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Impact of Ladder Drill and Pro-Agility Drill Training on Change of Direction Performance in Elite Amateur Futsal Athletes

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Abstract

COD ability is an important physical element in futsal, which requires numerous accelerations, decelerations, and energy transfers in short spaces. The impact of different training interventions on agility in different age groups is not currently known. The purpose of this study was to examine the effects of the ladder drill and pro agility drill on COD performance in elite amateur futsal athletes aged 17 years and under (U17) and over 19 years (U19), as well as determine the main effects for age compared with training method. A multistage sequence of changes of direction (COD) was implemented as part of a multi-week intervention in which 32 U17 and U19 athletes were tested for pre- and post-training performance. The results indicated that COD performance significantly increased in all groups after the two different training methods. The average increase in performance was greater in U19 than U17 athletes, which is a surprising finding since this suggests that there may be an effect of age on training response. The type of training also had minimum but significant differences between PAg, which showed a slightly greater effect, especially among U19s. Interaction analysis revealed age depended on the effectiveness of training. The ladder drill proved more effective for U17s and the pro agility drill for U19s. These findings indicate that there are variances in neuromuscular maturation, motor control, and biomechanical capabilities across age. Ladder drills and pro agility drills have been considered effective for training for the improvement of COD performance in young futsal players, but age may influence training response.

Keywords: Change of Direction, Ladder Drill, Pro Agility Drill, Futsal

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INTRODUCTION

The progress of sports activities has been followed by the growth of civilizations. This trend is characterized by the growing collective interest, involvement, and concern in all kinds of physical activities and sports events, amateur as well as professional (Harris et al., 2017). Many kinds of sports are considered today not just as leisure activities but also as a part of the development and realization of personal abilities, as well as serving for good health and success. Sport can be seen as an organized physical activity that involves the development of movement, strength, and awareness (Rosdiana & Sidik, 2023). Among the sports that are becoming more important, one of the growing importance is futsal, a sport practiced dynamically and very quickly, which gains fans among teenagers and young adults because it is open to easy access to all segments (Arede et al., 2025).

Futsal has a long-standing tradition since its inception in 1930 by Juan Carlos Ceriani, who was born in Montevideo, Uruguay. Futsal was created by Ceriani as a smaller version of football, taking elements from soccer, basketball, and water polo (Fahey, 2022). Creativity, speed, and skill are a blend that has also fostered the quick expansion of futsal and made it a sport with global appeal (Collins et al., 2021). Due to the development of talents in Brazil and some other South American countries, as well as similarities between futsal and five-a-side football, futsal has grown

rapidly in many nations. Unlike regular football, futsal is played on a smaller field and at a much faster rate by two teams of five players each. Additionally, futsal game play tends to have a high requirement for precision in the mastering of basic techniques such as passing, control, dribbling, and shooting, similar to that of fast movements (Ashar et al., 2021).

Futsal became famous in the late 1990s and grew substantially from earlier in 2000. Futsal has gained notable popularity, at least among urban populations and in crowded urban centers where it is hard to build camps (Fahey, 2022). The proliferation of futsal fields indoors there are some in cities like Jakarta, Bandung, and Surabaya, as well as in mid-sized cities such as Boyolali has made practice and competition more accessible. A major marker in the history of national futsal was the launch of the Asian competition by Indonesia in 2002, which led to leagues and competitions at a regional level (Woods, 2016). Futsal is becoming more and more popular among adolescents because it is fast, energetic, and competitive and can be played with fewer people and for a relatively short amount of time (Liskustyawati et al., 2024). Even though it has game spectacles, futsal is a fast-paced game that doesn't allow much space for movement, and therefore guy should have some good agility. Agility is the capacity to quickly move body or change direction while maintaining balance. Agility involves rapid adjustment time in movement, balance control, and high-velocity cutting (Pamungkas et al., 2023). Ability to keep the ball in tight places, maintain possession, and build up play is all determined by insistence on quick thinking. The players who have low "Agility ability find it difficult to get the rhythm of the game and lose many duels in 1×1.

The phenomenon of agility problems was also detected in the observations of 17-19-year-old youth athletes from Boyolali FC. Respond often One or more of your players were suboptimal in getting out of the way of opponent attacks, but not bad enough that they could nimbly scoot left and right between hurled magic balls with ease and grace, nor well enough to be standing on both feet at any given time. Consequently, their agility has not yet matured sufficiently to satisfy the requirements of competitive futsal. The main cause of this condition is the absence of well-planned training regimes that target agility (Albalad-aiguabella et al., 2025). 17-19-year-old players should be at a stage where they have big potential to improve physically. Late adolescence 15–19 years is a critical period for the transition into adulthood that involves decelerated growth in height, gain of muscle mass, and changes in body shape (Ashar et al., 2021). Loturco et al., (2020) says that in this phase, some parts of the body grow very quickly, resulting in more strength and improved motor abilities. With such marked physiological potential, specific training should produce large gains in agility performance. Woods, (2016) stresses that success does not happen overnight and is part of the journey right from an early age to peak performance. Training as a physical and mental preparation process, has to be planned by the professionals according to the principles of gradual loading, regularity, and individualization (Liskustyawati et al., 2024). Adolescent athletes will not achieve their full physical potential if they don't train the right way.

There are two types of training relevant to developing agility in futsal players ladder drills and pro-agility drills. Ladder drills are a type of training employed to enhance foot speed, coordination, rhythmic stepping, and neuromuscular control (Pramono et al., 2023). This training is well adapted to the specificities of futsal, such as fast feet working, changes of rhythm, and dealing with opponent pressure. Pro-agility drills are examples of specific exercises that give special attention to acceleration, deceleration, and deceleration during a short distance. This workout is good for flexor and extensor muscular strength as well as quick reaction to running direction change (Arnando et al., 2024). These exercises are considered effective means of enhancing agility, but the corresponding adaptations in these exercises are different.

METHOD

The designs were an experimental method with factorials that was done as the main approach to assess the impact of training treatments on agility enhancement among futsal players. The experimental approach was selected because it enables researchers to apply certain treatments in a controlled fashion to observe their effects on other variables. The experimental design works well for assessing the impact of an intervention on a dependent variable because it is conducted under controlled conditions so that any changes can be directly attributed to treatment. A 2 × 2 factorial design was used, making it possible to analyze the two independent variables type of training, ladder drill, and pro agility drill and their interaction between them and with the age category of the athlete 17 years and 19 years.

This study was carried out at the Boyolali FC Futsal Field, Boyolali Regency, Central Java. The research was carried out in a research environment chosen due to its suitable facilities, the presence of subjects who met the required criteria, and field conditions that guaranteed homogeneous performance for the training program and agility tests. This study's population was 32 U17 and U19 futsal players of Boyolali FC. The present population representative since all players followed a controlled training regimen or had similar anthropometric characteristics and play experience. Physical development and motor coordination in this age group are optimal for evaluating changes in agility training, such as the ladder drills exercise and pro agility drills.

The independent variation was the training type was ladder drill and pro agility drill, and the dependent one was athlete agility, while the attribute variables were age 17 and 19 years. Ladder drill is a series of exercises performed using an agility ladder to enhance coordination, the ability to pace speed, movement rhythm, and motor control. Pro agility drill is a shuttle run specific training, such as 5-10-5 track that showcases the responsiveness of an athlete to change his/her direction in-a-way that is rapid, efficient and under-control. Agility refers to the capability of an athlete to alter body position or direction rapidly without losing balance. Age group was checked using official player identification.

Agility performance was measured through the Illinois Agility Test (IAT), a traditional, popular apparatus in sports science for assessing change-of-direction ability. All the athletes were tested before and after treatment to determine any effectiveness. A digital stopwatch and traffic cones were employed to signal the trajectory, consistent with typical IAT methods. Time was recorded in seconds, with lesser time indicating better agility.

RESULT AND DISCUSSION

Descriptive Statistics of Change of Direction Performance

We first present descriptive statistics for changes in COD performance from pre- to post-intervention before conducting the inferential analysis to determine the effect of the ladder drill and pro-agility drill on improvements in COD ability. These descriptive statistics are critical for an initial description of data trends, patterns of changes, and differences at baseline between age groups and training types. The mean and the distribution of changes (SD Δ) enable readers to determine the initial response of athletes to the training program as well as detect signals showing effectiveness before jumping into further statistical tests. Categorizing the data according to age group (U17 and U19) and type of intervention allows for understanding of differences in physiological adaptations that may be induced as a result of different maturation, playing experience, and neuromuscular characteristics for the two ages.

Table 1. Pre–Post COD Performance Across Age Groups and Interventions

Age	Intervention	Mean Pre	Mean Post	Mean Δ	SD Δ
U17	Ladder Drill	0.44	0.50	0.40	-0.22
	Pro Agility Drill	1.47	1.53	0.37	0.13
U19	Ladder Drill	0.59	0.50	0.47	0.15
	Pro Agility Drill	1.21	1.20	0.47	0.21

The pre-test and post-test results in all groups indicated improved agility performance, as represented by the increasing value of the mean post-test score and the Δ mean test of each group (Table 1). Categorization of participants into different performance status groups All groups showed improvements, but the patterns of change in each group indicate a combination of age and physiological determinants contributing to changes derived from the training intervention.

The group of U17 players exposed to ladder drill training, a mean pre-value of 0.44 became a post-mean value of 0.50 with a mean Δ = 0.40. It also suggests ladder drills to be effective in enhancing agility with 17-year-old athletes. Such effectiveness may be due to the ability of middle adolescents' (17-year-old) neuromuscular development to allow for recurrent technique training, since only in this phase is their motor coordination and reaction speed still highly plastic. Ladder drill per se is also a training modality that requires motor coordination, step rhythm, dynamic balance, and speed of foot. The training happens when the central nervous system is still under active development, so the response to this type of fast and repetitive movement pattern-based training is also very optimal.

The group of U17 in PA-drill training, the mean pre-score reached 1.47 and the post-score reached 1.53, and the mean Δ was equal to 0.37. This increase was slightly less than the ladder drill group of the same age. This is likely because the nature of pro agility drill training tends to be

more intense in terms of acceleration, deceleration, and center of mass control, as well as greater requirements for lower body muscle strength when executing a sudden change of direction. At 17 years, although motor coordination development is relatively complete, physical capabilities of explosive strength, core stability control, and ability to resist forces during deceleration are not yet at the same high level as athletes aged 19. Thus, although it is effective, it is not as effective as ladder drills for those whose physical properties are still in the developmental stage of building on their muscular foundation power being generated between the younger athletes.

The U19 age group demonstrated a totally different profile. The mean pre-value increased from 0.59 to 0.50, with a mean Δ of 0.47. This increase in this age group was somewhat more than that of the U17, who received the identical therapy. Age is a key factor. At the age of 19, athletes have reached near full physical maturity in strength and coordination. When the neuromuscular system stabilizes, drills like ladder drills can be a very effective way to optimize footwork speed and reduce biomechanical responses going in different directions. Having a solid base of muscle strength at such a young age means that the high rate of step activity in ladder drill working variations not only develops coordination but also enhances the need for developing reactiveness between force production and changing direction. Therefore, footwork-based training may lead to more transfer effects on agility performance.

The U19 group training according to the pro agility drill program reached a pre-score of 1.21 and a post-score of 1.20 and a mean Δ of 0.47, the highest among all groups trained. This high level of efficacy is consistent with what would be expected from short sprint accelerator/decelerator training that is a hallmark feature of pro agility drill training. At 19 years of age, athletes have a more advanced level of relative strength capacity, explosive power production, and core stability/motor control to be able to withstand the high biomechanical demands placed on their bodies during pro agility drills. That these exercises' ability to rapidly descend the center of gravity stops, and then the opposition force goes up. It's a skill that requires eccentric strength in the quadriceps, hamstrings, and glutes, as well as the body's capability of controlling torque at the knees and hips. These features have developed more favorably such that there is a faster and stronger adaptive response to training. This is why the U19 with the pro agility drill session had the greatest increase.

The pattern of improvement observed can further be related to the fact that training characteristics match the physiological requirements in a certain age group. Ladder drills focus on gait speed, coordination, and a quick neuromuscular jump. This training applies especially to the middle-aged adolescent and represents stimulation for enhancing motor control. On the other hand, strength- and stability-oriented change of direction competencies, such as those seen in pro-agility drills, do develop at a later time point, being mostly developed during late adolescence. This helps to explain why the U17 responded more to ladder drills than pro-agility drills, while the U19 group demonstrated a larger response to pro-agility. Group SD Δ values illustrate the within-group consistency of SO performance improvement. The low SD Δ of −0.22 illustrates that variability was generally small, and most athletes responded uniformly to the training. In the U19 pro agility drill group, with an SD Δ = 0.21, higher variability suggests that though the average change was substantial, there are small differences between athletes' responses to changes. This might be due to diversity at the basic physical level and more training experience during older age.

Effects and Interactions

The subsequent analysis focused on examining the main effects and interactions between age group and training intervention type on changes in change of direction (COD) performance. This approach is essential because COD performance is influenced not only by the characteristics of the training stimulus but also by physical developmental, neuromuscular, and playing experience factors that differ across age groups. The interaction between age and training type can provide a deeper understanding of whether the effectiveness of a training protocol depends on the athlete's maturity level. The results provide a critical basis for determining whether observed performance changes are a direct effect of the intervention, an age-specific effect, or a combination of both.

Table 2. Effect of training type and age

Source	df	SS	MS	F	p-value
Age group	1	17.317	17.317	16.147	0.00
Training type	1	15.596	15.596	14.543	0.00
Age × Training type	1	4.621	4.621	4.309	0.04

Error	28	30.027	1.072	-	-
R^2 = 0.556; Adjusted R^2 = 0.508					

The effect of training based of type and age (In Table 2) shows that both the age group and the type of training had a big effect on how well futsal players could change direction. A significant interaction between age and training type was identified, suggesting that the efficacy of a training method is contingent upon the athlete's age group. The age group factor had an F-value of 16.147 and a p-value of 0.00, which means that there was a big difference in how well U17 and U19 athletes improved their COD performance. These results show that age or level of maturity as an athlete has a big effect on how well they adapt to agility training. U19 athletes, being physiologically and neuromuscularly more developed, generally exhibited more significant enhancements in COD performance compared to U17 athletes. The type of training had a big effect on changes in COD performance, with an F-value of 14.543 and a p-value of 0.00. These results show that Ladder Drill and Pro Agility Drill are not equally effective at helping people change direction. This difference is due to the fact that Ladder Drill focuses on coordination and stride speed, while Pro Agility Drill focuses more on acceleration-deceleration and sudden changes of direction. The analysis also showed a strong link between age group and training type (Age × Training Type), with an F-value of 4.309 and a p-value of 0.04. This finding shows that the Ladder Drill and Pro Agility Drill have different effects on COD performance depending on the age group. In other words, how well a type of training works depends on how physically and neurologically developed the athlete is. This is why some exercises work better for some people at different ages. For example, the Ladder Drill works better for younger athletes and the Pro Agility Drill works better for U19 athletes. The R^2 value of 0.556 shows that age and type of training together account for about 55.6% of the differences in COD performance. The Adjusted R^2 value of 0.508, on the other hand, shows that the model still has strong explanatory power even after taking into account the number of predictors and the size of the sample. This demonstrates that age and training type are significant factors in enhancing change of direction performance, although additional variables external to the model also affect training outcomes..

Age Group Comparison

This method permits a more detailed appreciation of the relative effects of Ladder Drill and Pro-Agility Drill on the adaptive responses in U17/U19-ages athletes. Given these results can evaluate whether both training regimens confer age-invariant gains at the level of group performance and how much individual differences within each group contribute to training effects.

Table 3. Comparing Performance Changes

Age	Intervention	Mean + SD	t	p	95% Confidence Interval	
					Lower	Upper
U17	Ladder Drill	0.40 ± 0.23	4.96	0.00	0.21	0.58
	Pro Agility Drill	0.38 ± 0.13	8.19	0.00	0.27	0.49
U19	Ladder Drill	0.47 ± 0.15	8.64	0.00	0.34	0.60
	Pro Agility Drill	0.48 ± 0.21	6.34	0.00	0.30	0.65

This is a more detailed look at how the athletes adapted to the training (Table 3). The analysis demonstrated that all groups exhibited statistically significant enhancements in change of direction (COD) performance, evidenced by a p-value of 0.00 across all four combinations of age and training type. This finding shows that both the Ladder Drill and the Pro Agility Drill consistently make it easier for athletes to change direction, no matter how old they are. Consequently, both training protocols are deemed effective in enhancing COD performance among adolescent futsal athletes, although the extent of improvement and the adaptation pattern differed between groups.

The U17 group that did the Ladder Drill saw an average improvement of 0.40 ± 0.23, which shows that this coordination-based training led to a big positive change. The t-value of 4.96 shows that the effect strength is strong, and the 95% confidence interval (0.21–0.58) shows that the improvements in performance were fairly consistent, even though people were different. This variability may indicate disparities in baseline coordination levels, previous training experience, or motor learning capabilities among 17-year-old athletes. The U17 group that did the Pro Agility Drill also showed a big improvement of 0.38 ± 0.13 with a higher t-value (8.19). The lower standard deviation in this group means that the adaptive response was more consistent. This is probably

because the Pro Agility Drill has more structured movement patterns that younger athletes can easily copy. The relatively narrow confidence interval (0.27–0.49) corroborates the conclusion that nearly all athletes in this cohort received consistent advantages from the training.

The group U19, the extent of performance enhancement was markedly greater for both training modalities. The U19 athletes who did the Ladder Drill showed an improvement of 0.47 ± 0.15 with a t-value of 8.64, which shows that the training had a very strong effect. The 95% confidence interval (0.34–0.60) shows that most athletes consistently got better at their sport. This means that when a person is 19 years old and has better neuromuscular maturity and biomechanical stability, they can use coordinative exercises like the Ladder Drill more effectively to improve their ability to change direction quickly. This change is probably due to better coordination and the athlete's ability to combine faster strides with better control of their center of mass.

The U19 group that did the Pro Agility Drill showed the most overall improvement, with a mean of 0.48 ± 0.21 and a t-value of 6.34. The standard deviation in this group was higher than in the other groups, but the 95% confidence interval (0.30–0.65) still showed a clear and statistically significant improvement. This higher variability means that the responses of the 19-year-old athletes were more different from each other. This could be because they had different explosive strength, braking ability, or more varied playing experience. But overall, Pro Agility Drill seems to work very well for this age group because it directly works on acceleration, deceleration, and quick changes of direction, which are all very important for competitive futsal.

DISCUSSION

The observed results of the study indicated that both training groups obtained a significant increase in COD performance on all group levels since $p < 0.05$ was shown for each age group and intervention comparison. These results agree with previous literature suggesting that intense agility-based training could ameliorate the capacity of acceleration-deceleration, coordination, and change of direction efficiency in fast game modes such as futsal (Loturco et al., 2020). The results in performance differences by age are in accordance with the neuromuscular maturation, suggesting that athletes aged 16–18 years have a significant improvement of muscle strength, motor control, and biomechanical efficiency (Williams et al., 2021). U19 sports players at moderate to high levels performed a higher increase of COD compared with U17 in both LD and PAD. This trend may be attributed to divergence in neuromuscular structural maturity, with U19 players possessing greater capacity for force production and more stable trunk control, leading to an exaggerated acceptance of stimuli required for explosive strength and braking ability (Read et al., 2019). These findings are supported by a study by Saini et al., (2025) which supposes that U19 ages respond more to plyometric and agility training because they could have better baseline strength.

The comparison it was also determined that the Pro-Agility Drill was a little more effective than the Ladder Drill, of paramount importance among U19. This might be due to differences in training stimulus features. Ladder drills activate footwork coordination, stride frequency, and timing of movement coordination, having a more localized effect on neural patterning and coordinative speed. Conversely, the Pro-Agility Drill requires fast acceleration and sudden deceleration and high production of horizontal and lateral biomechanical forces, parameters more related to COD performance in futsal games that are filled with short sprints, quick changes of direction, and high-intensity 1v1 situations (Carlos et al., 2019). This result is also in line with Goodson et al., (2022) they indicated force-vector training seems more effective to improve COD than pure coordinative training.

Results show that U19 athletes demonstrated greater improvements in COD performance, with both training interventions, than the U17. This gain indicates the effect of development not only in physiology but also in the neuromuscular aspect perceived in late adolescence. Physiologically, the 17 & 19-year-old age group is the stage when the neuromuscular system, lower limb muscle strength, and function have achieved a viable level of maturation (Junpalee et al., 2023). U19 players are generally past the rapid growth period (peak height velocity), so a high-force production and high-acceleration change of direction style is more effective as the body is structurally stable with more mature anthropometric proportions (Ravi & Divya, 2024). COD depends largely on explosive strength, eccentric breaking ability, postural control, and the ability to develop force within a small time. U19 athletes have higher muscle strength than middle adolescent athletes (U17), because the process of increasing muscle mass and bone density

probably continues into the early 20s age group (Effendi et al., 2025). This results in less ability to decelerate the body and redirect with greater biomechanical effectiveness. Local deceleration is the ability to immediately decrease momentum in the body. Acceleration and COD are important aspects in this sport. Late adolescents show more adult-like braking function as higher hamstring, quadriceps, and gastrocnemius activation occurs, which all coactivate combinedly to decelerate (Nugroho et al., 2022). This will allow for a higher emphasized training response in U19 athletes.

The playing experience factor also led to more increases in U19. Elder athletes usually present a higher volume of hours trained, competitive experience, and mature futsal-specific adaptations, e.g., reading of the game, anticipation, and mechanism responses (Teixeira et al., 2019). These skills are considered crucial for high-level performance in futsal. These long-term adaptations increase the efficiency of movement and therefore allow one to adapt more easily to training stimuli relevant for COD (Li et al., 2024). The results of this study are consistent with the findings of Shimi et al., (2025), which demonstrated U19 athletes could make significantly greater gains in plyometric and agility training than younger ones due to differences in baseline strength levels as well as neuromuscular maturity. Another study by Oliveira et al., (2025) reported the same trend, indicating that explosive training with fast movement patterns and high force production was effective for late adolescents.

Ladder Drill primarily improved coordination, footwork speed, rhythm, and neuromotor control. This exercise is mechanically light but neuromotorically intense, demanding high gait speed, precise foot placement, and eye-foot synchronization (Kevin et al., 2025). This rhythmic step pattern increases motor neuron activation, neural firing frequency, and movement transition speed, factors that are important for changes of direction with high stride frequency but low mechanical load. Meanwhile, Pro Agility Drill demands more complex biomechanical capacities rapid acceleration, sharp deceleration, lateral body control, 180° changes of direction, and significant horizontal force production (Loturco et al., 2021). The movement in the 5-10-5 test requires athletes to rapidly lower their center of gravity, generate eccentric force during braking, and then accelerate explosively in the opposite direction. This type of training is very similar to the physical demands of futsal, which is full of short sprints, quick reactions, and one-on-one duel situations.

Pro Agility Drill produced greater COD improvements than Ladder Drill in most groups, particularly in U19s. This finding supports previous research by Papadopoulos et al., (2020), which found that acceleration-deceleration and sharp change-of-direction-based training were more effective in improving COD performance than purely coordination-based training. Research by (Freitas et al., 2019) also reported similar results, indicating that training requiring high braking forces provided greater transfer to COD performance. Ladder Drill continued to provide significant benefits, particularly in U17s. This may be explained by the need for middle adolescents to improve coordinative abilities before developing high-force production capabilities. At age 17, the neuromuscular system is still developing, so coordination-based training provides an appropriate stimulus to build a foundation for motor control (Coutinho et al., 2017). By improving fundamental movement patterns, Ladder Drill helps athletes reduce motor errors, increase stride frequency, and establish a more efficient movement rhythm before moving on to more biomechanically demanding training.

Ladder Drills in U17 group provided a more appropriate stimulus because they emphasized coordination, rhythm, and movement control. Motor coordination is a fundamental aspect of middle adolescent development, where the nervous system is still in the process of refining neural connections and automatic motor patterns (Freitas et al., 2021). Ladder Drills help improve movement precision and efficiency, and facilitate important motor learning before athletes are ready to accept mechanical loads such as the high braking forces required in Pro Agility Drills. Gillen et al., (2018) supports this, stating that coordination training should form the foundation before athletes receive more intensive agility stimuli. U19 athletes responded more strongly to the Pro Agility Drill because at that age, physical capacities such as muscle strength, eccentric strength, and joint stability have already developed optimally. Pro Agility drills require athletes to generate large forces in very short periods of time, and these abilities develop rapidly in late adolescence. A study by Gillen et al., (2019) showed that braking ability and eccentric strength were the strongest predictors of COD performance in young adult athletes. Therefore, it is not surprising that U19 athletes showed the greatest improvements in this training protocol.

The findings of this study indicate that Ladder Drill and Pro Agility Drill are both capable of improving change of direction (COD) performance, but their effectiveness varies by age group.

These results align with a number of previous studies on the effectiveness of coordination-based agility training. A study by Asadi et al., (2017) reported that Ladder Drill can improve coordination, stride speed, and consistency of movement patterns, which impacts agility improvement in adolescent athletes. Another study by Baena-Raya et al., (2021) also showed that low-intensity footwork training can produce significant changes in agility performance, especially in athletes with suboptimal maturation levels. The results of previous studies confirm that Ladder Drill has a strong influence on neuromotor aspects, a finding consistent with the results of the U17 group in this study, which showed greater improvements through Ladder Drill compared to Pro Agility training. Meanwhile, the findings regarding the effectiveness of Pro Agility Drill in improving COD performance are consistent with a number of studies that focus on change of direction based on rapid deceleration and acceleration. The 5-10-5 (Pro Agility Shuttle) drill significantly improved lateral acceleration, braking force, and 180° change of direction (Blazevich et al., 2018). That COD performance in young adult athletes is strongly influenced by the eccentric strength of the lower leg muscles, the ability to lower the center of gravity, and horizontal force productionall key elements in the Pro Agility Drill (Iacono et al., 2016). Hopper et al., (2017) confirmed that differences in neuromuscular maturation levels play a significant role in differences in agility training responses across age groups in adolescents. Ojeda-Aravena et al., (2023) demonstrated that force production, balance control, and biomechanical efficiency increase rapidly after adolescents pass the peak height velocity phase. This consistency suggests that the differences in training responses between U17 and U19 athletes in this study are a phenomenon that can be explained by physiological development. From a scientific contribution perspective, this study extends previous findings by integrating two important variables rarely tested in a single design the interaction between age and type of agility training (Trecroci et al., 2019). Most previous studies evaluated the effects of Ladder Drill or Pro Agility separately without considering whether adaptive responses differ across age groups (Trecroci et al., 2018). This study highlights the importance of a maturation-based training approach, something that has not been explicitly tested in many agility studies on adolescent futsal athletes. The finding that Ladder is more effective for U17s and Pro Agility is more effective for U19s provides important practical and theoretical contributions and offers new directions for research on developmentally-based training design.

Based on the discussion, it can be concluded that ladder drills have a positive impact on the change-of-direction ability of elite amateur futsal athletes. This exercise helps improve footwork coordination, stride speed, and body control when making rapid changes of direction on the field. Pro-agility drills have also proven effective in improving futsal athletes' change-of-direction performance (Rahmad et al., 2019). Training patterns that emphasize acceleration, deceleration, and rapid changes of direction can train agility and the body's response to dynamic game situations (Sulistiyono et al., 2021). Improving change-of-direction ability through these two training methods is crucial in futsal because this sport is characterized by fast-paced play with limited space. Athletes who can change direction quickly will find it easier to attack and defend against opponent pressure (Purnama & Doewes, 2022). Ladder drills have a significant impact on improving athletes' neuromuscular coordination. Rapid and repetitive foot movements help improve synchronization between the nervous system and muscles, resulting in more efficient and responsive movements during futsal. Meanwhile, pro-agility drills are more dominant in improving the body's acceleration and deceleration abilities. Athletes are trained to move quickly, stop suddenly, and then change direction efficiently (Purwanto & Iwandana, 2022). These abilities are crucial in futsal match situations that demand quick reactions to changes in play. The combination of ladder drills and pro-agility drills provides more optimal results than either training method alone. These two exercises complement each other in improving the athlete's overall foot speed, balance, coordination, and agility (Nugroho et al., 2021). Regular, programmed training can lead to physiological adaptations in the athlete's body, particularly in leg muscle strength, muscle contraction speed, and body stability during movement (Agustiyanta et al., 2022). These adaptations contribute to significant improvements in change-of-direction performance. In addition to improving physical abilities, ladder drills and pro-agility drills also help improve athletes' concentration and decision-making abilities. Fast and complex movement patterns require athletes to focus, thus improving their response to game situations (Hermawan et al., 2022). The improvements in change-of-direction performance obtained from these two exercises can have a direct impact on overall futsal performance. Athletes become more agile in dribbling the ball, guarding opponents, finding space, and making more effective offensive and defensive transitions (Prasetya et al., 2020). Therefore,

ladder drills and pro-agility drills can be recommended as effective training methods for improving change-of-direction ability in elite amateur futsal athletes. These two exercises are easy to implement in a training program and can contribute positively to improving physical performance and futsal playing skills.

CONCLUSION

All groups showed significant improvements from pre-intervention to post-intervention, confirming that both coordination-based and acceleration-deceleration-based training positively contributed to improving agility in futsal athletes. These results reinforce the importance of specific training programs to develop accuracy, reaction speed, and movement efficiency. This study demonstrates that age plays a significant role in determining the extent of training adaptation. U19 athletes consistently demonstrated greater performance improvements than U17 athletes across both intervention types. These findings indicate that greater levels of neuromuscular maturation, muscle strength, and biomechanical efficiency at age 19 allow for a more optimal training response. This aligns with the principle of developmental physiology that late adolescents are in a phase of physical maturity that allows them to utilize training stimuli more effectively, particularly those involving complex horizontal forces, acceleration, deceleration, and center-of-mass control. Differences in effectiveness between training types were also clearly identified. Ladder Drill provides significant improvements, particularly in coordination, foot speed, and rhythmic control, which are particularly beneficial for athletes still in their motor development stages, such as the U17 group. Conversely, Pro Agility Drill has been shown to provide slightly greater improvements, particularly in the U19 group, as it directly mimics the mechanical demands of changing direction in futsal, involving high-intensity acceleration-deceleration, braking, and lateral thrust components. This differential effectiveness emphasizes that the selection of training types must consider the physiological needs and maturity level of the athletes.

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