International Journal of Human Movement and Sports Sciences 11(4): 864-871, 2023 http://www.hrpub.org
DOI: 10.13189/saj.2023.110421

The Effects of Multi-Sport Intervention on Agility Performance among Young Athletes

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Received February 24, 2023; Revised June 7, 2023; Accepted July 19, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Jorrye Jakiwa, Shahrulfadly Rustam, Siti Azilah Atan, Mohd Syrinaz Azli, Ahmad Bisyri Husin Musawi Maliki, Ahmad Nadzmi, Ahmad Fadly Abd Rahman, Md Safwan Samsir, Zhiwen Sun, Pang Tsun Kuo, Nitas Camillus Tan Sing Bee , "The Effects of Multi-Sport Intervention on Agility Performance among Young Athletes," International Journal of Human Movement and Sports Sciences, Vol. 11, No. 4, pp. 864 - 871, 2023. DOI: 10.13189/saj.2023.110421.*

(b): *Jorrye Jakiwa, Shahrulfadly Rustam, Siti Azilah Atan, Mohd Syrinaz Azli, Ahmad Bisyri Husin Musawi Maliki, Ahmad Nadzmi, Ahmad Fadly Abd Rahman, Md Safwan Samsir, Zhiwen Sun, Pang Tsun Kuo, Nitas Camillus Tan Sing Bee (2023). The Effects of Multi-Sport Intervention on Agility Performance among Young Athletes. International Journal of Human Movement and Sports Sciences, 11(4), 864 - 871. DOI: 10.13189/saj.2023.110421.*

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Abstract This study aimed to investigate the effect of a multi-sport intervention on the agility performance of young athletes aged 13 to 14 years old. A total of 40 athletes participated voluntarily in the study and were randomly assigned to either the experimental group 1 (n=20) or the multi-sport training group (n=20) using a quasi-experimental method. The experimental group 2 (EXP_2) underwent multi-sport training which included football, futsal, sepak takraw, volleyball, basketball, and netball, while the experimental group 1 (EXP_1) only received training in football and futsal. The Quadrant Jump Test was used to measure agility performance three times: pre-test (baseline), post-test 1 (week 6), and post-test 2 (week 12). The results showed that the multi-sport training group led to a significant improvement in agility performance, as indicated by a two-factor repeated measures ANOVA ($F(1, 19) = 10214.43$, $p < .001$) and significant main effects of both intervention and time on agility performance ($F(1, 19) = 28.65$, $p < .001$ and $F(1, 19) = 418.61$, $p < .001$, respectively). In conclusion, the multi-sport intervention proved to be beneficial for young athletes and should be included in the training routines of children and adolescents at all levels of sports academies and development.

Keywords Multilateral Development, Sport Coaching, Young Athlete, Physical Fitness, Quadrant Jump Test, Early Specialization

1. Introduction

Early participation in sports and physical activities significantly contributes to the development of motor skills, health, and academic performance, particularly among children and adolescents [1]. A key factor that leads to the development of motor skills is the learning process that occurs during participation in sports activities [2]. As a result, improvement in motor skills is thought to be associated with sports performance, which is largely determined by the athlete's motor skills, physical fitness, technical, tactical, and mental characteristics [3], [4]. Coaches and parents should therefore ensure that their players or children acquire sufficient fundamental skills to excel in sports.

Adolescent development is influenced by various factors, including the type of training they receive. According to Kliethermes et al. [5] and Bompa and Buzzichelli [6], two types of training are recommended for children: 1) multilateral training and 2) specialization training. Multilateral training aims to improve essential bio-motor abilities such as endurance, strength, speed, flexibility, and coordination [6]. One approach that supports multilateral training is multi-sport training [7], which involves participating in a range of sports and activities while delaying early specialization [8]. Engaging in diverse forms of physical activity from an early age is vital for enhancing motor skills and physical activities during adolescence. It is not only the quantity and intensity of exercise that matter but also the variety of physical activities that children engage in on a daily basis. This plays a crucial role in determining their future physical activity habits and overall health [9].

Multi-sport athletes have a higher rate of long-term success than single-sport athletes [10] and exhibit more consistent performance with fewer injuries. They are also more likely to remain active as adults [11]. Overuse injuries occur when an athlete repeatedly performs the same motion, and athletes who participate in multiple sports experience fewer injuries and have more opportunities to recover and develop diverse muscle groups, tendons, and ligaments [10]. Apart from injuries, burnout and/or dropout is another concern. Athletes who specialize reported higher levels of burnout than those who participate in sport diversification [12]. To reduce injuries, burnout, and promote long-term success in young athletes, it is recommended that coaches apply multi-sport training with a focus on fun activities, active play, and small-sided games to maximize the benefits of the training method.

As previously mentioned, multi-sport training has been shown to improve basic bio-motor abilities such as endurance, strength, speed, flexibility, and coordination [6]. However, the impact of multi-sport training on agility is yet to be determined. Agility can be defined as the ability to stabilize the body position and change the direction of movement quickly and effectively [13]. Sheppard and Young [14] describe agility as rapid whole-body movements with changes in speed and direction in response to stimuli, while Pojskic et al. [15] state that two important factors involved in agility are rapid changes in direction and perceptual and decision-making processes. Therefore, agility is a crucial component of skill-related fitness in many sports [16], [17] requiring both physical and mental aptitude, and athletes who possess a high level of agility would be able to excel in their sport. Training in agility should commence as early as possible to enable athletes to continually hone their skills. Currently, there are studies available that investigate agility performance across different sports. Sekulic et al. [18] mentioned that the change of direction speed (CODS) and reactive agility (RAG) tests are reliable and valid for distinguishing performance levels in futsal players. Additionally, the Illinois agility test, which investigates agility performance in 10 to 12-year-old soccer players, can differentiate stop, change direction, and acceleration actions across age groups [19]. However, to the best of our knowledge, there is still a lack of research on the impact of multi-sport training on agility performance. Furthermore, the assessment of agility performance by the use of the Quadrant Jump test that assesses the player's ability to change movements by jumping has not been up to now utilized. Therefore, this study aims to investigate the effects of multi-sport training on the possible improvement of agility performance among young athletes using the Quadrant Jump Test.

2. Methods

2.1. Participants

A total of 40 male young athletes aged between 13 and 14 years old volunteered to participate in this study, with an average age of 13.50 ± 0.51 years, height of 145.27 ± 5.89 cm, and weight of 36.68 ± 4.88 kg. All participants were currently active in sports and physical activities, and had not experienced any injury within the last 6 months, defined as not having been referred to a clinic or hospital and being free from soft tissue injuries, fractures, dislocations, and hard tissue injuries [20]. The sample size was calculated using the statistical power analysis method [21], which considered four factors: significance level, effect size, desired power, and variance expectations [22]. Based on Cohen's recommendation [21], a sample size of 12 participants was needed for a power of .80 and an effect size of .07. To account for potential dropouts during the study, 20 participants were selected for each group. All participants were able to complete the 12-week study without any injuries or dropouts.

Before collecting data, all participants were given written informed consent forms explaining the benefits and potential risks of the study. They were also informed that participation was voluntary and that their information would be kept strictly confidential. Forty participants received their parents' permission and were randomly divided into two experimental groups: experimental group 1 (EXP_1) and the experimental group 2 (EXP_2). The EXP_2engaged in multi-sport interventions such as playing football, futsal, sepak takraw, volleyball, basketball, and netball. The EXP_1 only participated in football and futsal training. The choice of different sports for the EXP_2 was based on several factors, including being team sports, able to be modified into small-sided games and incorporate changes in direction, such as quick twists and turns.

2.2. Design of the Study

A research design using a two-factorial ANOVA with repeated measures was applied [23]. This design is commonly used in quasi-experimental research to investigate the effects of different interventions or treatments on a particular outcome or behavior. For our current study, the independent variable is the effect of a multi-sport intervention, while the dependent variable is agility performance. Data was collected at three different times: pre-test (baseline), post-test 1 (week 6), and post-test 2 (week 12), over a period of 12 weeks. One of the variables in this design is typically a between-subjects' variable, meaning that it is measured on different groups of participants. The other variable is a within-subjects' variable, meaning that it is measured repeatedly on the same group of participants over time. By measuring the within-subjects' variable repeatedly, researchers can control individual differences between participants and increase the statistical power of the study. The dependent variable is the outcome or behavior of interest, which is measured at each time point or condition. Researchers can use statistical analysis, such as a two-factor ANOVA with repeated measures, to examine the main effects of each variable and the interaction between the two variables on the dependent variable [24].

2.3. Procedure

All participants went through a familiarization trial to become accustomed to the test. The research assistant or tester thoroughly explained the testing protocol and demonstrated the Quadrant Jump Test to the participants. During the test session, participants were encouraged to warm up for 10 to 15 minutes to prepare physically and mentally [25]. When ready, the test was performed with the assistance of three testers: Tester 1, Tester 2, and Tester 3, who were responsible for timekeeping, counting total jumps, and recording test errors, respectively.

2.4. Instrument

The agility performance was evaluated using the Quadrant Jump test [17]. This test was selected because it assesses the player's ability to change movements by jumping. Equipment required for the test includes a stopwatch, marker tape, and a flat surface. The quadrant squares were marked using marking tape, and numbers 1, 2, 3, and 4 were assigned as shown in Figure 1. To start the test, participants needed to stand at the starting mark and hop on both feet to the numbers in the squares (1, 2, 3, and 4) for 10 seconds. A stop signal was given by the tester to end the test. Three testers were required to assist the lead researcher, with one acting as the timekeeper, one counting the number of jumps, and one recording the number of errors committed. Participants were given two trials, and their best score was used as the data score. A half-point (1/2) was deducted for each offense, such as touching the line or landing in the wrong square.

2.5. Multi-Sport Intervention

The participants in the EXP_1 group underwent specific training, becoming trainees at the available futsal and football academy. On the other hand, the EXP_2 participated in a multi-sport training approach led by the head researcher. Figure 2 illustrates the characteristics of the multi-sport intervention, which includes fun activities or drills, a game-oriented approach, unstructured activities, opportunities for socialization with other participants, the inclusion of competition elements, a variety of drills or sports, and a focus on playing rather than rules.

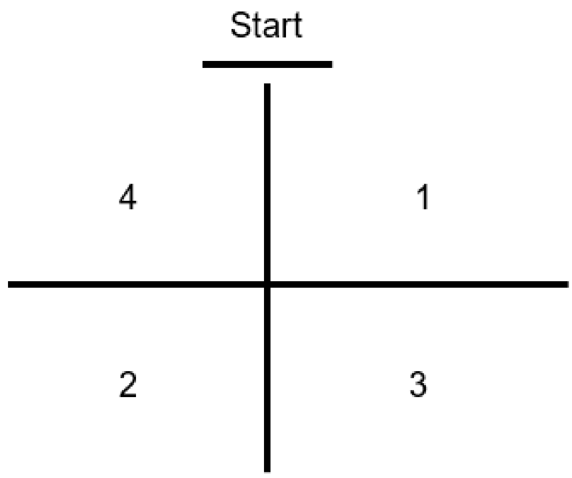

Figure 1. The illustration of the Quadrant Jump Test

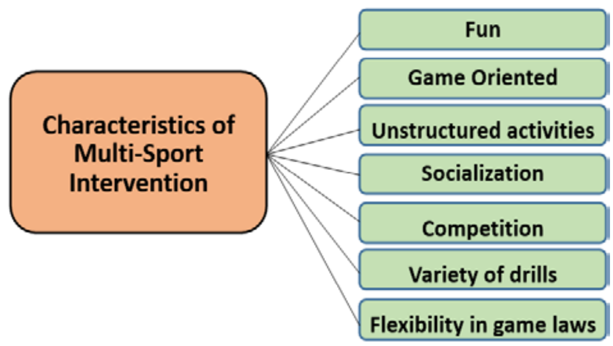

Figure 2. The characteristics of Multi-Sport Intervention

Before the intervention sessions, all participants followed a training structure designed by the head researcher. The structure included: 1) a dynamic warm-up lasting 10 to 15 minutes, which involved various movements such as fun activities, individual and group stretching, and changes in speed, tailored to the objectives of each training session, 2) the main training component lasted 40 to 60 minutes, which consisted primarily of game-like situations and small-sided games. Participants were divided into groups and trained through play, with a focus on free play and minimal attention to rules, and 3) a cool-down lasting 10 to 15 minutes, during which participants performed several movements in a static manner from head to toe. The coach also provided feedback, comments, and motivation to the participants to help improve their performance.

Table 1 displays the multi-sport training intervention, which lasted for 12 weeks. Training sessions were held three times a week, on Mondays, Wednesdays, and Fridays, for two hours each. Despite being set at a low to moderate intensity, the training was considered appropriate for the participants. The goal of the multi-sport intervention was to expose participants to a variety of sports and to enhance their motor skills through natural development. For this reason, six different sports were selected, including football, futsal, sepak takraw, volleyball, basketball, and netball. All drills, activities, and games were designed to resemble game situations and involved small-sided games (Table 1).

2.6. Statistical Analysis

The data is presented as descriptive statistics, including the mean and standard deviation. To determine the potential impact of the multi-sport intervention on agility performance, independent sample t-test and two-factor repeated measures ANOVA were performed, with group (EXP_1 vs EXP_2) as the fixed factor and time (Pre vs Post-1 vs Post-2) as the repeated-measure factor. Bonferroni post-hoc pairwise comparisons were used in cases where significant time effects were observed. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 25.0, with a significance level set at $p \leq 0.05$.

3. Results

Table 2 presents the results of the analysis of variance (ANOVA) tests of the between-subject effects on agility performance. The results indicate that there is a statistically significant difference between the EXP_1 and EXP_2 regarding the effectiveness of the interventions on agility performance, $F(1, 19) = 10214.43$, $p < .001$. This suggests that the intervention implemented in the EXP_2 had a significantly greater effect on improving agility performance compared to the EXP_1. The effect size, as indicated by the partial eta-squared, was very large, with 99.8% of the variance in agility performance being accounted for by the intervention.

The within-subject effects on agility performance were analyzed using ANOVA tests, and the results are presented in Table 3. The analysis demonstrated significant main effects of both intervention and time on agility performance. Specifically, intervention and time had $F(1, 19) = 28.65$, $p < .001$ and $F(1, 19) = 418.61$, $p < .001$, respectively, indicating that both factors have a significant impact on agility performance. The findings suggest that intervention accounts for 60% of the variance in performance, while time accounts for 99% of the variance.

Table 1. Multi-Sport training intervention

No.	Sports	Description	Activities
1	Futsal	Modification of sports activities based on the courts' size and the number of players used.	1v1, 2v2, 3v3, 4v4 and 5v5
2	Basketball		1v1, 2v2, 3v3, 4v4 and 5v5
3	Volleyball		1v1, 2v2, 3v3, 4v4 and 5v5
4	Football		1v1, 2v2, 3v3, 4v4 and 5v5
5	Netball		1v1, 2v2, 3v3, 4v4 and 5v5
6	Sepak takraw		1v1, 2v2 and 3v3

Table 2. ANOVA tests of between-subjects' effects on agility performance

Source	Type lll Sum of Squares	df	Mean Square	F	Sig.	Partial Eta-Squared
Intercept	44083.33	1	44083.33	10214.43	.000	.998
Error	82.00	19	4.32			

Table 3. ANOVA tests of within-subjects' effects on agility performance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intervention	64.53	1	64.53	28.65	.000	.60
	42.800	19	2.25			
Time	418.61	1	418.61	1295.91	.000	.99
	6.14	19	.32			
Intervention * Time	32.51	1	32.51	50.48	.000	.73
	12.24	19	.64			

Table 4. Post-hoc pairwise comparisons of time effects on agility performance

(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1 (17.00)	2 (18.93)	-1.925*	.137	.000	-2.285	-1.565
	3 (21.58)	-4.575*	.127	.000	-4.909	-4.241
2 (18.93)	1 (17.00)	1.925*	.137	.000	1.565	2.285
	3 (21.58)	-2.650*	.121	.000	-2.967	-2.333
3 (21.58)	1 (17.00)	4.575*	.127	.000	4.241	4.909
	2 (18.93)	2.650*	.121	.000	2.333	2.967

Based on estimated marginal means
*. The mean difference is significant at the .05 level
b. Adjustment for multiple comparisons: Bonferroni.

Table 5. The interaction of agility performance based on groups and time

Time	Groups	Mean	SD	*t*	*df*	*p*
Pre-test	EXP_1 (n=20)	16.80	1.28	-1.09	35.97	.28
	EXP_2 (n=20)	17.20	1.01			
Post-test 1	EXP_1 (n=20)	18.40	1.35	-2.79	34.96	.01*
	EXP_2 (n=20)	19.45	.99			
Post-test 2	EXP_1 (n=20)	20.10	1.21	-8.24	37.26	.00*
	EXP_2 (n=20)	23.05	1.05			

*level of significant at p<.05

Table 4 presents the results of the post-hoc pairwise comparisons of time effects on agility performance. This analysis was conducted to determine the significance of differences between the agility performance of groups at different time points. The results indicate that there were significant differences in agility performance among the pre-test (1), post-test 1 (2), and post-test 2 (3) time points, with $p < .05$. Specifically, the mean difference (I-J) showed that agility performance was significantly higher at post-test 2, with a mean repetition of 21.58, compared to post-test 1 and pre-test, with mean repetitions of 18.93 and 17.00, respectively. These findings suggest that the intervention has a significant positive effect on agility performance, which is most pronounced at post-test 2.

In Table 5, the comparison of agility performance based on groups over time is demonstrated. The findings reveal that during the pre-test, there was no significant difference observed between EXP_1 and EXP_2 (t (35.97) = -1.09, p (.28) > .05). However, the results from post-test 1 and post-test 2 indicate a significant difference in agility performance between the groups with values t (34.96) = -2.79, p (.01) > .05 for post-test 1, and t (37.26) = -8.24, p (.00) > .05 for post-test 2, respectively. Overall, the multi-sport training group performed significantly better in both post-test 1 and post-test 2 compared to EXP1.

To provide a more comprehensive understanding of the changes in agility performance over time and between groups, a plot (Figure 3) has been included in the study. The results demonstrate that in the final test after 12 weeks of the multi-sport intervention program, the EXP_2 performed significantly better, with a mean of jumps repetition of 23.05, compared to their mean agility performance during pre-test and post-test 1. Similarly, the EXP_1 also showed improved agility performance compared to pre-test and post-test 1, with a mean of jumps repetition of 20.10 in post-test 2. However, it is important to note that throughout the study, the EXP_2 consistently outperformed the EXP_1. This finding suggests that the multi-sport intervention implemented in the EXP_2 has a significant positive impact on their agility performance, resulting in greater improvements compared to the EXP_1.

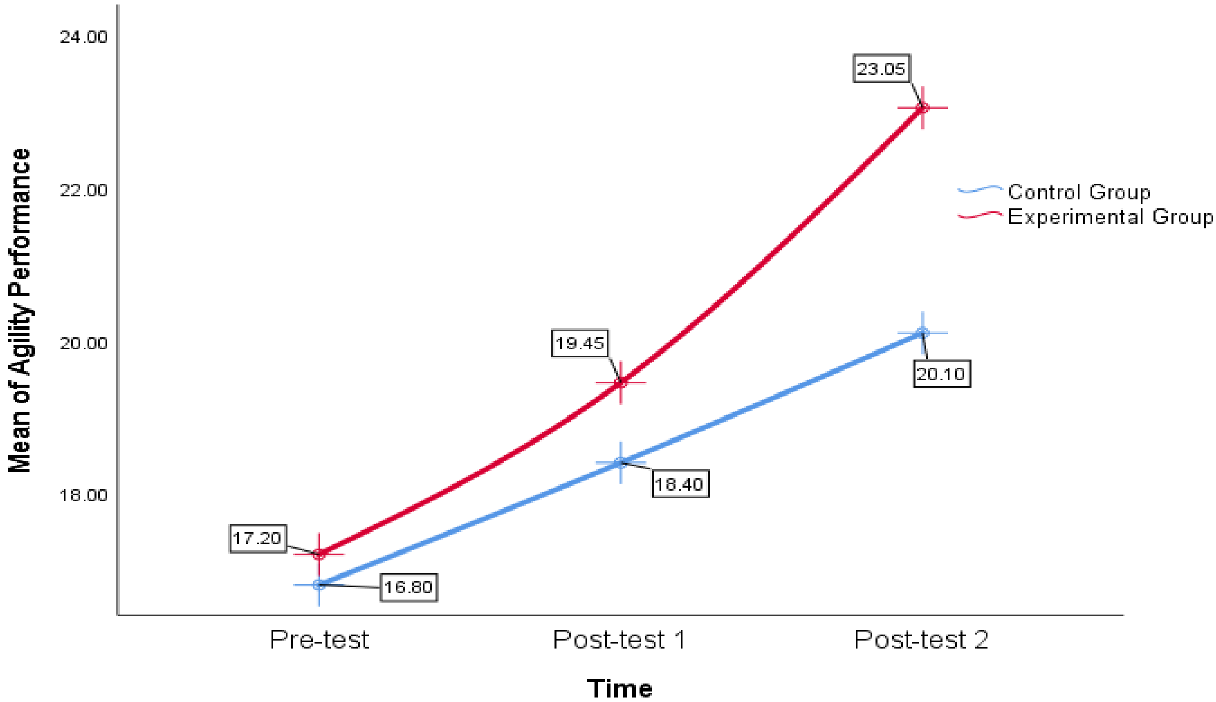

Figure 3. The mean of agility performance between groups and time

4. Discussion

The aim of this study was to investigate the impact of a multi-sport intervention on the agility performance of young athletes aged 13 to 14 years. The results showed that participants in the EXP_2 had a 34.01% improvement in agility performance compared to the lower improvement of 19.64% in EXP_1 after 12 weeks of training. The findings also revealed that both training methods improved agility performance over time. Specifically, the EXP_2 showed a mean jump performance from 17.20 to 23.05 jump repetitions whereas the EXP_1 showed a mean improvement in jump performance from 16.80 to 20.10 repetitions, respectively.

The present study's results are consistent with prior research conducted by Greco [2], Popovic et al. [7], Francesco and Greco [26], and Krasilshchikov [27], which have demonstrated the positive impact of multi-sport and multilateral training interventions on the physical fitness, motor skills, technique, and rhythm of children and adolescents aged 5 to 14 years old. Greco's study [2] found that multilateral training through a multi-sport approach led to significant improvements in karate technique, power, expressiveness, and rhythm among participants aged 8 to 10 years old after an 8-week training period. Similarly, the structured multi-sport program resulted in greater improvements in physical fitness compared to a formal training program among 5- to 6-year-old children [7]. Multilateral training combining various types of sports and activities effectively improved the physical capacity and motor skills of youth aged 13 to 14 years old [26]. Finally, Krasilshchikov [27] demonstrated that training with different sports and activities significantly improved physical fitness among 10-year-old children. The combination of various sports in training, including fundamental and fine motor skills, integration of various sports and activities, such as volleyball, basketball, handball, and soccer, along with running, walking, circuits, and sprint intervals, improved physical fitness as well as ball game-based exercises, may affected the improvement of agility performance among children. Taken together, these studies suggest that multi-sport and multilateral training interventions have a positive impact on the physical fitness and skill development of children and adolescents aged 5 to 14 years old.

The current study provides an evidence that the Quadrant Jump Test could be a valuable tool for measuring agility performance in young athletes. It is important to note, however, that this test does not evaluate running acceleration but instead focuses on assessing an athlete's quickness and jumping ability in response to visual cues. Several studies have utilized the Quadrant Jump Test to assess agility performance in athletes [17], [28]. For instance, Sabin's study [17] found significant improvements in agility performance among young basketball athletes aged 10-12 years old from the initial to the final test of the EXP_2. Meanwhile, Kusuma, Raharjo and Taathadi [29] and Liu and Wang [30] found that the Quadrant Jump Test was effective in detecting agility ability and quality in badminton sports among players aged 17-21 years old. Moreover, the Quadrant Jump Test has also been shown to be a valid and reliable measure of agility performance among football players [28]. Nonetheless, while the Quadrant Jump Test can provide crucial insights into an athlete's quickness and jumping ability, it may not be sufficient to offer a comprehensive evaluation of all aspects of their athletic performance. Hence, it may be necessary to combine the Quadrant Jump Test with additional performance tests to obtain a more comprehensive assessment of an athlete's abilities.

While multi-sport approach has demonstrated significant improvement on agility performance in this study, indeed single-sport or specific training has also shown slight improvement in agility performance among young athletes. Studies have shown that specific training, such as single-sport training, can improve physical fitness and performance [31], [32]. For example, specific training in combination with physical education improved physical fitness in 9 and 10-year-old children [31]. Guidetti et al. [33] found that participants improved their balance and leg power through specific training.

This study sheds light on various training approaches that may improve performance among young athletes. However, the selection of training should consider the physiological growth, development, and chronological age of the individual [34], [35]. In this study, the multi-sport approach was considered a better option for young athletes due to its group work aspect [7], low to medium intensity [36], and fun [27]. On the other hand, Smucny, Parikh, and Pandya [37] stated that specializing in specific training at a young age can be physically and emotionally detrimental, causing structural risks and burnout. Hence, parents and coaches should be cautious when implementing any training approach for children and young athletes.

5. Conclusions

In summary, the findings of this study indicate that both multi-sport training interventions and specific training can lead to improvements in the agility performance of young athletes aged 13 to 14 years old. However, it is noteworthy that multi-sport training demonstrated significantly greater improvements in agility performance compared to specific training after 12 weeks of training. The results also highlight the effectiveness of the Quadrant Jump Test in measuring the agility performance of participants. Future research could benefit from further examining the effects of multi-sport and specific training interventions, including the measurement of other aspects of physical fitness, as well as exploring potential gender differences in the outcomes. Overall, these findings contribute to the current understanding of the benefits of multi-sport training interventions on agility performance of young athletes and provide important implications for the development of training programs in this population.

Acknowledgements

I want to acknowledge the contributions of all the individuals who have directly or indirectly assisted me in completing this study. Their support and cooperation are deeply appreciated

Conflicts of Interest

The present study has no financial support from any agency. Therefore, there is no conflict of interest and no benefits in the study.

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