olarak katılmıştır. Sporcular 8 hafta boyunca haftada 3 gün ve 80 dakika/gün beceri tabanlı basketbol antrenmanı gerçekleştirmiştir. Antrenman öncesinde ve sonrasında 20 m sprint, T-koşu, 6 × 35 m tekrarlı sprint ve dikey sıçrama testleri uygulanmıştır. U17 ve U19 gruplarında ortalama anaerobik güç sırasıyla %6,07 ve %5,27, 20 m sprint performansı %2,25 ve %3,13, yön değiştirme performansı %1,76 ve %1,79, dikey sıçrama performansı her iki grupta %3,26 ve patlayıcı güç %4,39 ve %3,81 oranında iyileşme göstermiştir. Grup × zaman etkileşimi yalnızca yön değiştirme performansında anlamlı bulunmuştur ($p=0,007$); bu bulgu, iki yaş grubunda değişim örüntüsünün farklı olduğunu göstermektedir. Diğer performans ölçümlerinde anlamlı grup × zaman etkileşimi gözlenmemiştir ($p>0,05$). Sonuç olarak, beceri tabanlı basketbol antrenmanı sonrasında genç erkek basketbolcularda anaerobik ve nöromüsküler performans göstergelerinde iyileşmeler gözlenmiştir. Bununla birlikte, yön değiştirme performansı dışında, antrenman yanıtlarının U17 ve U19 grupları arasında farklılık göstermediği bulunmuştur.

Anahtar kelimeler: Anaerobik güç, yön değiştirme, dikey sıçrama, sprint.

Corresponding author: Hamza BUDAK
Department of Coaching Education, Faculty of Sport Sciences, Aksaray University, Aksaray, Türkiye
E-mail: hamzabudak@aksaray.edu.tr **ORCID ID:** 0000-0002-8482-6920
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1. Introduction

Basketball is a high-intensity, intermittent sport that requires technical skills and physical abilities, including speed, change of direction, anaerobic power, and explosive strength-attributes predominantly reliant on anaerobic energy systems (Shalom et al., 2023). Therefore, anaerobic performance characteristics are considered critical determinants of success in basketball competition (Ben Abdelkrim et al., 2007; Mancha-Triguero et al., 2020; Ramirez-Campillo et al., 2022).

Anaerobic performance progressively increases throughout childhood and adolescence due to neuromuscular maturation and enhancements in muscle architecture and coordination (Armstrong et al., 2015; Ratel & Blazevich, 2017). The late adolescent period, particularly among 17- and 19-year-olds, is characterized by significant improvements in anaerobic performance components, such as speed, change of direction, anaerobic power, and explosive power (Fabrizio et al., 2014). Adolescence signifies accelerated neuromuscular and physiological development, where individuals exhibit varying responsiveness to different training stimuli based on age, maturation status, and training history (Granacher et al., 2016; Lloyd et al., 2015). Hence, identifying effective training strategies during this critical phase is essential for enhancing both technical skills and physical attributes, contributing to athletes' long-term development.

Recently, skill-based training performed at maximum intensity has been recognized as an effective method for enhancing sport-specific performance traits in team athletes (Milanović et al., 2013; Süel, 2015; Kv & Kumar, 2024). Unlike traditional conditioning or general strength training, this approach combines sport-specific motor patterns with high metabolic demands to provide simultaneous stimulation for developing both technical skills and physical performance (Milanović et al., 2013). Furthermore, training at maximum effort while fatigued, especially in basketball, improves neuromuscular efficiency and simulates competitive match situations (Delextrat & Cohen, 2009). While many studies have explored the general effects of high-intensity or functional training on youth athletic performance, few, such as Milanović et al. (2013), have directly compared age-specific adaptations to skill-based training performed at maximum intensity, particularly in basketball.

Considering the anaerobic demands of basketball-such as short sprints, explosive jumps, and quick changes in direction-there is a strong reason to focus on enhancing anaerobic and explosive performance through specific interventions. Previous research has shown noteworthy gains in sprint speed, agility, and anaerobic power following skill-based training in youth groups (Shaikh & Mondal, 2012; Karahan, 2020), yet how responses vary with age remains largely unexplored. Consequently, it remains uncertain whether younger athletes (e.g., U17) and older adolescents (e.g., U19) respond similarly to these training methods, particularly in terms of improvements in anaerobic performance.

Therefore, the purpose of this study was to investigate the effects of an 8-week skill-based training program on anaerobic performance characteristics-including 20-meter sprint time, change of direction, vertical jump, explosive power, and anaerobic power-in male basketball players from two different age categories (U17 and U19). Another objective was to examine whether the magnitude of improvement differs between age groups, thereby offering practical insights for coaches and practitioners in designing age-appropriate performance training programs. It was hypothesized that the 8-week skill-based training program would result in significant improvements in anaerobic performance characteristics, including 20-m sprint time, change-of-direction performance, vertical jump, explosive power, and anaerobic power, in both U17 and U19 basketball players. In addition, it was hypothesized that the magnitude of these improvements would differ between the two age groups.

2. Method

2.1. Research Model

The study employed a quasi-experimental pretest–posttest design involving two pre-existing age groups (U17 and U19), with both groups completing the same 8-week skill-based basketball training program.

2.2. Participants

A total of 20 male basketball players participated in this study and were divided into two age-based groups: U17 (n = 10) and U19 (n = 10). Participants were classified into the U17 and U19 groups according to the official age categories defined by federation regulations. The U17 group had a mean age of 16.0 ± 0.5 years, a body height of 171.9 ± 2.5 cm, a body mass of 64.0 ± 3.82 kg, a BMI of 21.6 ± 2.7 kg/m², and 5.6 ± 0.6 years of basketball experience. The U19 group had a mean age of 17.8 ± 0.8 years, a body height of 183.6 ± 5.87 cm, a body mass of 75.8 ± 10.3 kg, a BMI of 22.4 ± 3.1 kg/m², and 7.8 ± 0.7 years of basketball experience. The demographic characteristics of the participants are presented in Table 1.

All participants were active licensed basketball players competing at the amateur level and were recruited from the same basketball club using convenience sampling. Both groups regularly participated in basketball training three days per week, with each training session lasting approximately 2 hours. The inclusion criteria were: (a) being an active licensed basketball player in the U17 or U19 age category, (b) participating regularly in team training, (c) having at least three years of basketball training experience, and (d) being able to complete all training and performance testing procedures. Participants were excluded if they had experienced a musculoskeletal injury within the previous three months, had any health condition that could limit participation in high-intensity exercise or performance testing, regularly used medication that could affect physical performance, had experienced a serious illness in the recent period, or failed to participate regularly in the training program.

An a priori power analysis was conducted using G*Power (version 3.1.9.7) for a repeated-measures ANOVA with a within–between interaction. Assuming an effect size of f = 0.40, an alpha level of 0.05, a statistical power of 0.80, two groups, two measurements, a correlation of 0.50 between repeated measures, and a nonsphericity correction of 1.0, the required minimum sample size was determined to be 20 participants.

The study procedures were approved by the Aksaray University Human Research Ethics Committee (Approval No: 2020/08-05). Written informed consent was obtained directly from participants aged 18 years or older. For participants under 18 years of age, assent was obtained from the athletes, and written informed consent was obtained from their parents or legal guardians. All participants were informed that participation was voluntary and that they had the right to withdraw from the study at any time without any consequences.

Table 1. Demographic characteristics of participants

Groups	**Age** (years)	**Body Height** (cm)	**Body Mass** (kg)	**Experience** (years)	**BMI** (kg/m^2)
U17 (n=10)	16±0.5	171.9±2.5	64±3.82	5.6±0.6	21.6±2.7
U19 (n=10)	17.8±0.8	183.6±5.87	75.8±10.3	7.8±0.7	22.4±3.1

2.3. Procedure

Participants completed an eight-week skill-based training program designed to develop basketball-specific physical and technical performance. Both U17 and U19 groups followed the same

standardized protocol, consisting of three 80-min sessions per week (Mondays, Wednesdays, and Fridays), with identical exercise durations, numbers of repetitions and sets, and recovery intervals throughout the intervention. All sessions were conducted by the same basketball coach, who had eight years of coaching experience, and supervised by the same researcher to ensure consistent implementation of the training protocol and adherence to standardized procedures.

Performance assessments were conducted 48 h before and 48 h after the eight-week intervention. The countermovement jump (CMJ), 20-m sprint, and T-test were performed on Tuesdays in the same standardized order, with a 5-min passive recovery interval between tests to minimize fatigue and order effects. The RAST was performed separately on Thursdays. The same testing order and procedures were maintained during both pre- and post-intervention assessments, and all measurements were conducted by the same researchers to enhance consistency and measurement reliability.

Before performance testing, all participants completed a standardized 15-min warm-up protocol consisting of 5 min of light jogging and multidirectional movements at low-to-moderate intensity, 5 min of dynamic mobility and stretching exercises, and 5 min of basketball-specific movement preparation, including progressive accelerations, decelerations, defensive slides, and ball-handling drills at moderate-to-high intensity. Following the warm-up, a standardized 5-min passive recovery period was provided before testing commenced. Participants were tested individually, and identical warm-up and testing procedures were applied during both the pre- and post-intervention assessments to ensure consistency. All sessions were conducted indoors on a hardwood basketball court under controlled environmental conditions (temperature: 21–23°C; relative humidity: 45–55%) between 3:00 PM and 5:00 PM. During performance testing, participants were instructed to perform each test with maximal effort and received standardized verbal encouragement. Participants were also instructed to refrain from additional physical activity and the consumption of high-fat foods for at least 2 h before each training and testing session.

2.4. Data Collection Instruments

Anaerobic Power: Anaerobic power was assessed using the Running-Based Anaerobic Sprint Test (RAST). Prior to the formal assessment, participants were familiarized with the testing procedures and completed several practice sprints to become accustomed to the sprint distance, starting procedure, and recovery format. These practice sprints were not included in the analysis. During the formal assessment, participants performed six 35-m maximal-effort sprints, with a 10-s passive recovery interval between consecutive sprints. The RAST was administered once at each assessment (pre- and post-intervention). Sprint times were recorded using photocells positioned at the start and finish lines at a height of 1 m above the ground. Power output for each sprint was calculated using the equation: Power (W) = Body mass (kg) × Distance² (m) / Time³ (s), as described by Zagatto et al. (2009). Although the RAST provides several performance indices, including peak power, minimum power, mean power, and fatigue index, only mean power was included in the present analysis as the primary RAST-derived measure of anaerobic power. Previous research has demonstrated acceptable test–retest reliability of the RAST for assessing anaerobic power (Zagatto et al., 2009).

20-m Sprint Test: Sprint performance was assessed using a photocell timing system positioned at the start and finish lines. Participants started from a standing position 0.5 m behind the first timing gate, using a self-selected foot position, and were instructed to accelerate maximally through the 20-m distance. Each participant completed three maximal-effort 20-m sprints, with a 90-s passive recovery interval between trials. The fastest sprint time (s) was recorded for analysis. A familiarization session was conducted prior to the formal assessment to minimize potential learning effects.

Change of Direction Test: Agility was assessed using the T-test according to the standard

protocol. Participants sprinted forward from the starting line to the center cone, shuffled laterally to one side and then to the opposite side, returned to the center cone, and backpedaled to the starting line. Participants were instructed to face forward throughout the lateral movements and to touch the designated cones without crossing their feet. Performance time was recorded using a photocell timing system, and the best performance was used for analysis.

Vertical Jump Height and Explosive Power: Lower-limb explosive power was assessed using the countermovement vertical jump (VCMJ). Jump height (cm) was recorded via a vertimetric sensor attached to the player's ankle. Participants began upright with their hands on their hips to eliminate arm swing. Each participant completed three maximal-effort trials, with 60 seconds of passive recovery between jumps. The highest jump height (cm) was recorded for analysis. Explosive power was calculated in watts using the formula developed by Johnson & Bahamonde (1996).

2.5. Training Program

The eight-week intervention period and training frequency of three 80-min sessions per week were selected based on previous training studies indicating that comparable intervention durations and frequencies are sufficient to elicit measurable adaptations in physical performance. During the pre-competition preparation phase, both U17 and U19 groups completed the same standardized skill-based basketball training program three days per week (Mondays, Wednesdays, and Fridays). Each 80-min session comprised a standardized warm-up, the skill-based training intervention, basketball-specific technical and tactical activities, and a cool-down period. Thus, the skill-based intervention represented a specific component of the overall training session rather than the entire 80-min session.

The skill-based intervention lasted approximately 20 min and consisted of three basketball-specific stations. At each station, participants performed two sets of three 20-s work bouts, with approximately 30 s of passive recovery between repetitions, 60 s between sets, and 3 min between stations. The same work-to-rest structure was applied to both age groups throughout the eight-week intervention. A time-based format was selected to standardize the duration of training exposure across participants while allowing athletes to perform the prescribed basketball-specific movements at an individually achievable pace. The 20-s work bouts were selected to reflect the short-duration and intermittent nature of basketball-specific actions, while the recovery intervals were intended to facilitate repeated efforts while maintaining the technical quality of exercise execution.

Table 2. Training program

Training Component	Duration	Content
Standardized Warm-Up	15 min	5 min light jogging and multidirectional movements; 5 min dynamic mobility/stretching; 5 min basketball-specific movement preparation including acceleration, deceleration, defensive slides, and ball-handling
Skill-Based Intervention	20 min	Three basketball-specific stations. Each station consisted of 2 sets × 3 repetitions × 20 s. 30 s of passive recovery between repetitions, 60 s between sets, and 3 min between stations.
Technical Training	20 min	Basketball-specific passing, shooting, ball-handling, and finishing drills
Tactical Training	20 min	Offensive and defensive organization, transition drills, and basketball-specific tactical exercises
Cool-Down	5 min	Low-intensity jogging/walking followed by light stretching
Total	80 min	—

Station 1 – Full-Court Speed Dribbling: Participants performed full-court dribbling drills over 28 m while

attempting to cover the prescribed distance as quickly as possible while maintaining ball control. The use of the right and left hands was standardized across participants to ensure consistency in technical execution.

Station 2: Participants performed change-of-direction drills combined with right- and left-side lay-ups while dribbling the ball. During each 20-s bout, participants alternated between the right and left sides to ensure balanced execution. The change-of-direction movement was performed at an approximately 45° angle before approaching the basket for the lay-up. The same movement sequence and standardized verbal instructions were applied to all participants throughout the intervention.

Station 3 – Combined Change-of-Direction, Rebounding, and Slalom-Dribbling Drill: Participants completed a continuous basketball-specific circuit combining change-of-direction movements, rebounding, and slalom dribbling. The drill began with multidirectional movements through the designated cones, followed by movement toward the basket to perform a rebound action. Participants then completed a slalom-dribbling section through the cones before returning to the starting position and repeating the sequence for the remainder of the 20-s bout.

2.6. Statistical Analyses

Statistical analyses were performed using SPSS Statistics (Version 23.0; IBM Corp., Armonk, NY, USA). Data are presented as mean ± standard deviation (SD), and statistical significance was set at $p < 0.05$. The normality of the data was assessed using the Shapiro–Wilk test and visual inspection of Q–Q plots, while homogeneity of variance was evaluated using Levene's test. Data were also examined for potential influential outliers before inferential analyses. A 2 × 2 mixed-design analysis of variance (ANOVA) was used for each performance outcome, with age group (U17 vs. U19) as the between-subjects factor and time (pre-intervention vs. post-intervention) as the within-subjects factor. The main effects of group and time, as well as the group × time interaction, were examined. Emphasis was placed on the group × time interaction to determine whether the magnitude of change following the training intervention differed between the two age groups. When a significant interaction was identified, simple main-effects analyses and Bonferroni-adjusted pairwise comparisons were performed as appropriate. Effect sizes for the main and interaction effects of the mixed-design ANOVA were reported as partial eta squared (ηp^2). For within-group pre–post comparisons, standardized effect sizes were additionally calculated using Cohen's d. Statistical significance and effect sizes were considered together when interpreting the findings.

3. Results

Descriptive statistics, effect sizes, and ANOVA results for all performance variables are presented in Table 3.

Table 3. Anaerobic performance results for the U17 and U19 groups in the pre- and post-tests

Tests	Group	Pre-test (mean±sd)	Post-test (mean±sd)	ES	F values		
					Time Effect	Group Effect	Interaction Effect
Mean Anaerobic Power (w)	U17	424.8±31	450.6±30	0.85	435.8*	40.6*	0.77
	U19	531.4±43	559.4±44	0.64			
20-m Sprint (s)	U17	4±0.2	3.91±0.22	0.6	202.92*	5.57*	0.117
	U19	3.83±0.15	3.71±0.15	0.8			
Change of Direction (s)	U17	11.94±0.17	11.73±0.23	1.34	138.3*	5.61*	**0.007**
	U19	11.74±0.17	11.53±0.16	1.27			
Vertical Jump (cm)	U17	38.4±1.7	39.65±1.65	0.75	166.6*	17.15*	0.247
	U19	41.4±1.7	42.75±1.5	0.81			
Explosive Power (w)	U17	1237.2±91	1291.5±85	0.6	296.5*	52.3*	0.8
	U19	1668.5±95	1732±98	0.66			

ES= Effect Size.
p<0.05.

Both the U17 and U19 groups demonstrated statistically significant improvements in anaerobic power, 20-m sprint time, change-of-direction ability, vertical jump height, and explosive power following the 8-week skill-based training program ($p<0.05$). In the anaerobic power test, the U17 group improved from 424.8±31 W to 450.6±30 W (effect size [ES]= 0.85), while the U19 group improved from 531.4±43 W to 559.4±44 W (ES= 0.64). Although the U17 group demonstrated a greater percentage increase (6.07% vs. 5.27%), the interaction effect between group and time was not statistically significant ($p>0.05$). In the 20-m sprint test, both groups showed significant reductions in sprint time. The U17 group improved from 4.00±0.20 s to 3.91±0.22 s (ES= 0.60), and the U19 group from 3.83±0.15 s to 3.71±0.15 s (ES= 0.80). Despite the greater effect size in the U19 group, no significant interaction was found ($p>0.05$). In the change of direction (change of direction) test, significant improvements were observed in both groups (U17: 11.94±0.17 s to 11.73±0.23 s, ES= 1.34; U19: 11.74±0.17 s to 11.53±0.16 s, ES= 1.27). A statistically significant group × time interaction was observed ($p= 0.007$), indicating that the pattern of change differed between the two age groups. U17 group achieved relatively greater gains in change of direction than the U19 group. For vertical jump performance, the U17 group improved from 38.4±1.7 cm to 39.65±1.65 cm (ES= 0.75), and the U19 group from 41.4±1.7 cm to 42.75±1.5 cm (ES= 0.81), with no significant interaction effect detected ($p>0.05$), indicating comparable improvements between groups. Finally, explosive power increased significantly in both groups (U17: 1237.2±91 W to 1291.5±85 W, ES= 0.60; U19: 1668.5±95 W to 1732.0±98 W, ES= 0.66). No significant group or interaction effects were observed for this variable.

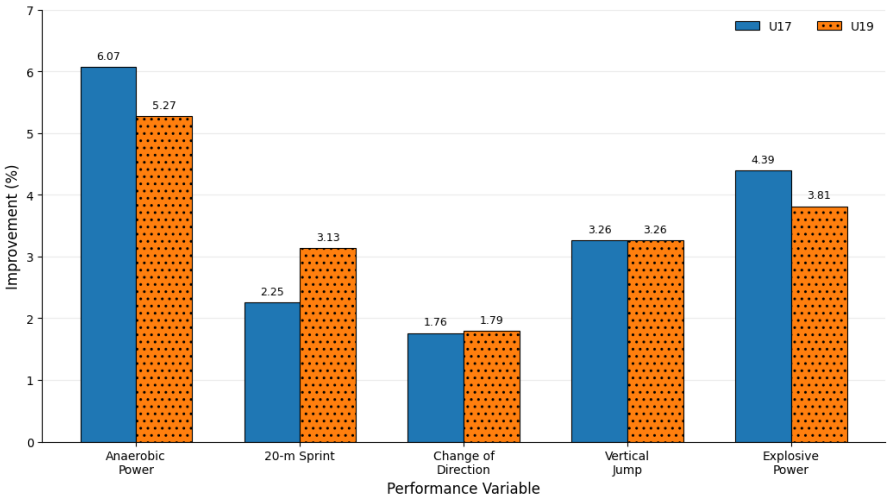


Figure 1. Percentage changes in performance variables in the U17 and U19 groups

As shown in Figure 1, both groups demonstrated improvements across all performance variables following the 8-week skill-based training program. The U17 group showed greater percentage improvements in mean anaerobic power (6.07% vs. 5.27%) and explosive power (4.39% vs. 3.81%), whereas the U19 group demonstrated a greater reduction in 20-m sprint time (3.13% vs. 2.25%). Changes in change-of-direction performance were similar between groups (1.76% vs. 1.79%), while vertical jump performance improved by 3.26% in both groups.

4. Discussion

This study investigated the effects of an 8-week skill-based training program on key physical performance parameters in U17 and U19 male basketball players. The findings showed that both groups demonstrated statistically significant improvements in anaerobic power, 20-m sprint performance, change-of-direction performance, vertical jump height, and explosive power

following the intervention. These findings suggest that regular sport-specific skill-based training may contribute to improvements in anaerobic and neuromuscular performance in young basketball players.

Consistent with previous research, training interventions incorporating sport-specific movement patterns have been associated with improvements in various physical performance measures (Miller et al., 2006; Markovic & Mikulic, 2010; Karahan, 2020; Kv & Kumar, 2024). In the present study, however, the magnitude of improvement varied across performance variables and age groups. The U17 group showed numerically greater percentage improvements in mean anaerobic power and explosive power, whereas the U19 group demonstrated a greater reduction in 20-m sprint time. Changes in vertical jump and change-of-direction performance were similar in magnitude between the groups. Importantly, most group × time interactions were not statistically significant, indicating that the overall patterns of adaptation were generally comparable between the U17 and U19 groups. Therefore, numerical differences in percentage change should be interpreted cautiously rather than as evidence of superior responsiveness in either age group.

Change-of-direction performance improved by 1.76% in the U17 group and 1.79% in the U19 group. Previous research has shown that sport-specific training incorporating repeated accelerations, decelerations, and directional changes can improve change-of-direction performance in young athletes (Karahan, 2012; Fernandez-Fernandez et al., 2017). Such improvements may be related to adaptations in neuromuscular coordination, movement efficiency, and motor control, which are considered important determinants of multidirectional performance (Ben Abdelkrim et al., 2007; Raya-González et al., 2021). Karahan (2020) also reported improvements in change-of-direction performance following skill-based training in young soccer players. Although the magnitude of improvement observed in the present study was relatively modest, both age groups demonstrated favorable changes. The significant group × time interaction observed for this variable indicates that the pattern of change differed between the two groups; however, considering the very similar percentage changes, this finding should be interpreted cautiously and in conjunction with the overall statistical results.

Vertical jump performance increased by 3.26% in both the U17 and U19 groups following the 8-week skill-based training program. Improvements in jump performance may reflect adaptations in neuromuscular function, including motor unit recruitment, intermuscular coordination, and stretch-shortening cycle efficiency (Cormie et al., 2011). Shaikh and Mondal (2012) similarly reported improvements in anaerobic power-related performance following skill-oriented and plyometric training in male basketball players, while Karahan (2020) observed improvements in vertical jump performance following skill-based training in young soccer players. The identical percentage improvement observed in the two groups in the present study, together with the absence of a significant group × time interaction, suggests that vertical jump adaptations were comparable between U17 and U19 players.

Explosive power and mean anaerobic power also improved significantly following the intervention. The U17 group demonstrated improvements of 4.39% in explosive power and 6.07% in mean anaerobic power, whereas the corresponding improvements in the U19 group were 3.81% and 5.27%, respectively. These findings may reflect adaptations associated with repeated sport-specific actions involving acceleration, jumping, change of direction, and rapid force production. Such physical qualities are particularly relevant to basketball, which requires frequent short-duration high-intensity actions during competition (Gervasi et al., 2024). Previous studies have also reported favorable changes in anaerobic and explosive performance following skill-based or sport-specific training interventions in young athletes (Karahan, 2020; Süel, 2015). Although the U17 group demonstrated numerically greater percentage improvements in both variables, the absence of significant group × time interactions indicate that the magnitude of adaptation did not differ statistically between the age groups. Accordingly, these numerical differences should not be

interpreted as evidence that the intervention was more effective in the U17 group.

The results of this study also showed that 20-m sprint performance improved significantly in both groups, with reductions in sprint time of 2.25% in the U17 group and 3.13% in the U19 group. Sprint performance is influenced by several neuromuscular factors, including rate of force development, intermuscular coordination, stride mechanics, and recruitment of fast-twitch muscle fibers (Delecluse, 1997; Ross et al., 2001). The basketball-specific drills used in the present intervention incorporated acceleration, directional changes, dribbling, and other rapid movements and may therefore have provided a training stimulus relevant to short-distance sprint performance. This interpretation is consistent with the principle of training specificity (Bompa & Buzzichelli, 2019). Previous studies have similarly reported improvements in sprint performance following sport-specific or skill-based training interventions (Karahan, 2020; Süel, 2015). Although the U19 group demonstrated a numerically greater percentage reduction in sprint time than the U17 group, the group × time interaction was not statistically significant. Therefore, the present findings indicate improvement in both age groups without evidence of a statistically different sprint response between U17 and U19 players.

Overall, the findings indicate that the 8-week skill-based training program was associated with improvements across all measured performance variables in both U17 and U19 basketball players. However, the generally non-significant group × time interactions suggest that the magnitude of adaptation was largely comparable between age groups. This is important because chronological age alone may not adequately explain individual responsiveness to training during adolescence. Biological maturation, previous training experience, neuromuscular development, and individual variability may also influence training adaptations (Lloyd & Oliver, 2012; Lloyd et al., 2015; Granacher et al., 2016). Therefore, although the present findings support the potential value of skill-based basketball training for adolescent athletes, age-related differences should be interpreted cautiously, particularly because biological maturation was not directly assessed.

5. Conclusion

In conclusion, the eight-week skill-based training program was associated with significant improvements in all measured anaerobic performance characteristics in both U17 and U19 basketball players. Although numerical differences in the magnitude of improvement were observed between the groups, no statistically significant between-group differences were observed for most variables. The effect sizes further supported the practical relevance of these improvements, with most variables demonstrating moderate to large effects. Change-of-direction performance showed large effect sizes in both groups (U17: d=1.34; U19: d=1.27), suggesting meaningful improvements in multidirectional movement ability, an important physical component of basketball performance. However, given the absence of a control group, the observed improvements cannot be attributed exclusively to the intervention, as the potential contributions of regular training exposure, repeated testing, and natural growth and maturation cannot be fully distinguished. Therefore, the findings suggest that this training model may have potential applicability across adolescent age groups; however, controlled studies with larger samples and assessments of biological maturation are needed to confirm its effectiveness and generalisability.

Limitations and Future Directions

While the findings provide valuable insights, several limitations should be acknowledged. First, the relatively small sample size (n=20) limits the generalisability of the findings. Second, biological maturation status was not assessed; therefore, differences in training responsiveness between the U17 and U19 groups cannot be attributed solely to chronological age, as variations in maturation may have influenced the observed adaptations. In addition, physiological and hormonal factors that may contribute to individual differences in training responses were not evaluated. Future studies

should include larger and more diverse samples and incorporate assessments of biological maturation and relevant physiological or hormonal markers to better explain differences in training adaptations among adolescent athletes. Longer follow-up periods are also warranted to determine the retention of performance gains and their transfer to game-specific performance. Furthermore, incorporating qualitative and game-specific performance measures, such as in-game movement analysis and coach assessments, may provide a more comprehensive understanding of the practical relevance of observed physical adaptations. Additionally, the absence of a non-training control group limits the extent to which the observed improvements can be attributed specifically to the skill-based training intervention.

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