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Effect of footwork exercises on agility and balance among badminton players of Vadodara

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Abstract

Background: Footwork is essential in badminton for maintaining balance, reducing injury risk, and enhancing agility and performance. Incorporating footwork drills is key to achieving these benefits. Aim was to investigate the effect of footwork exercise on balance and agility among badminton players of Vadodara using the Y Balance test and Illinois agility test respectively to determine the effect of footwork exercise.

Methods: 60 badminton players were allocated into two groups: the experimental Group A (n= 30 players) and the control Group B (n=30 players). Assessments for agility and balance were conducted at the baseline and after a 4-week intervention. During this period, the experimental group engaged in footwork exercises three times a week, while the control group continued their routine training.

Results: Within-group analysis in Experimental Group A with paired t-test showed a significant difference in p-value (0.0001) between the pre and post-scores in the Illinois agility test in comparison to the control group. On Y balance test, the Experimental Group A on paired t-test it showed a significant difference in p-value (0.0001). Between-group analysis by unpaired t-test in Experimental Group A showed a statistically significant improvement p-value (0.0001) on Illinois agility test scores as compared to the control group. Between the experimental group A and control group B on Y balance showed significant difference p value (0.0001).

Conclusion: Engaging in footwork exercises has significant effects on the agility and balance of badminton players in Vadodara002.

Keywords: Illinois agility test, y –balance test, ladder drills, figure of 8 run

Introduction

Badminton is recognized as one of the most widely practiced sports globally, with over 200 million participants, according to the International Federation of Sport for All and the Madison Beach Volley Tour [1]. In badminton, the essential elements of physical fitness are aerobic stamina, agility, strength, explosive power, speed, flexibility, balance and co-ordination. Players must display top-tier athleticism, requiring lightning-fast response times, agility, and quickness to meet escalating demands [2]. Badminton injuries are the sixth most common sports injury, with nearly half of them involving the lower extremity [3]. The majority of injuries occurred suddenly (59.26%) due to acute incidents, with overuse being the most prevalent type (70%), followed by strains (15%), sprains (10%), and fractures (4%) [4].

Footwork is the skill of quickly adjusting speed and direction on the field, crucial for precise shots and top performance. It involves moving through six court zones with various steps, lunges, and coordinated arm movements [5]. Footwork in badminton involves starting, moving, braking, and returning. Good footwork enhances speed and efficiency, allowing players to reach the shuttle and stabilize quickly [6]. Key elements include the base point, waiting position, split step, and body balance, all of which ensure stability, quick reactions, and swift recovery, emphasizing the importance of a low centre of gravity [7].

In badminton, footwork training emphasizes flexibility, speed, and rhythm, crucial for smooth transitions, rapid movements, and strategic positioning. Essential techniques include the double step, advance step, stride, and cross step. Integrated footwork enhances shot quality and strategic play. Mastering rhythm, with high and low, fast and slow patterns, showcases a player's control and tempo mastery [8]. Agility is defined as the ability to change direction rapidly [9]. Without losing balance it also requires to change the position of the body movement quickly and accurately [10].

Agile movement in badminton involves swiftly adjusting speed in response to opponents, relying on perceptual and decision-making skills. It's spontaneous and reactive. Agility relies on cognitive factors, including sensory abilities and pattern recognition, crucial for executing movements effectively [11]. Agility exercises emphasize quick changes in direction through lateral movements, jumps, and angled exercises. The central nervous system coordinates muscle contractions based on movement patterns and feedback from proprioceptors in muscles and joints. Practice enhances this coordination, with feedback from proprioceptors providing updates on muscle and joint conditions, crucial for agility performance [12].

Balance is characterized as the ability to sustain a stable base with minimal movement and dynamically execute a motor task while maintaining stability [13]. Badminton players require strong dynamic balance for agile movements, crucial for optimal performance and injury prevention. Balance involves maintaining the body's position both statically and dynamically. Mechanoreceptors provide essential information about body position and movement to the central nervous system by converting mechanical energy into nerve signals, aiding in balance maintenance [14].

In badminton players, balance addresses issues of controlled COG, twisting movements particularly of the pivot foot, jump smash and offensive and defensive attacks [15]. Maintaining balance in sports relies on the body's centre of gravity. Lowering it enhances stability during gameplay, with techniques like widening the stance aiding balance and shot control. Proper footwork, such as bending the knee during a lunge, is essential for balance and agility in badminton, where dynamic balance during landings is crucial due to the sport's rapid movements [16]. In badminton, maintaining dynamic balance is crucial, as players often lose balance upon landing. Body coordination and agility are essential for coping with the sport's fast-paced, high-intensity nature, emphasizing the importance of balance and agility. Effective footwork is fundamental for achieving excellence in badminton [17, 18]. However, there's a lack of research on the impact of footwork exercises on agility and balance in young adults. Therefore, a study aims to investigate this gap among badminton players in Vadodara.

Materials and Methods

Participants and study design

The study was conducted at the Sports Complex in Vadodara with a study population consisting of badminton players, with a sample size of n=60 selected through convenience sampling over a duration of 9-10 months, employing an experimental pre-test and post-test study design. Inclusion criteria [19] were Badminton players playing at least twice a week, playing badminton for at least more than 1 year, 18-30 years of age, Male and Female badminton players, willing to complete 4-week intervention. Exclusion criteria [19] were recent injuries regularly participated in particular sports other than badminton Had ACL, hamstring, meniscus, ankle, or any other Lower extremities that are associated with diminished dynamic balance during last 3 years. Materials used were Cones and Markers, Ladder, Stopwatch, Board markers, tape, pen, Measuring tape. Approval of the study was obtained from the Ethics Committee of Biomedical Health and Research [KPGU/KSPR/EC/23/03/27.3].

60 badminton players who met the inclusion and exclusion criteria were recruited. Pre-intervention data were gathered at the beginning. Then, the players were divided equally into two groups: Group A (n=30) received footwork exercises along with routine exercises. At the same time, Group B (n=30) served as the control group and only received routine exercises. Both groups trained for 3 days per week over 4 weeks. All players provided informed consent, and verbal instructions were provided regarding the intervention. Post-exercise data were collected upon completion of the intervention period.

Intervention

Table 1: Intervention for Group A + Routine training

	Footwork drills	Sets*Reps	
Warm up for 5-10 mins	Ladder drills: Lateral shuffle(fig.1) Lateral in & outs(fig.3) Ali shuffle Skiers (fig.2) Ickey shuffle	2*2	Cool down for 5 mins
	Figure of 8 (5m)	3*10	
	Backpedal sprint	3*10	
	Squat jumps	3*10	
	Single leg jumps	3*10	

Group B: only routine training like warm-up - stretching, jogging, around the court, skipping rope, push-ups, on-court shuttle practice.

Outcome measures

Y Balance Test: [20]

The Y Balance Test evaluates dynamic balance by assessing a person's ability to reach in various directions, emphasizing comfortable attire and proper footwear.

Procedure

After explaining the procedure and emphasizing safety, conduct a brief warm-up including light aerobic activity and dynamic stretches. During testing, participants stand on one leg and reach as far as possible in designated directions, recording distances for each leg. Scores are analysed for asymmetries and deficits, with results compared to norms for interpretation and intervention development. Document scores and observations, followed by a cool-down and feedback. Schedule follow-up assessments as needed for progress monitoring and intervention adjustments. The Y Balance Test demonstrates strong levels of reliability when assessed by entry-level doctorate physical therapy students, with interrater test-retest reliability ranging from 0.80 to 0.85. Additionally, another study reported high levels of intra-rater reliability (ICC: 0.85 to 0.91) and inter-rater reliability (ICC: 0.99 to 1.00), with composite reach score reliability measuring at 0.91 for intra-rater and 0.99 for interrater reliability. Overall, the test reliability ranges from 0.88 to 0.99.

Illinois agility test [21]

The Illinois Agility Test evaluates agility, speed, and coordination. First, arrange cones or markers to set up the agility course, ensuring standardized distances and dimensions for consistency. Then, position timing gates or prepare manual timing methods to accurately record completion time.

Procedure

Participants should begin with a dynamic warm-up to prevent injuries and enhance performance. Next, explain the test layout and rules, emphasizing clarity for participants. Starting from a designated point behind the initial set of cones, runners navigate from cone 1 to cone 8, weaving through cones 3, 4, 5, and 6 along the way. Accurate timing methods should be used to record each participant's completion time. Allow three trials with rest intervals between each, recording the best time achieved. Assessment involves comparing completion times to established norms for agility and speed evaluation. Adequate rest periods between trials are crucial to minimize fatigue. Throughout the test, offer encouragement to participants to maintain motivation and achieve optimal performance. The reliability of this test is 0.85-0.98.

Results

The result of the study were analysed by using IBM SPSS Version 29.0.0 (Armonk, NY: IBM Corp). The sample size was calculated by using G-Power software version 3.1.9.4. The main outcome variable taken into consideration for sample size calculation from the previous study conducted by M. Yuskel *et al*. The outcome variable values (Illinois Agility test) were before protocol mean=21.9, after protocol mean = 21. Keeping the values of α error as 0.05 since (95% confidence interval) and β error as 0.2 (since power of study 80%). The calculated sample size is 44 (22 in each group).

The age of the participants in this study was from 18 to 30 Years. Total 60 Participants participated in the study. The mean age of the participant's was 21.51.There were 23 Female and 37 Male participants. Mean age of the female was 21.47and the mean age of male was 22.38.

As shown in given table/graph:

Table 2: Demographic data of participants

	Male	Female
Participants	3 37	23
Age	21.47	22.38

Table 3: Within Group analysis Group A on Y balance test and Illinois agility test

Outcomes	Pre Mean ± SD	Post Mean ± SD	T Value	P Value
Y Balance Right	85.92± 10.33	94.73±12.13	7.38	0.0001
Y Balance Left	85.84±8.52	95.86±11.64	7.95	0.0001
IAT	22.67±3.26	19.95±2.70	11.92	0.0001

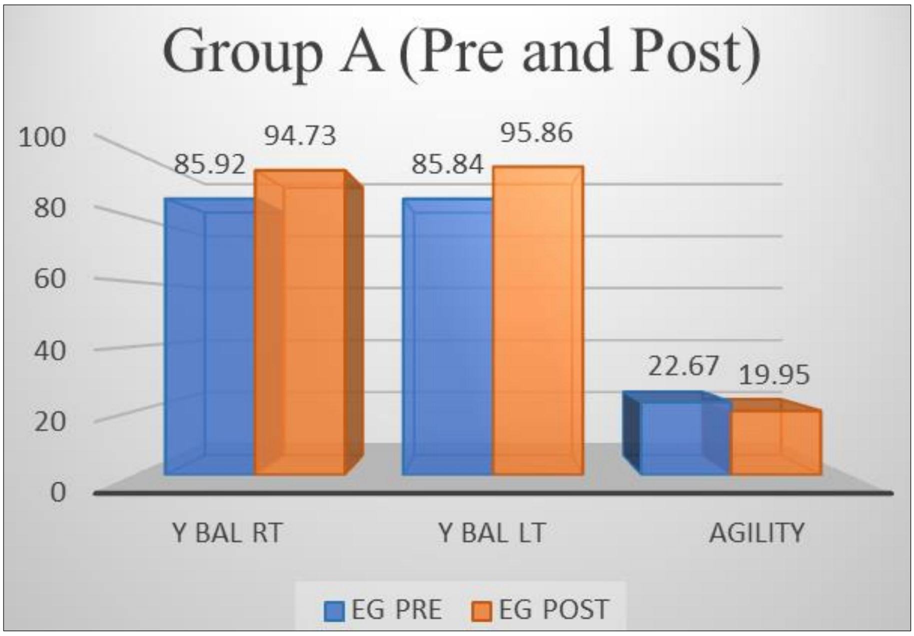

Fig 1: Within Group analysis Group A on Y balance test and Illinois agility test

Table 4: Within Group analysis Group B on Y balance test and Illinois agility test:

Outcomes	Pre Mean ± SD	Post Mean ± SD	T Value	P Value
Y Balance Right	83.28±7.66	83.11±7.79	1.44	0.1599
Y Balance Left	81.89±6.66	81.78±6.53	1.20	0.2387
IAT	20.8±3.64	21.02±3.76	1.21	0.23

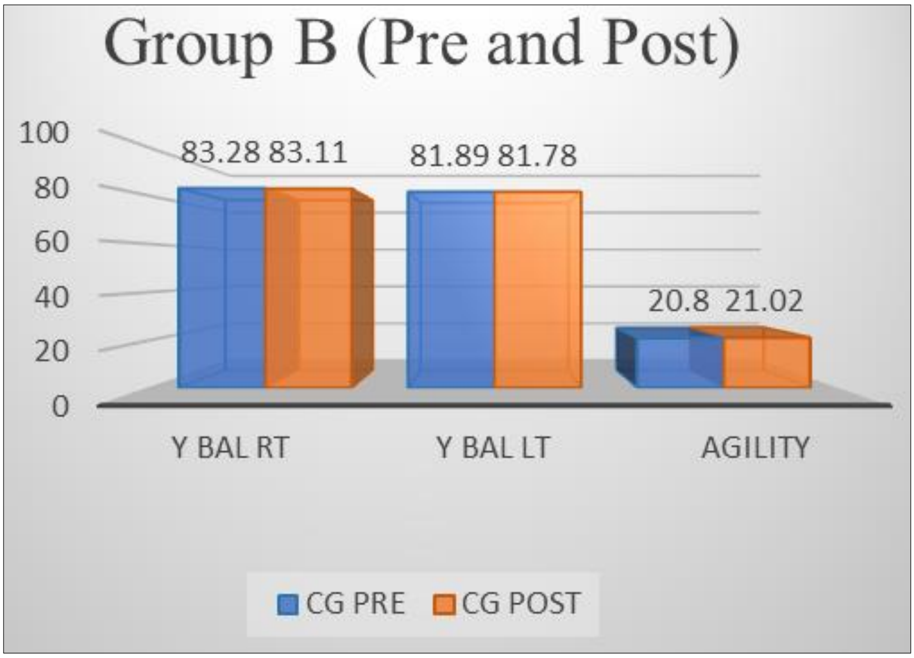

Fig 2: Within Group analysis Group B on Y balance test and Illinois agility test

Table 5: Between group analysis of Group A & B on Y balance test and Illinois agility test:

Outcomes	Group A (Intervention) Mean ± SD	Group B (Conservative) Mean ± SD	T Value	P Value
Y Balance Right	95.31±13.56	83.11±7.79	4.3196	0.0001
Y Balance Left	95.99±11.94	81.84±6.52	5.6958	0.0001
IAT	19.96±2.72	22.82±2.28	4.4161	0.0001

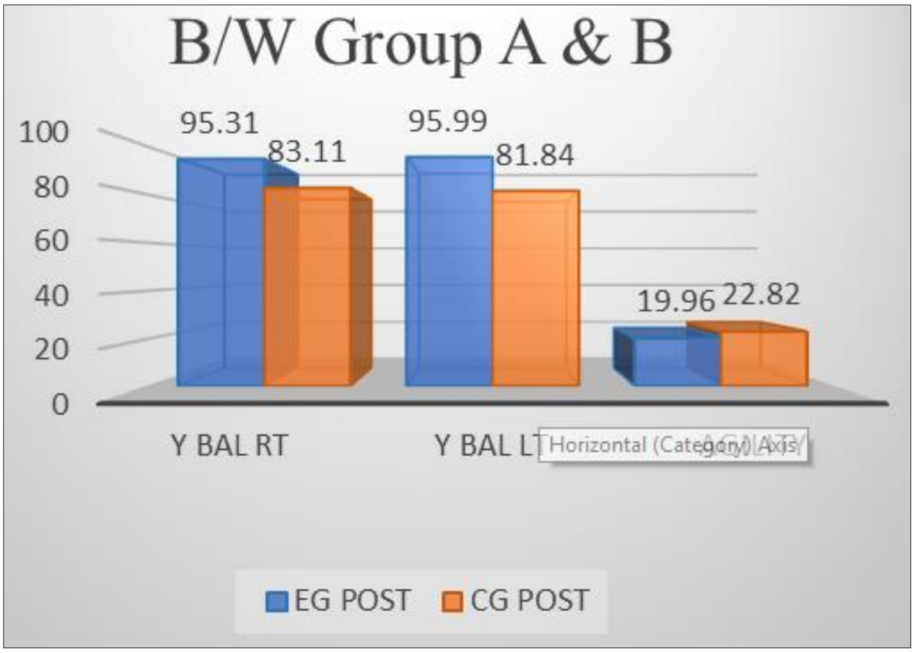

Fig 3: Between group analysis of Group A & B on Y balance test and Illinois agility test

Discussion

The study outcomes of balance suggest that after the intervention, there was improvement, in balance attributed to the footwork exercises among the experimental group on assessing with the Y balance test as shown in Table 3, showing significant differences between pre and post intervention Whereas, Table 4 shows no significant difference between the pre and post values in Group B (Control group). These results align with the research conducted by Ng RS, Cheung CW and Raymond KS [22] where agility ladder drills were implemented three times a week for 6 weeks in the experimental group, while the control group maintained their regular exercise routine. The study concluded that dynamic balance significantly improved among the school boys in the experimental group. Moreover, the data corresponds with the findings of Wahyuni R, S, Prasetyo Y, *et al* [23], who determined that drill training led to enhanced balance among badminton athletes. This improvement was observed after a 4 week training period, with sessions conducted 3 times a week, employing a single-group pretest-posttest design as drill training that involve foot movements, position shifts, and body movements in various directions help in improving balance. Table 5 showing significant improvement on balance among badminton players in Group A as compared to Group B. These findings are consistent with the study conducted by W.P.P Josheeta, S [24] concluded that on comparison of both plyometric and SAQ training were equally effective in improving agility, power, speed, dynamic balance and reaction time among thirty six amaetuer badminton players aged between 13-25 years on 6 weeks of training. The improvement seen in balance can be explained due to the changes in the velocity of the impulses generated by alpha motor neurons which occurs as a result of neuromuscular stimulation with rapid change of directions and muscular contractions during the drills which helps in developing control on balance. Enhanced balance is evident from performing the exercises and maneuvers on agility ladders or ladder drills, where muscle contractions synchronize with joint movements, leading to increased flexibility. Involvement in dynamic and swift motions on the ladder encourages muscles to adapt to intricate movements and stabilize body weight, promoting the capability to maintain balance effectively Ashar A, Setijono H, *et al* [25]. Balance also depends on muscle strength and neuromuscular coordination, which may be one of the reasons why the interventions enhanced the balance Castillo de Lima V, Castaño LAA *et al* [26].

The result of the study of agility indicates an improvement, footwork exercises helped in enhancing their agility among the experimental group on assessing with the Illinois agility test. As shown in Table 3, shows significant differences between pre and post-intervention. in Group A (Experimental group). Whereas, Table 4, shows no significant difference between the pre and post-values in Group B (Control group). Chandra kumar N, Ramesh C.[27] observed that an 8-week training program, with three sessions per week, involving ladder drills for one group and Speed Agility Quickness (SAQ) training for another group, led to enhanced speed and agility among badminton players in a sports club. The results indicated that ladder drills were more effective in improving agility, while SAQ training yielded better outcomes in terms of speed. These findings align with those of Sethu S [28], who discovered that both plyometrics and ladder training resulted in comparable enhancements in speed, power, and agility among footballers following an 8-week intervention. However, when comparing the two training methods based on parameters such as sprinting speed, vertical explosive power, and agility in male football players, ladder training demonstrated significantly superior outcomes, particularly in agility. Similarly, Primasoni N, Prakosa DM [29], concluded that both shuttle run and 3-corner drills have a notable impact on agility. Nevertheless, the shuttle run exhibited more substantial improvements compared to the 3-corner drills when implemented during the training sessions held three times a week for a total of 16 sessions among soccer players as shuttle training exercises are oriented to footwork and speed based on the fast running movements by change of direction of the body which also trains body balance as a component of agile motion thus improving agility. Also, when performing shuttle runs, isometric contractions occur to keep legs and feet moving and when reducing speed to change direction eccentric contractions occur in hip, knee extensors which slow down the momentum of the body moving forward and move the body to a new position therefore body adaption to improve agility. Rohini G, Jayabalan P *et al* [19], determined that incorporating ladder exercises was successful in enhancing footwork skills among badminton players. This improvement was observed after a 6-week training period, with sessions conducted 4 times per week, and assessments were conducted using the 10 m agility shuttle and 50 m run tests due to muscle elasticity the muscles lengthen, therefore giving stronger, faster muscle contractions and quicker footsteps. In addition, as the muscle fibres and muscle contractions increase the speed improves leading to an improvement in agility. Fajar MK [30]. A study found ladder training showed more effectiveness than plyometric training and control group on agility on training 30 taekwondo players. The improvement observed in agility is due to neuromuscular adaption. These results align with, Pratama NE, Mintarto E, *et al* [31] conducted a study involving 30 children, evenly distributed among three groups: a ladder training group, a jump rope training group, and a control group. The results demonstrated that ladder drills were more effective than both the jump rope and control groups in enhancing agility and speed, as assessed through the 30 m test and Agility T test before and after the intervention. Pawar SB, Borkar P [32]. Observed enhanced agility performance among female Kabaddi players after a 6-week ladder training program conducted 4 days a week. This improvement was evident when comparing the intervention group to the control group using the Agility T test before and after the intervention. The activity's repetition teaches the CNS to react more quickly. The CNS receives feedback from the repeated stimulus, which allows it to modify muscle spindle length via motor neuron activation to match the length of the muscle during contraction. The CNS expedites the stimulation pattern by coordinating the activation of the muscle fibres and the muscle spindle at the same time, thereby saving time. The central nervous system (CNS) perceives overall muscle tension and movement, which can be translated into faster times, through the golgi tendon organ and other proprioceptors. Also, once the movement is decided the central nervous decides which muscles are needed and sequence of their contraction. Then it makes adjustments by changing the number of muscle fibres involved as the movement is practiced consistently, responds to a directional order it takes away the ability to anticipate thus improving the co-ordination between the central nervous system and proprioceptive feedback it receives. Thereby increasing the neural connections with foot movements which imitate on field quick foot movements to hit the shuttle effectively. Hence, boiling it down to neural adaptation Craig BW [12], Robin KV, Raj YL [33]. This explains effectiveness of footwork exercises on agility.

Conclusion
This 4 week intervention consisting of the footwork exercises among the experimental group (Group A) has shown to be more effective in boosting their agility and improving their balance as compared to the control group (Group B) who continued with their routine training.

Clinical Implication
The incorporation of these footwork exercises can yield in better performance thereby, increase their likelihood to sweep the board in each match as this present study's results prove its effectiveness in enhancing their agility and balance.

Limitation
Unequal distribution of male and female participants, sample size is small to extrapolate the entire population, samples taken were only from Vadodara district are the limitations of this study.

Future scope
It can be done on large sample size, follow up can be taken to see the long term effects in balance and agility.

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References
1. Cabello-Manrique D, Lorente JA, Padial-Ruz R, Puga-González E. Play Badminton Forever: A Systematic Review of Health Benefits. Int J Environ Res Public Health [Internet]. 2022 Jul 26;19(15):9077. Available from: https://doi.org/10.3390/ijerph19159077
2. Woodward M, Wright I. Badminton Coach Education Coach's Manual. Badminton Federation; 2011.
3. Phomsoupha M, Laffaye G. Injuries in badminton: A review. Sci Sports [Internet]. 2020 Sep 1;35(4):189-199. Available from: https://doi.org/10.1016/j.scispo.2020.01.002
4. Bhagat C, Sarvanan M, Bhura P. Prevalence of musculoskeletal injuries among badminton players of Vadodara. Int J Phys Educ Sports Health. 2022;9(5):161-163.
5. Malwanage KT, Senadheera VV, Dassanayake TL. Effect of balance training on footwork performance in badminton: An interventional study. PLoS One [Internet]. 2022 Nov 17;17(11). Available from: https://doi.org/10.1371/journal.pone.0277775
6. Yu L, Mohamad NI. Development of Badminton-specific Footwork Training from Traditional Physical Exercise to Novel Intervention Approaches. Phys Act Health [Internet]. 2022 Jan 1;6(1):219-225. Available from: https://doi.org/10.5334/paah.207
7. The Badminton Hub. Badminton Coaching and Training Melbourne. The Badminton Hub. The Badminton Hub Melbourne. Available from: https://thebadmintonhub.com/. Published March 5, 2024.
8. Wang B. Discussion on Footwork Training Skills in Badminton Teaching. Front Educ Res [Internet]. 2020 Dec 25;3(15). Available from: https://francis-press.com/uploads/papers/1UEQ36PHTSVZVoOmT0vQ7L0Kg0gkq6PQLYiLxNWa.pdf
9. Applied anatomy and biomechanics in sport. Choice Rev [Internet]. 2009 Apr 1;46(08):46-4509. Available from: https://doi.org/10.5860/choice.46-4509
10. Gusliandi F, Ramadi N, Juita A, Welis W. The Effect of Footwork Exercise on Agility in Badminton. In: Proceedings of the 1st Progress in Social Science,

Humanities and Education Research Symposium (PSSHERS 2019) [Internet]. 2020 Jan 1; Available from: https://doi.org/10.2991/assehr.k.200824.186
11. Sheppard JM, Young WB. Agility literature review: classifications, training and testing. J Sports Sci [Internet]. 2006;24(9):919-932. Available from: https://doi.org/10.1080/02640410500457109
12. Craig BW. What is the Scientific Basis of Speed and Agility? Strength Cond J [Internet]. 2004;26:13-14. Available from: https://doi.org/10.1519/00126548-200406000-00002
13. Bressel E, Yonker JC, Kras J, Heath EM. Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. J Athl Train [Internet]. 2007;42(1):42-46. Available from: https://www.ncbi.nlm.nih.gov/pubmed/17597942
14. Alikhani R, Shahrjerdi S, Golpaigany M, Kazemi M. The effect of a six-week plyometric training on dynamic balance and knee proprioception in female badminton players. J Can Chiropr Assoc [Internet]. 2019;63(3):144-153. Available from: https://www.ncbi.nlm.nih.gov/pubmed/31988535
15. Guo Z, Huang Y, Zhou Z, Leng B, Gong W, Cui Y, *et al*. The Effect of 6-Week Combined Balance and Plyometric Training on Change of Direction Performance of Elite Badminton Players. Front Psychol [Internet]. 2021 Jun 10;12:684964. Available from: https://doi.org/10.3389/fpsyg.2021.684964
16. The Badminton Guide. The Badminton Guide [Internet]. 2020 Oct 6. Available from: https://thebadmintonguide.com/
17. Manan V, Digpal R, Apoorva T, Manit A. Analysis of static, dynamic, and pelvic stability in junior badminton players of South Asia. J Sports Med Ther [Internet]. 2018 Jan 1;3(4):80-88. Available from: https://doi.org/10.29328/journal.jsmt.1001031
18. Savla HN, Sangaonkar M, Palekar T. Correlation of Core Strength and Agility in Badminton Players. Int J Appl Res. 2020;6(12):383-387. Available from: https://www.allresearchjournal.com/archives/2020/vol6issue12/PartF/6-12-68-571.pdf
19. Rohini G, Jayabalan P, Sivakumar S. Efficacy of using footwork drills on footwork improvement among badminton players-quasi experimental study. Int J Sci Res. 2022;11(3):1209-1213.
20. Plisky P, Schwartkopf-Phifer K, Huebner B, Garner MB, Bullock G. Systematic Review and Meta-Analysis of the Y-Balance Test Lower Quarter: Reliability, Discriminant Validity, and Predictive Validity. Int J Sports Phys Ther [Internet]. 2021 Oct 1;16(5). Available from: https://doi.org/10.26603/001c.27634
21. Hachana Y, Chaabène H, Nabli MA, Attia A, Moualhi J, Farhat N, Elloumi M. Test-Retest Reliability, Criterion-Related Validity, and Minimal Detectable Change of the Illinois Agility Test in Male Team Sport Athletes. J Strength Cond Res [Internet]. 2013 Oct 1;27(10):2752-2759. Available from: https://doi.org/10.1519/jsc.0b013e3182890ac3
22. Ng RS, Cheung CW, Raymond KS. Effects of 6-week agility ladder drills during recess intervention on dynamic balance performance. J Phys Educ Sport. 2017;17(1).
23. Wahyuni R, Prasetyo Y, Nugroho S, Nasrulloh A. The Effect of Drilling Training on Improving the Balance of Badminton Athletes. Int J Multidiscip Res Anal [Internet]. 2023 Jun 20;6(6). Available from: https://doi.org/10.47191/ijmra/v6-i6-42
24. P WP, Josheeta S. Effect of Plyometric Exercises Versus Speed Agility Quickness Training on Agility, Speed, Power, Dynamic Balance and Reaction Time in Amateur Badminton Players. Int J Physiother Res [Internet]. 2023 Jun 11;11(3):4524-4530. Available from: https://doi.org/10.16965/ijpr.2023.124
25. Ashar A, Setijono H, Mintarto E. The Effect of Unilateral and Bilateral Training Circuit with Ladder Drill and Plyometric Cone on Speed, Agility, Reaction and Balance of Elementary School Students in Indonesia. Int J Hum Mov Sports Sci [Internet]. 2021 Nov 1;9(6):1453-1459. Available from: https://doi.org/10.13189/saj.2021.090642
26. De Lima VC, Castaño LAA, Sampaio RAC, Sampaio PYS, Teixeira CVL, Uchida MC. Effect of agility ladder training with a cognitive task (dual task) on physical and cognitive functions: a randomized study. Front Public Health [Internet]. 2023 Jun 21;11. Available from: https://doi.org/10.3389/fpubh.2023.1159343
27. Chandrakumar N, Ramesh C. Effect of Ladder Drill and SAQ Training on Speed and Agility Among Sports Club Badminton Players. Int J Appl Res. 2015;1(12):527-529. Available from: https://www.allresearchjournal.com/archives/2015/vol1issue12/PartH/1-12-27.pdf
28. Sethu S. Comparison of plyometric training and ladder training on sprinting speed, vertical explosive power and agility. Int J Recent Res Appl Stud. 2014;1(1).
29. Primasoni N, Prakosa DM, Anugrah T. The effects of shuttle run and three corner drill on the agility of soccer players in soccer academy. J Keolahragaan [Internet]. 2022 Sep 26;10(2):175-182. Available from: https://doi.org/10.21831/jk.v10i2.52005
30. Fajar MK. The Effect of Plyometric Exercise and Ladder Drill on Power, Agility, and Resting Pulse in Taekwondo Athletes at State Colleges. Int J Multicult Multirelig Underst. 2022;9(3):311-318.
31. Pratama NE, Mintarto E, Kusnanik NW, Pratama NE. The influence of ladder drills and jump rope exercise towards speed, agility, and power of limb muscle. J Sports Phys Educ. 2018;5(1):22-29.
32. Pawar SB, Borkar P. Effect of ladder drills training in female kabaddi players. Int J Phys Educ Sports Health. 2018;5(2):180-184.
33. Robin KV, Raj YL. Impact of ladder training on the agility performance of footballers. Hum Mov Sports Sci. 2019;4(1).