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The Effects of Ladder Drill and Plyometric Training on Agility in Futsal Players Considering Body Mass Index

Ilham[1ABC], Raffiandy Alsyifa Putra[1ADE], Bekir Erhan Orhan[2ACD], Tri Prasetyo[1ADE], Rully Effendi[1ABD], Randi Kurniawan[1ADE] and Vlad Adrian Geantă[3AD]

[1]Universitas Negeri Padang
[2]Istanbul Aydın University
[3]Aurel Vlaicu University of Arad

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Ilham, e-mail: ilhamf@fik.unp.ac.id
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Abstract

Objectives. This study aimed to investigate the effects of ladder drills and plyometric training on agility among futsal players, considering their Body Mass Index (BMI) classifications.

Materials and methods. Twenty male futsal athletes from Vamos Academy Padang participated in the study and were divided into two groups based on their BMI (high BMI and low BMI groups). Each BMI group was assigned to either ladder drill or plyometric training interventions for six weeks. Agility was assessed using the Illinois Agility Test before and after the intervention. Data analysis included paired and independent t-tests, as well as two-way ANOVA, to evaluate group differences.

Results. Both training interventions significantly improved agility performance ($p < .05$). However, ladder drill training resulted in greater enhancement of agility when compared with plyometric training across all BMI classifications. Moreover, athletes in the low BMI group showed more marked improvements than those in the high BMI group. A significant interaction was found between training type and BMI classification, indicating that body composition influences the effectiveness of agility training programs.

Conclusions. Ladder drill training was more effective than plyometric training for enhancing agility in futsal players, particularly those with a lower BMI. These findings suggest that coaches should consider athletes' BMI when designing agility training programs to optimize performance outcomes.

Keywords: agility, ladder drill, plyometric training, body mass index, motor coordination.

Introduction

Agility is a crucial physical attribute in futsal, characterized by its rapid pace, confined playing space, and constant directional shifts (Ilham et al., 2024a; Setyawan & Peking, 2023; Komang et al., 2024). Dynamic and unpredictable game scenarios may necessitate rapid, unforeseen decelerations, prompt directional changes, and intricate footwork patterns (Hung et al., 2020; Ripoll & Genevois, 2022; Malwanage, 2022).

The physical requirements render agility an essential component of individual performance and a determinant of overall team success in offensive and defensive maneuvers. In high-intensity games, improved agility gives a competitive edge by enabling players to respond quicker, keep balance under stress, and carry out tactical plays more efficiently (Trecroci et al., 2022; Carvutto, Damasco, & De Candia, 2021; Kováčiková & Zemková, 2020). Developing agility is, therefore, a primary focus in the training of futsal players.

Ladder drill exercises and plyometric training are commonly utilized strategies to improve the neuromuscular and biomechanical components of agile performance (Rasyid et al., 2023; Dave & Singh, 2024; Prakash, Sadvika, & Chakravarthi, 2021; Pramono, Rahayu, & Yudhistira, 2023). Ladder drills involve precise, rapid foot movements across a ground-level ladder, training athletes to synchronize quick steps, control body movements, and maintain balance during swift directional shifts (Ilham et al., 2024a; Liu, 2023; Hanani et al., 2024).

This training emphasizes rhythm, timing, and fine motor control essential attributes for improving reactive and anticipatory movements in competitive settings (Uehara, Togo, & Hanakawa, 2022; Wang, Frank, Hung, & Schack, 2022; Song et al., 2020).

Plyometric training, by contrast, focuses on developing explosive muscular power through exercises such as jumps, hops, and bounds (Pandoyo et al., 2020; Huang H, Huang W, & Wu, 2023; Wang et al., 2023). By improving the efficiency of the stretch-shortening cycle in muscles, plyometric exercises enhance an athlete's ability to generate force rapidly, contributing to faster takeoffs, quicker decelerations, and more powerful changes in direction (Duchateau & Amiridis, 2023; Roy & Debnath, 2023; Khan, 2023). Plyometric exercises also help build lower body strength and neuromuscular efficiency, which are critical for sustaining high levels of performance throughout the physical demands of a futsal match (Roy & Debnath, 2023; Hasan, 2023; Drouzas et al., 2020).

Although ladder drills and plyometric training have been proven to contribute positively to agility, there is an ongoing discussion regarding which method is more effective for enhancing specific aspects of movement performance (Prakash, Sadvika, & Chakravarthi, 2021; Bassa et al., 2024; Das, 2020; Dave & Singh, 2024). Physical characteristics such as body mass index (BMI) may also influence how athletes respond to different training approaches. BMI, which relates body weight to height, is an important indicator of body composition and physical fitness (Chen, Cui, Zhang, & Peng, 2020; Qin, G., Qin, Y. & Liu, 2022; Mendoza-Muñoz et al., 2020). A higher BMI, especially with higher fat mass, may impair agility by increasing the mechanical load during rapid movements, reducing speed, and limiting the ability to perform quick directional changes (Hidayat et al., 2022; Patel & Thakrar, 2024; Fauziah et al., 2024; Arianti et al., 2025). Conversely, a lower BMI may be associated with improved movement efficiency, better acceleration, and greater ease of movement during dynamic activities (Baillot et al., 2022; Suorsa et al., 2023).

Despite the recognized influence of BMI on physical performance, few studies have examined how BMI interacts with specific agility training methods to affect training outcomes. Whether athletes with different BMI levels benefit differently from ladder drills or plyometric training is valuable for designing more individualized and effective training programs. It also helps maximize players' agility development depending on their physical profiles, improving general team performance and lowering the injury risk connected with ineffective movement patterns.

This study aims to assess the impact of ladder drills and plyometric training on futsal players' agility while considering the possible moderating influence of body mass index.

By closing this gap, the research provides creative ideas to help coaches, trainers, and sports experts choose the most suitable training interventions for athletes with different physical traits, improving their performance potential on the futsal court.

Materials and Methods

Research Design

This study employed a 2×2 factorial design to examine the effects of ladder drills and plyometric training on agility in futsal players, considering BMI as a moderating factor. The experimental approach allowed for the analysis of the main and the interaction effects of training type and BMI on agility performance. Participants were randomly assigned to one of four groups, ensuring a balanced distribution across conditions. The study lasted six weeks, during which training interventions were applied systematically to measure their impact on agility.

To ensure consistency, certified coaches supervised all training sessions, and the intervention protocol was standardized across groups. Participants were instructed to maintain their diet and avoid additional high-intensity training during the study period to control for external influences.

Table 1. The number of participants in each treatment group

BMI (B)	AF Training (A)				Total (n)
	SJ (A1) LD methods	n	HJ (A2) PT methods	n	
High (B1)	A1B1	5	A2B1	5	10
Low (B2)	A1B2	5	A2B2	5	10
Total	A1	10	A2	10	20

Notes: BMI = Body Mass Index, SJ = snake jump, LD = ladder drill, HJ = hurdle jumps, PT = plyometric training, AF = agility

Participants

The study participants included 38 futsal players from Vamos Academy Padang. Based on BMI percentiles, 27% of the highest and lowest BMI values were selected, resulting in 10 players with high BMI and 10 with low BMI, totaling 20 participants (mean age: 17.2 ± 0.763 years) (Ilham et al., 2024a; Ilham et al., 2024b; Sari et al., 2025). Participants had to meet specific inclusion criteria, including resting heart rate, appropriate oxygen saturation levels, and normal systolic and diastolic blood pressure (SpO_2: 96-100%). Once the BMI data was collected, further analysis was conducted using the ordinal pairing technique to identify the experimental groups (fig. 1).

Randomization was performed using the A-B-B-A pairing technique to ensure balanced group assignment. The randomization process was conducted using IBM SPSS Version 25, which generated randomized group assignments

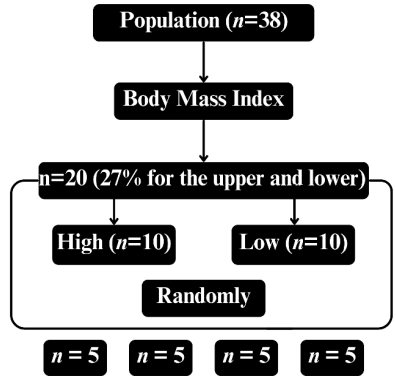

Fig. 1. Methods for assigning participants to treatment groups in the study

to eliminate selection bias. A 30-meter sprint test was conducted, and BMI classification depended on the best and worst outcomes. Participants were then assigned to two groups based on agility levels (Padli et al., 2024; Prasetyo et al., 2024; Selviani et al., 2024). All participants were informed about the study procedures and provided written informed consent prior to participation. For participants under the age of 18, the written consent of the parent or legal guardian and the verbal or written consent of the minor has been obtained in accordance with applicable ethical and legal requirements. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the University of Negeri Padang (13.02/KEP-UNP/5/2024).

Training Protocol

The intervention lasted six weeks, with training sessions held three times per week. Each session commenced with a 10-minute warm-up incorporating static and dynamic stretching exercises. The primary agility training lasted 30 minutes, during which participants performed either ladder drill exercises—emphasizing rapid foot movement, coordination, and directional changes—or plyometric training, focusing on developing explosive power through hurdle jumps. Each session concluded with a five-minute cool-down consisting of active recovery activities and stretching exercises.

Training intensity progressively increased each week, following the principles of overload and individualization. The first two weeks focused on movement familiarization and technique refinement with moderate intensity. By weeks three and four, the complexity and intensity of drills increased, incorporating multi-directional movements and speed variations. Weeks five and six emphasized maximal effort, speed, and quick transitions. A tapering period was implemented in week four to facilitate recovery before the final phase of the intervention.

Table 2. The two-way factorial ANOVA design.

BMI (B)	Agility (A)	
	Snake Jump A1 (ladder drill)	Hurdle Jumps A2 (Plyometric Training)
High (B1)	A1B1	A2B1
Low (B2)	A1B2	A2B2
Total	A1	A2

Notes: BMI = Body Mass Index, SJ = snake jump, LD = ladder drill, HJ = hurdle jumps, PT = plyometric training, AF = agility

Measurements and Data Collection

We used a digital scale (OMRON Model HN-289, Japan) to measure weight in kilograms and a portable Seca® stadiometer (North America) the Body Mass Index (BMI) may be calculated by measuring the height in meters. BMI was determined using the conventional formula, which is the product of the square of the height in meters and the weight in kilograms.

Agility performance was assessed using the Illinois Agility Test, administered under standardized conditions. The test was conducted on a marked futsal court with cones placed at precise intervals. Participants completed three trials with a two-minute rest period between each trial. The fastest recorded time was used for statistical analysis. A certified coach supervised the test to ensure proper execution and minimize variability in results.

Statistical Analysis

Descriptive statistics were calculated to summarize participant characteristics and training effects. The Shapiro-Wilk test was applied to assess the normality of the data distribution, and Levene's test was used to verify the homogeneity of variances. A two-way ANOVA was conducted to examine the main and interaction effects of training modality and BMI on agility performance. Post hoc pairwise comparisons were performed using the Tukey test ($p < 0.05$). The magnitude of observed effects was quantified using partial eta squared ($\eta^2 p$). Additionally, 95% confidence intervals were reported to strengthen the interpretation of the results. All statistical analyses were performed using IBM SPSS Statistics Version 25, with the significance level set at $p < 0.05$.

Results

According to the research, the average and standard deviation of agility before and after the test showed increasing trends as follows: A1B1 (18.32±0.343 to 16.02±0.359), A1B2 (18.26±0.202 to 17.28±0.263), A2B1 (18.59±0.21 to 17.32±0.248), and A2B2 (18.16±0.416 to 16.74±0.268). The initial evaluation revealed that group A1B2 had the highest percentage at 10.85% (1.98). The A2B2 group subsequently had a 7.83% increase (1.42) and secured the second position. Subsequently, the A1B1 group exhibited the third highest proportion at 7.09% (1.3). The A2B1 group exhibited a 6.82% growth (1.26), securing fourth place. For additional information, please consult Table 3.

According to the research, the results showed that groups A1 and A2 had average agility scores of 16.66 ± 0.49 and 17.03 ± 0.39, respectively. The averages for group B1 were 17.18 ± 0.34 and for group B2, 16.51 ± 0.35. Group

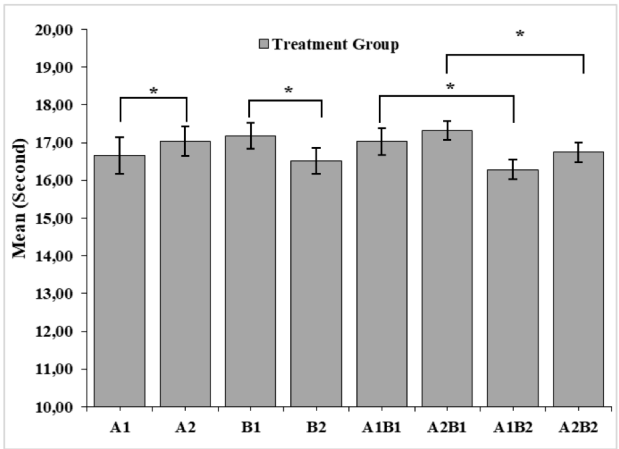

Fig. 2. A comparison was made between the average agility of each treatment group (*p<0.05). For agility, the data is shown with standard deviation and mean values

Table 3. The average differences, standard deviations, and percentage enhancements in pre-test and post-test agility scores for each treatment group

AFE Method	AFE BMI level of each group (n-=5)	Pre-Test	Post Test	Δ	%
		M ± SD	M ± SD		
LD (SJ)	High (A1B1)	18.32 ± 0.343	16.02 ± 0.359	1.3	7.09
	Low (A1B2)	18.26 ± 0.202	17.28 ± 0.263	1.98	10.85
PT (HJ)	High (A2B1)	18.59 ± 0.21	17.32 ± 0.248	1.26	6.82
	Low (A2B2)	18.16 ± 0.416	16.74 ± 0.268	1.42	7.83

Note: AFE = agility exercise, BMI = body mass index, SJ = snake jump, LD = ladder drill, HJ = hurdle jumps, PT = plyometric training, Δ = delta

Table 4. The outcomes of the agility for each treatment group

Group	n	Min	Max	M ± SD
A1	10	16.01	17.34	16.66 ± 0.49
A2	10	16.52	17.72	17.03 ± 0.39
B1	10	16.34	17.72	17.18 ± 0.34
B2	10	16.01	17.18	16.51 ± 0.35
A1B1	5	16.34	17.34	17.03 ± 0.36
A2B1	5	17.02	17.72	17.32 ± 0.25
A1B2	5	16.01	16.72	16.28 ± 0.26
A2B2	5	16.52	17.18	16.74 ± 0.27

Note: Agility, as measured in seconds, is the dependent variable. "A1" denotes ladder drills, which include snake leaps, "A2" denotes plyometric training (hurdle jumps), "B1" indicates high BMI, "B2" signifies low BMI, "A1B1" represents ladder drills (snake jumps) with high BMI, "A2B1" pertains to plyometric training (hurdle jumps) with high BMI, "A1B2" describes ladder drills (snake jumps) with low BMI, and "A2B2" relates to plyometric training (hurdle jumps) with low BMI.

A2B1 had an average agility of 17.32 ± 0.25, while Group A1B1 had 17.03 ± 0.36. At the same time, A1B2 had a value of 16.28 ± 0.26, and A2B2 had a value of 16.74 ± 0.27. According to Table 3, the A1B2 group showed the most notable average increase out of all the treatment groups. Two visual representations of the data are Figure 2 and Table 4. Results from the tests for normalcy and homogeneity are shown in Table 5, demonstrating that all of the data points are consistent and normal (P > 0.05). Both the normality and detrended plots are shown in Figure 3.

Table 5. Testing for normality and homogeneity

Normality test			Homogeneity test		
Shapiro-Wilk			Levene's		
Statistic	df	p	df1	df2	P
0.142	20	0.345	3	16	0.926

Note: Data is normally distributed and homogeneous (P>0.05).

Table 6. Two-way factorial ANOVA

Origin	Type III Sum of Squares	df	Mean Square	F	P
Agility Training (A)	0.711	1	0.711	52.249	0.019
BMI (B)	2.198	1	2.198	72.316	0.000
Agility Training (A) * BMI (B)	0.633	1	0.633	6.508	0.000

Note: The dependent variable in this study was agility. Groups A1 and A2 showed a distinct difference (P<0.05) about "agility training (ladder drill and plyometric)", which indicates that it had an impact on agility. The B1 and B2 groups demonstrated a statistically significant difference (P<0.05) in the "BMI" readings. When the "agility training" and "BMI" groups (A and B) interacted, it significantly impacted agility (P<0.05)

In Table 6 below, you can see the outcomes of the two-way ANOVA. The table indicates that there are substantial differences in explosive power between groups A1 and A2 (P<0.05) and B1 and B2 (P<0.05). As seen in Figure 4, there is a substantial interaction between Groups A and B (P<0.05). Next, we used the Tukey test as a follow-up to determine which treatment group improved agility the most.

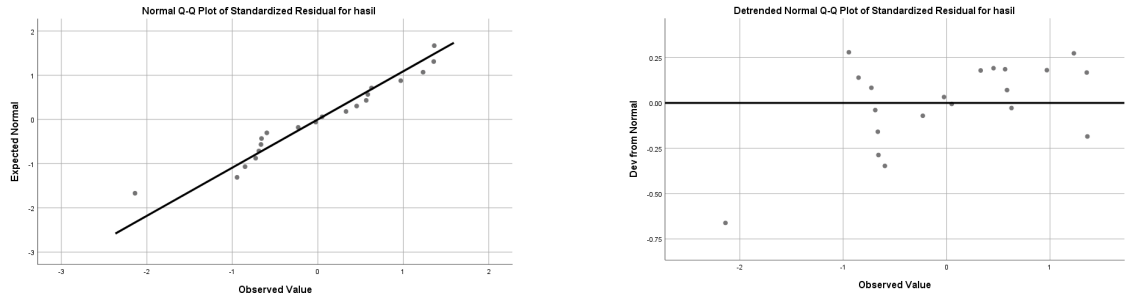

Fig. 3. Normality plot and detrended normality plot graphs

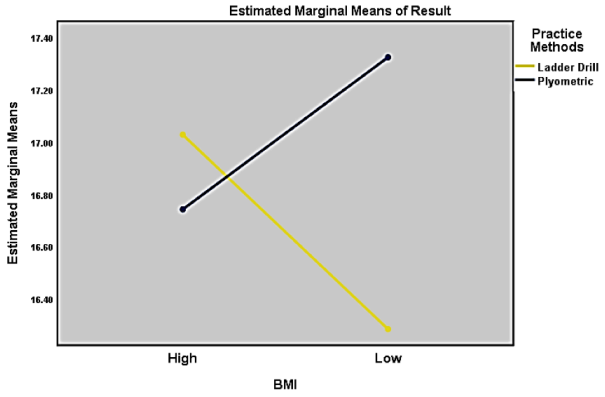

Fig. 4. An examination of the correlation between agility training and BMI

According to Table 7, which is based on Tukey's post hoc analysis, Group A1 improved agility more than Group A2 (P<0.05). For example, consider that 16.66 is often less than 17.03. According to the results, group B1 had a faster speed than group B2 (P < 0.05), as shown by an average of 17.72 < 17.18. Groups A1B1 and A2B1 had substantially different agility test results (P < 0.05), with group A1B1 average 17.03 and group A2B1 17.23. Furthermore, when contrasted with the A2B1 group, the A1B1 group had significantly better agility outcomes (P < 0.05).

Table 7. Tukey's test

Compare Groups	P	Conclusion
A1 and A2	0.000	Significant
B1 and B2	0.001	Significant
A1B1 and A1B2	0.000	Significant
A2B1 and A2B2	0.003	Significant

Note: The variable that depends on others is agility. The difference is statistically significant (P < 0.05).

Discussion

The present study examined the effects of ladder drills and plyometric training on the agility of futsal players while considering the moderating role of BMI. The findings revealed that both training modalities significantly improved agility performance. However, ladder drill training demonstrated superior outcomes to plyometric training across different BMI categories. Furthermore, it was found that BMI influenced the extent of agility improvements, with players possessing a lower BMI showing more significant enhancement in performance.

The greater effectiveness of ladder drill training can be attributed to the specific nature of the exercises involved. Ladder workouts place great emphasis on quick foot movements, exact body control, rhythm, balance, and regular directional changes (Ashar, Setijono, & Mintarto, 2021; Bassa et al., 2024; Sanrijaya, Wiriawan, & Wibowo, 2023; Saini, Dubey, & Vishwakarma, 2025). These characteristics closely mirror the movement needs experienced during futsal matches, where quick, multi-directional footwork is essential (Yiannaki et al., 2020; Belo et al., 2024; Rico-González et al., 2020). Ladder drills are thought to have generated neuromuscular adaptations using continuous repetition and progression, improving motor unit recruitment, coordination, and reaction speed (Ravi & K, 2024; Neto et al., 2024; James et al., 2021). Players thus grew increasingly skilled at carrying out quick motions, accelerating, decelerating, and changing direction with little loss of speed and balance. Plyometric training enhanced agility, but its emphasis on explosive force and vertical jump performance may not directly correlate with the unique movement patterns necessary in futsal. Plyometric exercises increase muscle strength and reactive force generation, which is beneficial for sports with jumping and sprinting (Gross et al., 2022; Ramirez-Campillo et al., 2023; Matuszczyk et al., 2025). However, in futsal, agility often demands quick, subtle, low-amplitude movements and rapid footwork over short distances, where control and efficiency are prioritized over pure explosive strength (Ari et al., 2024; Lima et al., 2024; Serrano et al., 2020). Thus, whereas plyometric training increased general athleticism, ladder drills seemed more closely suited to the functional agility needs of the sport.

Another key finding was the moderating effect of BMI on agility development. Players with lower BMI demonstrated more noticeable increases in agility after the training sessions. This can be attributed to their reduced mechanical resistance, which facilitates quicker acceleration, sharper directional changes, and smoother transitions during movement. Conversely, individuals with elevated BMI may have increased inertia during rapid directional shifts, necessitating more significant effort to initiate and control their movements (Granero-Gil et al., 2020; Popowczak et al., 2022). Extra body mass could also affect stability and balance during quick movements, hence reducing the general efficacy of agility-focused training (Fauziah et al., 2024; Koltai et al., 2021). Still, it is remarkable that those with greater BMI gained from ladder drills and plyometric exercises, suggesting that organized agility programs are useful for all body types. The degree of improvement, nevertheless, was lower, suggesting that extra interventions targeting body composition, strength-to-weight ratio, and mobility could enhance the effectiveness of agility training for this group. Maximizing the agility potential of every athlete may call for tailored training prescriptions considering BMI and other relevant physical characteristics.

Coaches, trainers, and sports scientists working in futsal and related sports will find these results practical. Agility training programs should prioritize exercises that closely simulate sport-specific movement patterns, such as ladder drills, to achieve more meaningful improvements in player performance. Athlete screening should also include body composition assessments to tailor training loads, progression programs, and other therapies depending on individual needs. From a wider angle, this study's findings underline the need to use a whole strategy for athletic growth. Agility is influenced by technical drills or muscular strength and a complex interaction of neuromuscular synchronization, biomechanical efficiency, body composition, and physical fitness. Acknowledging and handling these elements will help to provide more thorough and helpful training results.

Moreover, this study emphasizes the possibility of future research to find the best combinations of training strategies suited to athletes with different physical traits. Investigating integrated programs that blend agility drills,

plyometric exercises, strength training, and conditioning in personalized formats could lead to even more significant performance gains. Extending the duration of interventions and including varied training intensities may yield valuable insights into the long-term development and preservation of agility during an athlete's career.

The findings emphasize the need for strategically planned, customized training techniques that consider significant physical aspects, including BMI and support the basic relevance of agility in futsal. Ladder drill training proved a very efficient approach to increasing agility across player profiles, with reasonable, sport-specific advantages.

Conclusion

The study verified that ladder drills and plyometric training improve futsal players' agility. Ladder drill training was more successful than plyometric workouts in improving agility regardless of the athletes' BMI. The results also revealed that those with lower BMI had more significant agility improvements than their higher-BMI counterparts, stressing the importance of body composition in training response.

The findings highlight the value of ladder drills in agility-focused conditioning programs, mainly due to their emphasis on quick foot movements, coordination, and dynamic balance all of which are essential in futsal. The effect of BMI on agility results underlines the need to customize training courses to fit individual physical traits. Programs tailored for BMI differences should improve agility development and offer fair progress among athletes with different body types. Training tailored to BMI differences might improve agility growth and offer fair advancement among athletes with different body types.

Future studies should evaluate additional physical characteristics such as muscular strength, power, flexibility, and cardiovascular endurance to determine how they interact with agility training responses. Long-term intervention studies are also recommended to analyze the sustainability of training benefits and discover the most effective combinations of approaches across different age groups, competitive levels, and physical profiles. Such studies will help to create more thorough, customized training courses to maximize futsal and related sports.

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Conflict of Interest

All authors assert the absence of any conflict of interest.

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Вплив застосування вправ із використанням координаційної драбини та пліометричного тренування на спритність футзалістів з урахуванням індексу маси тіла

Ільхам[1ABC], Раффіанді Алсіфа Путра[1ADE], Бекір Ерхан Орхан[2ACD], Три Прасетіо[1ADE], Рулі Еффенді[1ABD], Ренді Курніаван[1ADE], Влад Адріан Геанта[3AD]

[1]Державний університет Падангу
[2]Стамбульський університет Айдин
[3]Університет Аурела Влайку в Араді

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 7 табл., 4 рис., 64 джерела.

Мета дослідження. Мета цього дослідження полягала у вивченні впливу застосування вправ із використанням координаційної драбини та пліометричного тренування на спритність футзалістів, враховуючи їх класифікацію за індексом маси тіла (ІМТ).

Матеріали та методи. У дослідженні взяли участь двадцять чоловіків-футзалістів з академії "Vamos Academy Padang", яких було розділено на дві групи за індексом маси тіла (групи із високим ІМТ та низьким ІМТ). Кожна група за ІМТ була розподілена відповідно до типу інтервенційної методики, що передбачала проведення комплексу вправ із використанням координаційної драбини та пліометричних тренувань протягом шести тижнів. На етапах перед- та постінтервенційної програми було проведено оцінку показників спритності за допомогою Іллінойського тесту на спритність. Аналіз даних включав парні та незалежні t-критерії, а також двофакторний дисперсійний аналіз з метою оцінки групових відмінностей.

Результати. Обидві тренувальні інтервенції сприяли значному покращенню показників спритності ($p < .05$). Однак тренування із використанням координаційної драбини призвели до суттєвішого поліпшення спритності порівняно з пліометричним тренуванням за всіма класифікаціями ІМТ. Крім того, спортсмени з низьким ІМТ продемонстрували більш виражені позитивні результати, ніж спортсмени з високим ІМТ. Встановлено значну взаємодію між типом тренування та класифікацією ІМТ, що свідчить про вплив композиції тіла на ефективність програм з тренування спритності.

Висновки. Тренування із використанням координаційної драбини виявилося ефективнішим за пліометричне тренування з точки зору підвищення спритності у футзалістів, особливо тих, хто має нижчий показник ІМТ. Отримані результати вказують на необхідність врахування тренерами ІМТ спортсменів при розробленні програм з тренування спритності задля оптимізації показників результативності.

Ключові слова: спритність, вправи із використанням координаційної драбини, пліометричне тренування, індекс маси тіла, координація рухів.

Information about the authors:

Ilham, Ilham: ilhamf@fik.unp.ac.id; https://orcid.org/0000-0002-6985-1677; Department of Health and Recreation, Faculty of Sport Science, Universitas Negeri Padang, Indonesia.

Putra, Raffiandy Alsyifa: raffiandy15@gmail.com; https://orcid.org/0000-0001-9151-3191; Department of Health and Recreation, Faculty of Sport Science, Universitas Negeri Padang, Indonesia.

Orhan, Bekir Erhan: bekirerhanorhan@aydin.edu.tr; https://orcid.org/0000-0002-3149-6630; Faculty of Sports Sciences, Istanbul Aydın University, Turkey.

Prasetyo, Tri: triprasetyodurai@gmail.com; https://orcid.org/0009-0003-2291-2406; Department of Health and Recreation, Faculty of Sport Science, Universitas Negeri Padang, Indonesia.

Effendi, Rully: rullyeffendi17@gmail.com; https://orcid.org/0009-0004-1411-3628; Department of Health and Recreation, Faculty of Sport Science, Universitas Negeri Padang, Indonesia.

Kurniawan, Randi: arip09822@gmail.com; https://orcid.org/0000-0003-4756-1131; Department of Health and Recreation, Faculty of Sport Science, Universitas Negeri Padang, Indonesia.

Geantă, Vlad Adrian: vladu.geanta@gmail.com; https://orcid.org/0000-0002-8488-1698; Faculty of Physical Education and Sport, Aurel Vlaicu University of Arad, Romania.

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