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ORIGINAL ARTICLE

EFFECT OF LADDER DRILL TRAINING AND NORDIC HAMSTRING CURL ON REACTIVE STRENGTH AND REACTIVE AGILITY AMONG AMATEUR BASKETBALL PLAYERS

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ABSTRACT

Introduction: The performance of basketball players is closely linked to various physical attributes, particularly reactive strength and agility. There is limited research specifically examining how different training methods influence reactive strength and agility in amateur basketball players. This study aims to fill this gap by investigating the effects of ladder drill training and Nordic hamstring curls on reactive strength and reactive agility among amateur basketball players, providing insights into effective training strategies for enhancing performance. The primary objective of this study is to examine the effects of ladder drill training and Nordic hamstring curls on performance metrics specifically the reactive strength and reactive agility among amateur basketball players. **Methods**: A sample of 78 amateur basketball players, meeting the inclusion and exclusion criteria, was selected for this study. The participants were divided into two groups: GROUP A (Experimental) and GROUP B (Control). Group A performed ladder drills and Nordic hamstring curls, while Group B engaged in regular strength training. Both groups trained 3 times per week for 6 weeks. Pre- and post-test data were collected using the Counter Movement Jump test to assess reactive strength and the Y shaped Agility test for reactive agility. **Result:** Group A demonstrated statistically significant improvements in both RSI ($p<0.001$) and RAT ($p<0.001$). Group B showed only a marginal increase in RSI ($p<0.001$) and in RAT ($p<0.05$). Between-group comparisons revealed significantly greater gains in Group A for both outcome measures ($p<0.05$). **Conclusion:** The findings of this result suggest that ladder drills improve neuromuscular coordination, agility, and movement efficiency, enhancing direction changes and response times. The Nordic Hamstring Curl targets eccentric hamstring strength, optimizing force production and deceleration. Combined, these training methods enhance reactive strength and agility, boosting athletic performance.

Keywords: Reactive strength, Reactive agility, Amateur basketball players, Counter movement jump, Y-agility test

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INTRODUCTION

More than 70 million people play basketball and over 210 countries are members of FIBA.[1] Basketball is a court-based team sport that requires contributions from various physical parameters and bio-motor abilities. These broad arrays of skills are principal components of in-game performance.[2] One full-time game of basketball contains at least 35 to 46 vertical jumping and landing motions which are two to four times more than soccer and volleyball.[3] Amateur sport is defined as participation by individuals who have never received payment for competing, or who may receive limited compensation under specific conditions set by a governing body. It highlights sport as a non-professional, recreational pursuit rather than a primary occupation.[4]

For teams to succeed in a competition, basketball players need to exhibit strong strength and quickness. In comparison to other physical activities, the neuromuscular system is under a lot of stress due to the technical and tactical aspects of the game.[2] Any player's ability to perform will be influenced by his level of physical fitness.[1]

The physiological demands of sports include elevated aerobic and anaerobic capacities in addition to the integration of physical characteristic such as muscle strength, power, endurance, flexibility, speed, agility and skill.[5] A player's ability to dribble, shoot, and pass is vital at any competition level as they are subjected to a lot of eccentric loading, but these skills must be supported by physiological factors such as anthropometric measurements, body composition, leg muscle strength, endurance, power, aerobic capacity, flexibility, and agility, as each of these technical and fitness elements are interconnected.[1,5]

In recent years, A new training technique has been created recently to enhance power, speed, coordination, and agility. The technique is called ladder drill, and it's a great way to exercise for increased speed, coordination, agility, and overall power.[6] Different ladder training drills focus on various rhythms or step patterns, including jumps, hops, bounds, or combinations of these movements. These drills help athletes control their center of gravity while in motion, while also enhancing foot speed and reaction time.[7]

Enhancing footwork is essential for optimizing athletic performance through ladder training. It is the multi directional training which helps to improve strength, power, balance, agility, coordination, proprioception, core and joint stability, foot speed, hand eye coordination, reaction time and mobility. Each component should be incorporated into daily training sessions. Ladder drills are enjoyable and practical methods for teaching movement skills, helping the body and mind learn various footwork patterns.[6] For maintaining perfectly timed and rhythmic motions that are essential for the exercise, ladder training involves the coordination of multiple muscle groups. These muscle groups work together to enhance an athlete's capacity for dynamic balance and the ability to keep their balance while performing intricate, powerful, and multidirectional motions.[8] Ladder training is a great way of improving total training volume that works effectively for almost every exercise and gives the trainee an opportunity to perform more tasks than they would typically be able to in a more traditional training environment.[9]

Power sports are associated with a high incidence of hamstring muscle strain-type injuries Eighty percent of hamstring injuries occur in the long head of the biceps femoris during high-speed actions (e.g., sprinting and jumping), especially at a longer-than-optimal length. 210 hamstring injuries occurred in the National Basketball Association from 2016-2021. Basketball frequently involves physical contact and is characterized by intermittent bursts of activity. Most hamstring injuries in the sport result from overstretching or an inability to withstand eccentric loading. During various high-intensity movements—such as sprinting, jumping, and sudden direction changes—basketball players are required to perform with both power and explosiveness. [10]

Eccentric activation increases muscular tension, which strengthens the muscle and lowers the likelihood of injury. Maximum eccentric strength is well known to be a crucial component of quick and successful deceleration in basketball.[11] Therefore, maximal eccentric strength is an important factor for successful and fast deceleration.[12] The Nordic hamstring exercise is highly effective for developing greater maximal eccentric strength in the hamstring muscles. Additionally, performing Nordic hamstring curls can support the maintenance of a balanced hamstring-to-quadriceps strength ratio.[13]

Reactive strength is the ability of the musculotendinous unit to produce a powerful concentric contraction after a rapid eccentric contraction. Certain structural characteristics and neuronal properties determine reactive-strength attributes. Superior eccentric strength allows increased negative acceleration and momentum, allowing for utilization of SSC mechanisms (ie, series elastic component and stretch-reflex mechanisms), ultimately leading to improved concentric force, impulse, and jump height.[14]

Reactive strength is essential in basketball for quick changes of direction, explosive jumps, and rapid movements on the court. The reactive strength index (RSI) is a measure of force and the time that is taken to develop it, by calculating the jump height divided by ground contact time.[15] According to a recent study, sport scientists may have another way to measure reactive strength during various plyometric workouts with the Reactive Strength Index Modified (RSImod). By replacing the ground contact time with the time to take off, the original reactive strength index equation is modified to calculate RSI mod. This modification enables the evaluation of more plyometric workouts that start from the ground, like the countermovement jump (CMJ), rather than the depth jump. The evaluation of RSI mod during a CMJ is especially relevant since athlete performance monitoring frequently uses CMJs.[16]

RSI mod is calculated as the ratio of CMJ height to time to take-off (TtT). In layman's words, the RSImod shows the relationship between the total jump height (JH) and the time required to flex and extend the legs during the CMJ. In general, it is said that the RSImod represents or quantifies an athlete's degree of "explosiveness".[17]CMJ has been associated with slow-SSC (>250 ms in duration) performance, which has been related to sprint acceleration, where ground contact time is longer.[5,6] For basketball players, who frequently need to accelerate and decelerate, this makes the CMJ evaluation an essential tool for evaluating important performance indices. This is because jumping places high physical demands on the lower limbs, particularly through rapid eccentric loading. This eccentric phase is crucial for generating the force needed to propel the body into the air. [18]A stronger athlete is likely to have better reactive strength, as there appears to be a strong correlation between maximal strength and RSI mod, particularly when it comes to relative body mass.(19)

Basketball players typically engage in a number of quick directional shifts during the game, resulting some to propose that agility is a physiological requirement. The speed at which an object changes direction determines its agility performance, which has been found to be influenced by muscle coordination, explosive strength, balance, and flexibility. [20]

Agility has always focused mostly on motor skills rather than integrating perception and judgment during motion changes in athletes. As such, it became essential to improve reactive agility—a combination of perception, agility, and decision making—in training and assessment. Reactive agility is defined as the whole body's movement in changing its speed or direction after responding to a stimulus. The combination of stimulative elements including information processing and direction shifts makes up reactive agility. [21]

The capacity to change direction quickly has been reinterpreted as planned agility, or change of direction speed. Planned agility refers to the ability of participants to know the precise movement pattern needed prior to the commencement of an exam. This makes it possible to distinguish between agility and the more modern definition, which defines agility as a whole-body movement that changes direction or velocity in response to a stimulus. This latter definition, which calls for participants to alter course in reaction to a specific stimulus mid-test, has been dubbed reactive agility.[20] This ability is influenced by key factors, including decision-making processes, neuromuscular coordination, and proprioceptive awareness. Therefore, reactive agility has to be enhanced in both training and assessment.[16]

Need for Study: Basketball players must rapidly switch between forward, backward, lateral, and vertical movements, requiring high levels of power, strength, endurance, flexibility, and agility. Ladder drills improve foot speed, control, balance, and coordination, enhancing both offensive and defensive positioning. The hamstrings play a key role in the propulsion phase of jumping, working alongside the quadriceps and glutes. Enhanced hamstring strength can result in higher vertical jumps, improving rebounding, shot-blocking, and dunking abilities. Nordic Hamstring Curls (NHC) focus on eccentric muscle contractions, where the muscle lengthens under tension. Increased eccentric strength helps athletes decelerate more effectively, control their movements, and absorb impact forces during landings and directional changes. It also enhances the ability to change direction quickly by improving muscle-tendon unit function and neuromuscular control. Reactive strength is essential for high-level performance, injury prevention, energy conservation, and improved jumping, directional changes, agility, speed, and overall effectiveness and reactive agility is crucial for quick, effective responses in the fast-paced game, thus enhanced reactive strength and agility give players a decisive edge in competitive settings. Therefore, a need arises to determine the effect of ladder drill training and Nordic hamstring curl on reactive strength and reactive agility among amateur basketball players

Objective: To determine the effect of Ladder Drill Training and Nordic Hamstring Curls on reactive strength and reactive agility among amateur basketball players.

METHODOLOGY

Source of data: Beagles Basketball Club and Baseline Academy

Method of collection of data

Population: Amateur basketball players.

Sample design: Simple Random Sampling

Sample size: 78

Type of study: Experimental Study

Study design: True experimental design

Duration of study: 6 months

Inclusion Criteria:

Amateur basketball players, Age group 18-25, Players with experience of one year, Players who practice for at least 5-8 hours a week, Both male and female, BMI of 18.5-24.9, RSI <1.2 m/s

Materials Required: Ladder (made up of rubber or plastic)**,** Inch tape, Cones, Stopwatch, My jump app, Flags , Good quality camera (3840 × 2160 pixels, 60fps)

Figure 1: Materials required

METHODOLOGY

Ethical clearance was obtained from the Institutional Ethical Committee with Reference No. PIEC/PIP/16/2024 dated 20/06/2024. Permission was obtained from the respective clubs and the subjects to carry out the study. Participants who fulfilled the inclusion and exclusion criteria were selected for the study, and informed consent was taken before conducting the study. Demographic information such as name, age, gender, height, weight and number of playing years were documented. Both groups underwent the training 3 times a week for 6 weeks. Pre and post-data were taken using outcome measures.

Procedure:

WEEK	EXERCISE ITEM	EXERCISE DOSAGE
1	Item 1: In and out shuffle Item 2: Two feet forward Item 3: Two in lateral Item 4: Lateral two in two out	Volume (rep × sets) : 6×1 Rest between reps: 30s Rest between sets: 60s
2	Item 1: In and out shuffle Item 2: Two feet forward Item 3: Two in lateral Item 4: Lateral two in two out	Volume (rep × sets): 5 ×2 Rest between reps: 30s Rest between sets: 60s
3	Item 1: One lateral Item 2: Lateral ickey shuffle Item 3: Ickey shuffle backward Item 4: Ickey shuffle	Volume (rep × sets): 5 × 2 Rest between reps: 30s Rest between sets: 60s
4	Item 1: One lateral Item 2: Lateral ickey shuffle Item 3: Ickey shuffle backward Item 4: Ickey shuffle	Volume (rep × sets): 3× 4 Rest between reps: 30s Rest between sets: 60s
5	Item 1: Frontal two in two out forward Item 2: Zig-zag crossover shuffle Item 3: Zig-zag crossover shuffle backward Item 4: Frontal two in two out backward	Volume (rep × sets): 3 × 4 Rest between reps: 30s Rest between sets: 60s
6	Item 1: Frontal two in two out forward Item 2: Zig-zag crossover shuffle Item 3: Zig-zag crossover shuffle backward Item 4: Frontal two in two out backward	Volume (rep × sets): 7 × 2 Rest between reps: 30s Rest between sets: 60s

A pre-test was conducted for all the selected participants prior to the training session. All the instructions regarding the pre-test were explained in detail to all the participants and a trail run was conducted for the same. The participants were divided equally into two groups, Group A and group B. Group A received ladder drill training and Nordic hamstring curls and Group B regular strength training. Both the groups received the respective interventions for a period of 6 weeks, attending sessions 3 times a week. Both the groups received a warm-up session and a cooldown session for 10-minutes each prior to each training session, that included light stretching exercises that specifically targets the lower limbs. The pre and post data of both the

groups were assessed using Counter Movement Jump test for reactive strength and Y agility test for reactive agility.

GROUP A-Experimental group

Participants of this group were given ladder drill training and Nordic hamstring curls.

LADDER DRILL TRAINING: [41]

In this the participants followed the training protocol as mentioned in the table

Table 1: Ladder drill training


Figure 2a: Ladder drill training **Figure 2b:** Ladder drill training

Nordic Hamstring Curl :[3]

Then the participants were given Nordic hamstring exercise for 3 sets × 8-12 repetitions, rest for 45-60 seconds between the set for 6 weeks.

During training sessions, the participants kneeled on a padded surface with the researcher stabilizing lower legs. Participants were instructed to descend their torsos to the floor. Maintaining a stiff torso position with only the knee joint moving. At the level of the Shoulder joints, the participant's arms were flexed at the elbow joint so that the palms of their hands faced front. The participants were allowed to use their arms to cushion the fall in the last stages of the action. The subject used their upper limbs to avoid concentric hamstring activity throughout the return to the NHC starting posture.

Figure 3: Nordic hamstring curl

GROUP B-Control group

This group received regular strength training consisting of squats, lunges, jumping jacks, hamstring curls and single leg balance

Outcome measures:

Counter movement jump test (reactive strength):

The measuring device for jump was set up and calibrated correctly. The athlete stood upright with hands on hips to prevent arm swing, then performed a rapid downward movement (countermovement) followed by an immediate upward jump. They fully extended their legs during the jump and landed with slightly bent knees to absorb the impact. Three tests were performed, with 45 seconds of passive recovery between attempts, and the best jump from the three was recorded for analysis. The app was used to manually identify the take-off and landing frames. Jump height was then calculated based on flight time using validated biomechanical equations.

Figure 4: Counter movement jump test

Y shaped agility test (reactive agility) [38]

At the sound of the whistle, the participant sprinted 2 meters to the stimulus line, where the tester moved the flag to the right or left. Upon seeing the flag, the participant changed direction and sprinted the remaining 4 meters to the finish line. The tester stopped the stopwatch when the participant crossed the finish line. The test was repeated three times, and the average time was recorded.

Outcome Measures

Counter movement jump test to measure Reactive strength.

Y- agility test to measure Reactive agility.

DATA ANALYSIS

The data on baseline characteristics and outcome measures were carefully elicited and recorded. The data was collected and recorded in MS Excel and analysed by using statistical software SPSS (21.0). The significance will be at 5% level (α=0.05).

The following statistical methods were used:

- The frequency and percentage analysis was used to describe the qualitative background variables.

- The range, mean, standard deviation was used to describe the quantitative background variables and the outcome measures of the groups
- The paired t-test was used to test the significance of pre and post test outcome measures in each group.
- The unpaired t-test was used to test the significance of pre and post test outcome measures in between the groups.
- The unpaired t-test was used to test the equality of mean age of the subjects in between the groups
- The Chi-square test was used to test the homogeneity of gender proportion of subjects between the groups
- The MS word and SPSS graphical editor was used to generate the tables and graphs.

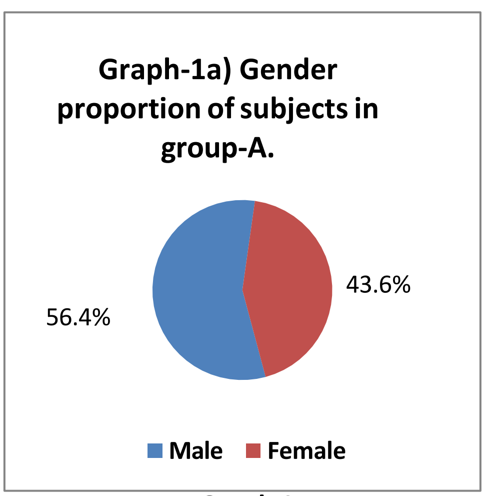
RESULTS

Table-2: Distribution of amateur basketball players according to gender in both the groups

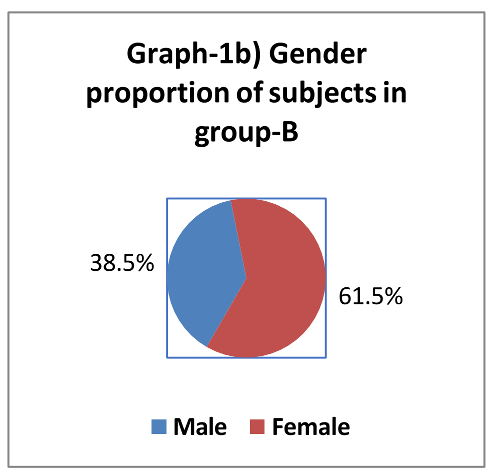
Sl.No.	Background Variable	Group-A	Group-B	Chi-Square value, df & p-value
		No. & (%)	No. & (%)	
1	Gender (m/f)	22(56.4%) / 17(43.6%)	15(38.5%) / 24(61.5%)	2.519 df=1, p>0.05,NS

NS-Not significant. ie., p>0.05.

Table-1 presents the gender distribution of amateur basketball players in two groups. Group-A consisted of 22 males (56.4%) and 17 females (43.6%), while Group-B had 15 males (38.5%) and 24 females (61.5%). A Chi-square test revealed no statistically significant difference in gender distribution between the groups (p > 0.05), indicating that gender was similarly distributed across both groups.



Graph 1



Graph 2

Table-3: Range, mean and SD of quantitative background variables of amateur basketball players in both the groups.

Sl.No.	Variable	Group-A		Group-B		Unpaired t-test
		Range	Mean ± SD	Range	Mean ± SD	
1.	**Age in years**	18-25	21.87±2.17	19-24	21.77±1.81	t=0.226, p>0.05, NS
2.	**BMI**	18.65-24.68	22.31±1.70	18.52-24.88	22.10±1.68	t=0.542, p>0.05, NS
3.	**No. of years playing**	1-9	2.77±1.87	1-5	2.18±1.07	z=1.162, p>0.05, NS

Note; * denotes –Significant (p<0.05), z- Wilcoxon test, t=Unpaired t-test

Table-2 compares the quantitative background variables—age, BMI, and number of playing years of amateur basketball players in Group-A and Group-B. The age range for Group-A was 18–25 years with a mean of 21.87 ± 2.17, and for Group-B, 19–24 years with mean 21.77 ± 1.8. BMI ranged from 18.65–24.68 in Group-A with mean 22.31 ± 1.70 and 18.52–24.88 in Group-B with mean 22.10 ± 1.68. Years of playing experience ranged from 1–9 years in Group-A with mean 2.77 ± 1.87 and 1–5 years in Group-B with mean 2.18 ± 1.07. Statistical tests showed no significant differences between the groups for any of the variables (p > 0.05), indicating the groups were comparable in their background characteristics.

Table-4: Range, mean and SD of outcome measures of amateur basketball players in group-A

Sl.No.	Outcome measures	Group-A				Paired t-test	p-value
		Pre test		Post test			
		Range	Mean ±SD	Range	Mean ±SD		
1	**RAT(sec)**	3.97-5.10	4.54±0.31	3.20-4.68	3.94±0.36	t=11.717*	p<0.001
2	**RSI(m/s)**	0.11-1.12	0.56±0.26	0.25-1.56	0.76±0.32	t=7.98*	p<0.001

Note; * denotes –Significant (p<0.05), t=Paired t-test

Table-3 shows the pre and posttest comparison of outcome measures among amateur basketball players following the exercise protocol in Group A. In Group A, the Pre-test RAT ranged from 3.97-5.10 seconds, with a mean of 4.54±0.31, while the post-test values improved to a range of 3.20-4.68 seconds, with a reduced mean of 3.94±0.36.

Similarly, the reactive strength index (RSI) showed improvement, with pre-test values ranging from 0.11-1.12 m/s and a mean of 0.56 ± 0.26, increasing post-intervention to a range of 0.25-1.56 m/s and a mean of 0.76 ± 0.32. Statistical analysis using the Wilcoxon test revealed significant improvements in both outcome measures after the intervention, (p<0.001) indicating high statistical significance.

Table-5: Range, mean and SD of outcome measures of amateur basketball players in group-B

Sl.No.	Outcome measures	Group-B				Paired t-test	p-value
		Pre test		Post test			
		Range	Mean ±SD	Range	Mean ±SD		
1	**RAT(sec)**	3.90-5.10	4.54±0.30	3.81-4.80	4.32±0.19	t=3.641*	P<0.05
2	**RSI(m/s)**	0.30-0.83	0.51±0.16	0.33-0.86	0.52±0.16	t=5.891*	p<0.001

Note; * denotes –Significant (p<0.05), z- Wilcoxon test , t=Paired t-test

Table-4 shows the pre and posttest comparison of outcome measures among amateur basketball players following the exercise protocol in Group B. The pre-test RAT ranged from 3.90-5.10seconds, with a mean of 4.54±0.30, while the post-test scores ranged from 3.81-4.80seconds, with a mean of 4.32±0.19. For RSI, pre-test values ranged from 0.30-0.83 m/s, with a mean of 0.51 ± 0.16, and post-test values ranged from 0.33- 0.86 m/s, with a mean of 0.52 ± 0.16. Statistical analysis using the Wilcoxon test showed that the improvement in RAT was statistically significant (*p* < 0.05), and the RSI demonstrated a statistically significant improvement with (p < 0.001), indicating a significant enhancement in reactive strength and agility following regular strength training.

Table 6: Comparison of pre and posttest outcome measures of Amateur basketball players in between the groups

Sl.No.	Outcome measures	Pre test		Post test	
		Group-A	Group-B	Group-A	Group-B
		Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
1	**RAT(sec)**	4.54±0.31	4.54±0.30	3.94±0.36	4.32±0.19
2	**RSI (m/s)**	0.56±0.26	0.51±0.16	0.76±0.32	0.52±0.16
Between group comparisons: **Unpaired t-test**		• RAT: t=0.004, p>0.05, NS • RSI: t=1.027, p>0.05, NS		• RAT: t=5.713, p<0.001, S • RSI: t=4.047, p<0.05, S	

S-denotes significant (p<0.05); NS – not significant (p>0.05)

Table-5 illustrates the between-group comparison of outcome measures. In the pre-test, Group A had a mean RAT of 5.87 ± 0.80 seconds, and Group B had 4.82 ± 0.79 seconds, while RSI values were 0.56 ± 0.26 m/s in Group A and 0.51 ± 0.16 m/s in Group B. Both the groups were homogenous (p>0.05). In post-test, both groups showed improvements however, Group A demonstrated greater gains. The post-test RAT mean was 5.44 ± 0.82 seconds in Group A compared to 4.78 ± 0.78 seconds in Group B, and RSI increased to 0.76 ± 0.32 m/s in Group A compared to 0.52 ± 0.16 m/s in Group B. The unpaired t-test revealed statistically significant differences in both RAT (p<0.05) and RSI (p<0.05), suggesting that Group A made significantly greater improvements in both reactive agility and reactive strength compared to Group B.

DISCUSSION

The present study included 78 amateur basketball players and aimed to determine the effect of ladder drill training and Nordic hamstring curls on reactive strength and reactive agility. The participants were randomly divided into two groups: Group A (experimental group) received ladder drill training and Nordic hamstring curls, while Group B (control group) received conventional strength training. The outcomes were assessed using the Y-shaped Agility Test for reactive agility and the Countermovement Jump test for reactive strength, measured through the Reactive Strength Index Modified (RSImod).

In the present study, the analysis of baseline characteristics as shown in table-1 and table-2 revealed no statistically significant differences between Group A and Group B in terms of gender distribution (p > 0.05), age (p > 0.05), BMI (p > 0.05), or playing experience (p > 0.05), indicating that the groups were demographically comparable. This homogeneity is crucial in experimental research, as it reduces the risk of confounding variables influencing the outcomes, particularly when assessing performance-based measures like reactive strength and agility. According to a study by Suchomel et al., and Beattie et al., gender-related physiological differences, such as muscle mass and neuromuscular efficiency, can affect performance.[13,15] A study by Negra et al. further emphasizes that balanced gender representation enhances the validity of training outcome evaluations by minimizing physiological bias.[43]

The age group was appropriately chosen, as prior studies done by Bin Shamshuddin et al., and Sankar and Thanalakshmi have shown that young adult athletes respond optimally to neuromuscular training interventions such as plyometric and agility-based exercises.[44] Similarly, BMI influences biomechanical efficiency during explosive movements as seen in a study done by Aksović et al., and training experience affects responsiveness to sport-specific interventions as demonstrated by Lockie et al., and Horníková & Zemková .[34,37] Thus, the lack of significant differences across these variables strengthens the internal validity of the study and supports the attribution of post-intervention outcomes to the training protocols rather than pre-existing group differences.

The within-group analysis of Group A, as presented in Table 3, revealed a statistically significant improvement in reactive agility following six weeks of combined ladder drill training and Nordic hamstring curls (p < 0.001). The mean reactive agility time (RAT) decreased from 4.54±0.31seconds to 3.94±0.36 seconds, indicating an enhancement in neuromuscular efficiency and agility performance. These findings are consistent with previous studies by Wahyono et al., and Pradana et al., where ladder drills have been shown to improve agility by enhancing foot speed, proprioception, and lower limb coordination. Additionally, the study done by Potosí-Moya et al., and Siddle et al., showed that the inclusion of Nordic hamstring curls, which target eccentric strength, likely contributed to better control during rapid deceleration and re-acceleration phases.[10,22,30]

In contrast, Group B, which underwent regular strength training, showed only a marginal but statistically significant change in RAT, from 4.54 ± 0.30 seconds to 4.32 ± 0.10 seconds ($p < 0.05$). Although both groups demonstrated improved post-test scores, the between-group comparison favoured Group A, which exhibited significantly better performance ($p < 0.001$). This supports the superior efficacy of the combined ladder drill and eccentric training intervention in enhancing reactive agility in amateur basketball players, compared to conventional strength training alone.

In the present study, participants in the experimental group who engaged in ladder drills demonstrated notable gains in reactive agility. This improvement suggests that structured footwork drills can facilitate neuroplastic adaptations, optimizing motor patterns and accelerating muscle response times essential for rapid, unpredictable changes in direction. Ladder drills, by targeting proprioceptive feedback and dynamic stability, enhance an athlete's ability to react swiftly and maintain control when navigating complex, multi-planar movements under varying external pressures.

Similarly, the analysis of reactive strength, as measured by the Reactive Strength Index, revealed significant improvements in Group A following six weeks of ladder drill and Nordic hamstring curl training. The mean RSI increased from 0.56 ± 0.26 m/s to 0.76 ± 0.32 m/s ($p < 0.001$), indicating a statistically significant enhancement in explosive reactive capacity. In contrast, Group B, which received conventional strength training, exhibited only a minimal improvement in RSI—from 0.51 ± 0.16 m/s to 0.52 ± 0.16 m/s ($p < 0.001$). Although the change in Group B reached statistical significance, the magnitude of improvement was notably smaller. Furthermore, the between-group post-test comparison demonstrated a significant difference in favor of Group A ($p < 0.05$), confirming the superiority of the ladder drill and eccentric hamstring training protocol in enhancing reactive strength.

The results of the present study demonstrate that ladder drill training combined with Nordic Hamstring Curls significantly improves both reactive agility and reactive strength in amateur basketball players. These findings align with those of Michael Vogt et al., who highlighted that plyometric and eccentric-based training enhances neuromuscular efficiency, optimizes stretch-shortening cycle (SSC) function, and improves directional responsiveness—key elements for athletic success in dynamic sports settings.[27]

This is consistent with findings from Potosí-Moya et al., who reported that NHCs effectively enhance explosive and absolute strength, particularly in sports reliant on lower limb force production, such as basketball and athletics. As an eccentric exercise, the NHC targets hamstrings during lengthening contractions, improving their ability to absorb high-force loads, enhance deceleration control, increase take-off power, and delay fatigue during high-intensity actions—all of which are critical for elevating RSI values.[10]

Vogt and Hoppeler further support this by noting that eccentric training improves muscle-tendon stiffness, neuromuscular coordination, and force production at extended muscle lengths, which collectively enhance SSC efficiency. In basketball, where rapid transitions between absorbing and generating force are routine, such adaptations contribute directly to improved jumping ability, first-step speed, and reactive movement performance.

Therefore, the gains in RSImod observed in this study reflect the physiological adaptations induced by eccentric loading. Athletes who effectively utilize stored elastic energy and rapidly transition from stretch to contraction exhibit superior explosiveness, agility, and injury resilience. These findings are also in agreement with Beattie et al., who demonstrated a strong correlation between maximal strength and reactive strength, showing that well-developed eccentric and concentric capacities enable athletes to produce higher force outputs more rapidly, thereby enhancing both vertical and lateral movement performance, which are essential in basketball. [13]

Based on these findings, it is recommended that sports conditioning programs for basketball players integrate eccentric hamstring exercises and agility ladder drills to improve neuromuscular coordination, reactive strength, and quick directional shifts. The incorporation of ladder drills and eccentric overload (Nordic curls) offers a dual stimulus to enhance the lower body's force absorption and redirection capabilities.

Limitations

1. The study focused on short-term effects and did not assess the long-term retention of improvements in reactive strength and agility.
2. Factors such as diet, hydration, sleep patterns and academic stress were not controlled, which may have affected the performance outcomes.

Future Recommendations

1. Future studies could extend the training duration to evaluate the long-term effects and retention of the ladder drill and nordic hamstring curl on reactive strength and agility.
2. Future research could explore the effects of these training interventions across different age groups and skill levels, from youth players to professionals, to assess their broader applicability.
3. Future studies could investigate the effects of cross-training, combining aerobic conditioning with strength or agility training, on overall athletic performance.

CONCLUSION

In conclusion, Ladder Drill training and Nordic Hamstring Curls significantly enhance reactive strength and reactive agility in amateur basketball players. Ladder Drills improve coordination and directional changes, while Nordic Hamstring Curls boost hamstring strength and deceleration control, aiding performance and injury prevention. Their combined use offers a comprehensive strategy for athletic development.

Therefore, the integration of Ladder Drill training and Nordic Hamstring Curls is recommended as an effective strategy to improve reactive strength and agility among amateur basketball players. These findings support the alternate hypothesis that states that there is a significant effect of ladder drill training and Nordic hamstring curls on reactive strength and reactive agility. Further research is warranted to investigate their long-term efficacy and comparative effectiveness with other training interventions.

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