Effects of Plyometrics and Pilates Training on Physical Fitness Skills of Male Karate Athletes

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Abstract

Background: *There has been an increase in the participation in Karate in the past decades and now it is practiced and played across the worldwide. The success of the karate player mainly depends on the physical fitness qualities like agility, power and speed. Improvement in these physical variables depends upon the type of exercise training used by the athletes. In the Indian context there is lack of literature that supporting the use of Pilates and Plyometric training programme in training of Karate players. Therefore, to achieve success in the sport best training method should be chosen by athletes or coaches.*

Purpose: *To compare the effectiveness of two training programs Pilates and Plyometric on sports specific physical skills of aspiring National level male Karate players.*

Materials and Methods: *The design of this study was experimental and sampling technique was simple random sampling. This study is conducted on a sample size of 40 in each group Experimental group A (Plyometrics, N=40), Experimental group B (Pilates, N=40) and Control group C (N= 40). The national level male karate players (age 18 to 24 Years) with playing experience of 5 years were included. Recreational players, players with recent injury in past 6 months, any musculoskeletal and neurological problem, player addicted to any drug or alcohol were excluded. The plyometric and pilates training were carried out in experimental groups for three days per week for 8 weeks and no training method implemented in the control group. Three reading were recorded, at the baseline, at the 4th week and at the 8th week. Agility, power and speed were the outcome measurements. All analysis was done using the SPSS*

version 2.0. Descriptive statistics were reported as mean, Standard Deviation (SD) and ANOVA were calculated. The significance level was set at p< 0.05.

Results: *When the pre and post test values of the experimental groups have been compared at the 4th week and 8th week of the study, the significant improvement (p< 0.005) was found in the agility, power and 40 yard sprint test of the plyometric group (group A). Both the training methods have showed improvements in the physical fitness skills.*

Conclusion: *The findings of the present study revealed that plyometrics and pilates both can improve physical fitness skills of karate players but the plyometric training method had more positive and better effects on agility, power and speed on karate athletes than pilates group in the view of sports performance.*

Keywords: *karate, plyometrics, pilates, martial arts, agility, power, speed*

Introduction

Karate is a type of combat sport and now it is one of the most widely practiced system of Japanese martial arts in the world [1]. The literal meaning of karate is “empty hands” that means freedom to use hands without using weapons against an opponent [2]. It is a competitive sport in which two competitors use multiple reactions and methods of defense and attack as well as the foot work and require fast performance for relatively a long period of time, which requires high level of functional efficiency of the player and reflecting his ability to continue in the performance [3]. Karate fight requires agility, muscle strength, power, speed, flexibility, coordination and balance [4-6]. Training of Karate had significant impact on agility, coordination and core-strength which are major determinants of fighting efficiency in Karate [7]. Speed and force were significantly increased following Karate training to improve the fighting efficiency [7,8]. The one of the most important element for sustained high performance of these athletes is an effective strength and conditioning program to develop overall fitness [9]. The main benefits of strength and conditioning program are the decrease in injuries occurrence and improvement in performance [10].

There have been a lot of studies which have usually focused on methods of pilates and its effect on coordination motor skills such as strength, agility, flexibility and endurance [11-13]. Pilates exercise works on the principle of trunk stability which is also known as “core stability”. The “Core” is a box which consists of following muscles: abdominals (transversus) in front, paraspinals (multifidus) in back, diaphragm in top and pelvic floor at the botto [14]. Pilates is a set of exercises defined to build muscular power, flexibility, muscular endurance and achieving the whole body balance through motor performance with suitable breathing to re improve the relation between mind and body. Pilates training strengthens the

deep core muscles and improves movement, efficiency and muscle control [15]. Plyometrics, also known as “jump training” exercises based around having muscles exert maximum force in at a time as possible, with the goal of increasing both speed and power. This training focuses on learning to move from a muscle extension to a contraction in a explosive way, for example , repeated jumping. Plyometrics are primarily used by athletes to improve performance and are used in the fitness field to a much lesser degree [16]. Several studies have established a positive relationship between muscle power and sprinting abilities [17-22]. Speed, power, and balance are the highly related to each other and suggested to be important predictors of agility [23]. Specific training programs can increase the force of a muscle or groups of muscle as force is a component of power, it directly increases power, which is evident in numerous studies [24-26].

So in summary, a well designed strength and conditioning program can assist participants in karate by increasing performance and decreasing potential rates of injury. An athlete requires an effective strength and conditioning program which would allow him or her to practice longer and harder by creating more power and strength that will allow a better performance and generate more powerful punch, kick, a stronger clinch and defence techniques [10,27]. Keeping in account the importance given to the karate in recent years in India, it is necessary to study the effective training protocols in this sport. Very little work has been done in the field of physical fitness pertaining to karate.

Aim

To evaluate the effectiveness of two training programs Pilates and Plyometric on sports specific physical skills in male National level Karate players.

Materials and Methods

This is an experimental design which conducted on120 karate players of NCR region. The Research Proposal of the study was approved by Institutional Clinical Ethical Committee (I.C.E.C.) of SGT University, Gurugram. Players were divided into 3 groups (Plyometric group, Pilates group and control group) 40 in each group. It included male players with age 18 to 24 years (21.00 ± 1.77) with experience of playing past 5 years. Recreational Karate players and players with recent injury in the previous 6 month have been excluded.

Outcome measures were agility, power and speed. Agility T test for agility, sargent jump test for power and 40m sprint test for speed were conducted. Group A underwent plyometric training programme, Group B underwent Pilates training programme and Group C acted as control. The training program was limited to three days per week for 8 weeks. The dependent variables selected for the study were as follows:

agility, power and speed. All the subjects were tested prior to and after 4th and 8th week of the experimental period on the selected dependent variables.

Training Programs

The detailed training protocols [28,29] are explained in (Table 1) and (Table 2). The control group (group C) was asked to do their conventional training for 60 min and routine exercises including warm up for 10 min and cool down for 5 min.

Weeks	Plyometric Training Program	Sets	Reps
1.	Side to side ankle hops Standing jump and reach Front cone hops	15 15 6	2 2 5
2.	Side to side ankle hops Standing long jump Lateral jump over barrier Double leg hops	15 6 15 6	2 5 2 5
3.	Side to side ankle hops Standing long jump Lateral jump over barrier Double leg hops Lateral cone hops	12 6 12 8 12	2 4 2 3 2
4.	Diagonal cone hops Standing long jump with lateral sprint Lateral cone hops Single leg bounding Lateral jump single leg	8 8 12 7 6	4 4 2 4 4
5.	Diagonal cone hops Standing long jump with lateral sprint Lateral cone hops Cone hops with 180 degree turn Single leg bounding Lateral jump single leg	7 7 7 7 7 7	2 4 4 4 4 2
6.	Diagonal cone hops Hexagon drill Cone hops with change of direction sprint Double leg hops Lateral jump single leg	8 8 12 7 6	4 4 2 4 4
7.	Diagonal cone hops Standing long jump with lateral sprint Cone hops with 180 degree turn Single leg bounding Lateral jump single leg	7 7 7 7 7	2 4 4 4 4

8.	Side to side ankle hops Standing long jump Lateral jump over barrier Double leg hops Lateral cone hops	12 6 12 8 12	2 4 2 3 2

[Table-1]: Eight Week Plyometric Training Program (Group A)

Weeks	Exercises	Repetitions
1	Hundreds	5
2	One leg stretch 1, Double leg stretch 1/2, Clam	6
3	One leg stretch 2 Shoulder bridge 2	7
4	Shoulder bridge 2 Hip twist	7
5	Scissors 1, One leg kick	8
6	Scissors 2, Side kick 1	10
7	Side kick 2, One leg circle ½	10
8	Side kick 2, One leg circle ½	10

[Table- 2]: Eight Week Pilates Training Program (Group B)

Description outcome measures

1. **Agility**

Agility will be measured by the agility T – tests. It will be measured at Base line, 4th week and at the end of 8th week. The T- test course consists of 10m straight sections forming the shape of letter T. It includes a forward sprint (10m), side shuffle to left (5m), side shuffle to right (10m), side shuffle to left (5m), and back peddled 10m back to the stat. The same equipment as in the previous test was used for measuring the test time. Pauole et al. (2000) reported a high intra-trail reliability of the test (ICC=0.98) [30].

2. **Power**

Power will be measured by Sargent Test [31]. It will be measured at Base line, 4th week and at the end of 8th week. A Vertical Jump test is a very common test for measuring explosive leg power. The subject stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach height. The

athlete then stands away from the wall, and leaps vertically as high as possible using both arms and legs to assist in projecting the body upwards. The jumping technique can or cannot use a countermovement. Attempt to touch the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height is the score. The best of three attempts will be recorded.

3. Speed

Speed will be measured by 40-Yd Sprint Test [32]. It will be measured at Base line, 4th week and at end of 8th week. The aim of this test will be determine 40-Yd Sprint. Sprints of 40 yd were used to determine quickness. A distance of 40 yd was measured with a marker at the halfway point (20 yd). Individuals started in a three-point stance with their fingers on a touch-and-release starter for the electronic timer. As soon as the athlete released pressure from the touch pad, the timer began. A speed trap II electronic timer was used to measure time for the 40-yd sprint. Individuals were only allowed one attempt unless the previous attempt was not performed properly. In that case, 3–5 minutes of rest was allowed between attempts.

Statistical Analysis

All analysis was done using the SPSS version 2.0. The normality distribution of all variables was verified by using Shapiro–Wilk test or Kolmogorov-Smirnov test.. Variables that were found to be non normal distribution were log transformed for further analysis. Repeated measures ANOVA (Analysis of Variance) was used for time and frequency domain measures to find out the main effect (time effect and group effect) and time ×group interaction followed by the post hoc analysis. All data are presented as mean ±SD. The significance level was set at $p< 0.05$.

Results

Table 3 showed the comparison of demographics (age, height, weight and BMI) of plyometric, pilates and control group. All groups were similar at the beginning (before) of the study.

Table 3.Comparison of demographic variables between the groups at baseline.

Variables	Plyometric	Pilates	Control	F -value	p-value
Age	21.10 ± 1.48	21.00 ± 1.77	21.10 ± 1.87	0.05	0.96
Height	174.23 ± 3.21	174.50 ± 3.42	174.50 ± 3.84	0.08	0.92
Weight	65.2 ± 3.49	65.25 ± 3.06	65.85 ± 3.80	0.33	0.72
BMI	21.65 ± .80	21.43 ± .83	21.61 ± .78	0.83	0.44

Table 4 showed the outcome variables of plyometric group and pilates group and control group on selected physical variables such as agility, power, speed were analyzed at the baseline and the details of

analysis of each variable is shown in the table. Table 4 shows the baseline Mean and Standard deviation (SD) of agility T test values of Plyometric Training group (group A),Pilates training group (group B) and control group (group C) are 9.94±0.08, 9.94 ± 0.07and 9.94 ± 0.07respectively. The Mean and SD at the 4^{th} week are 9.71 ± 0.07, 9.79± 0.06 and 9.93 ±0.06respectively and at the 8^{th} week are 9.53 ± 0.05, 9.64 ± 0.06and 9.90 ± 0.18respectively.

The baseline mean and standard deviation (SD) of power Sargent test values of Plyometric Training group (group A),pilates training group (group B) and control group (group C) are 60.62±3.17, 60.27±2.61 and 60.77±2.85 respectively. The mean and SD at the 4^{th} week are 65.78±2.75, 63.87±2.88 and 61.28±2.86 respectively and at the 8^{th} week are 71.34±2.38, 68.06±3.10 and 61.79±2.61 respectively. The mean and standard deviation (SD) of 40 m sprint test of Plyometric Training group (group A), pilates training group (group B) and control group (group C) are 5.77±0.18, 5.78±0.11 and 5.78±0.17 respectively. The mean and SD of the Plyometric, Pilates and Control group at the 4^{th} week are 5.39±0.22, 5.60±0.11 and 5.77±0.17 respectively and at the 8^{th} week are 4.97±0.16, 5.28±0.22 and 5.77±0.17 respectively.

The p- value of agility T test, Sargent jump test and 40 yard sprint test of Plyometrics, Pilates and Control group at baseline, at the 4^{th} week and at the 8^{th} week was<0.0001. The results of the present study showed that there was a significant difference between Plyometric Training group and Pilates Training group, Plyometric Training group and Control group, Pilates Training group and Control group. It was found that Plyometrics Training group (Group A) had shown better performance than Pilates Training group and Control in physical skill tests.

Table 4: Comparison of mean of Agility, Power, Speed of experimental and control group

Outcome variables	Plyometric Group A Mean ±SD	Pilates Group B Mean ±SD	Control Group C Mean ±SD	Group effect (p- value)	Time effect (p- value)	G×T interaction (p- value)
Agility (T-Test) sec Baseline 4th week 8th week	 9.94 ± 0.08 9.71 ± 0.07 9.53 ± 0.05	 9.94 ± 0.07 9.79± 0.06 9.64 ± 0.06	 9.94 ± 0.07 9.93 ±0.06 9.90 ± 0.18	<0.0001**	<0.0001**	<0.0001**
Power (Sargent Test) cm Baseline 4th week 8th week	 60.62 ± 3.17 65.78 ± 2.75 71.34 ± 2.38	 60.27 ± 2.61 63.87 ± 2.88 68.06 ± 3.10	 60.77 ± 2.85 61.28 ± 2.86 61.79 ± 2.61	<0.0001**	<0.0001**	<0.0001**
Speed (40yard Sprint) sec Baseline 4th week 8th week	 5.77 ± 0.18 5.39 ± 0.22 4.97 ± 0.16	 5.78 ± 0.11 5.60 ± 0.11 5.28 ± 0.22	 5.78 ± 0.17 5.77 ± 0.17 5.77 ± 0.17	<0.0001**	<0.0001**	<0.0001**

*= significant, **= Highly Significant, mSEBT= modified Star Excursion Balance Test

The Mean values Baseline, 4th week and 8th week of Plyometric Training group, Pilates Training group and Control group on agility T test are graphically represented in the Figure 1.1. The Mean values Baseline, 4th week and 8th week of Plyometric Training group, Pilates Training group and Control group on power (Sargent jump test) are graphically represented in the Figure 1.2. The Mean values Baseline, 4th week and 8th week of Plyometric Training group, Pilates Training group and Control group on 40 m speed test are graphically represented in the Figure 1.3.

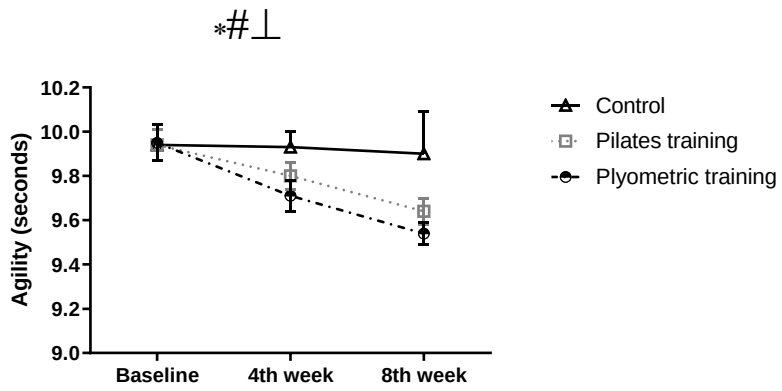

Fig-1.1: Agility T Test

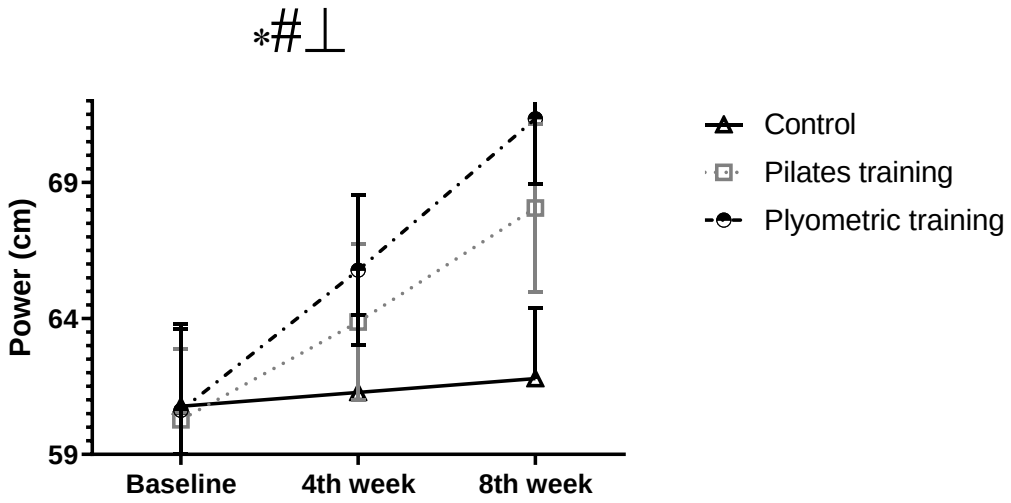

Fig-1.2: Sargent Jump Test

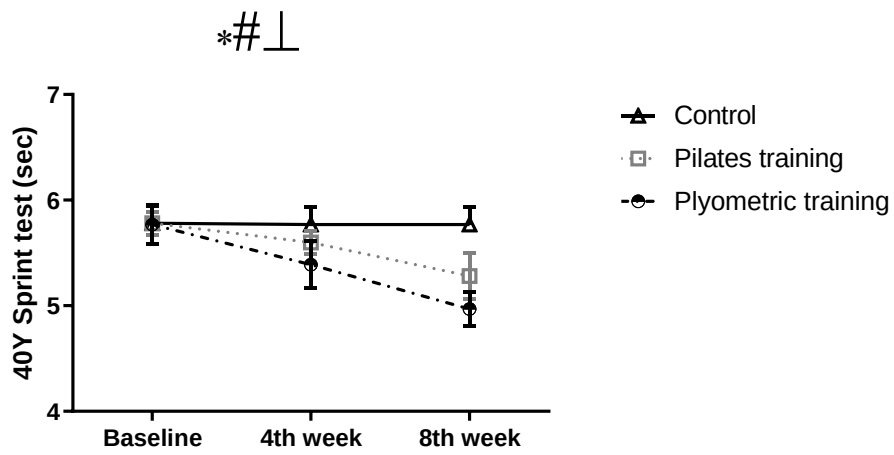

Fig-1.3: 40 Yard Sprint (speed) Test

Table 5 represents inter group comparison by post hoc analysis ($p<0.005$) of all the variables of groups A verses B, B verses and C verses A. Significant differences were observed between training groups i.e. Agility T test, Sargent test and 40 yard sprint test.

Table 5: Intergroup comparison of dependent variables

Variables	Group	Mean Difference	Std. Error	p-value
Agility (T-Test) sec	Group A Vs Group B	-.006	.002	.001***
	Group B Vs Group C	-.013	.002	.001***
	Group C Vs Group A	.020	.002	.001***
Power (Sargent Test) cm	Group A Vs Group B	.027	.010	.015**
	Group B Vs Group C	.043	.010	.001***
	Group C Vs Group A	-.071	.010	.001***
Speed (40yard Sprint) sec	Group A Vs Group B	-.034	.007	.001***
	Group B Vs Group C	-.039	.007	.001***
	Group C Vs Group A	.073	.007	.001***

Table 6, 7 and 8 showed pair wise comparison of all variables of agility T test, Sargent test and 40 yard sprint test.

Table 6: Pair wise comparison of variables of Group A (Plyometric Group)

Outcome variables	Duration	Mean Difference	SEM	p- Value
Agility (T-Test) sec	Baseline Vs 4th week	.024	.001	.001***
	4th week Vs 8th week	.018	.001	.001***
	8th week Vs Baseline	-.042	.001	.001***
Power (Sargent Test) cm	Baseline Vs 4th week	-.082	.003	.001***
	4th week Vs 8th week	-.081	.003	.001***
	8th week Vs Baseline	.164	.005	.001***
Speed (40yard Sprint) sec	Baseline Vs 4th week	.067	.003	.001***
	4th week Vs 8th week	.080	.004	.001***
	8th week Vs Baseline	-.148	.004	.001***

Table 7: Pairwise comparison of outcomevariables for Group B (Pilates Group)

Outcome variables	Duration	Mean Difference	SEM	p- Value
Agility (T-Test) sec	Baseline Vs 4th week	.015	.001	.001***
	4th week Vs 8th week	.016	.001	.001***
	8th week Vs Baseline	-.031	.001	.001***
Power (Sargent Test) cm	Baseline Vs 4th week	-.058	.002	.001***
	4th week Vs 8th week	-.064	.004	.001***
	8th week Vs Baseline	.122	.005	.001***
Speed (40yard Sprint) sec	Baseline Vs 4th week	.032	.003	.001***
	4th week Vs 8th week	.059	.006	.001***
	8th week Vs Baseline	-.092	.007	.001***

Table 8: Pair wise comparison of outcome variables for Group C (Control Group)

Outcome variables	Duration	Mean Difference	SEM	p- Value
Agility (T-Test) sec	Baseline Vs 4th week	.001	.000	.001***
	4th week Vs 8th week	.003	.003	.921*
	8th week Vs Baseline	-.004	.003	.474*
Power (Sargent Test) cm	Baseline Vs 4th week	-.008	.002	.001***
	4th week Vs 8th week	-.008	.002	.001***
	8th week Vs Baseline	.017	.003	.001***
Speed (40yard Sprint) sec	Baseline Vs 4th week	.002	.000	.001***
	4th week Vs 8th week	-.001	.001	.273*
	8th week Vs Baseline	-.001	.000	.025**

*= NOT SIGNIFICANT, **= SIGNIFICANT, ***=HIGHLY SIGNIFICANT

Discussion

The main aim of present study was to compare the effectiveness of pilates and plyometric training on sports specific skills of karate athletes. The present study showed the significant differences in the experimental group and little or no effect in control group in the agility component of karate athletes. It was found that at the end of 4th week of training program, the differences were 2.31% in plyometric training group, 1.50% pilates training group and 0.10% in control group. And at the end of 8th week of intervention the differences were 4.12% in plyometric training group, 3.01% pilates training group and 0.40% in control group. These findings are supported by Miller et al. (2006) who evaluated the effect of six week of plyometric on agility of sportspersons [33]. A significant group effect and p value=0.0000 was observed for the agility T test in their study. The results of this study showed that six week plyometric training can be an effective training technique to improve an athlete's agility performance. It may be speculated that in the present investigation plyometric training improved agility due to more motor unit recruitment. It improves reaction times in the agility test measures because of either better motor recruitment or neural adaptations [34]. Moreover, significant improvement in the agility was also reported by Davaran et al. (2014) post 6 weeks of plyometric training [35]. The previous studies that reported positive effects of land plyometric training on agility performance [36,37].

In case of vertical jump, we observed significant improvement found in Plyometric training group in present study. It was found that at the end of 4th week of training program, the differences were 8.51% in plyometric training group, 5.97% pilates training group and 0.83% in control group. And at the end of 8th week of intervention the differences were 17.68% in plyometric training group, 12.92% pilates training group and 1.67% in control group. It was found that Plyometrics Training group (Group A) had shown better performance than Pilates Training group and Control in Sargent jump test. The results of present study are consistent with a previous study of Singh et al. (2015) which found that 6 weeks of plyometric

training shows significant improvement ($p<0.01$) in taekwondo players [38]. Similarly, Aminaei et al. (2017) investigated the effects of plyometric and cluster resistance training on explosive power and maximum strength in karate players and showed that the exercise of strength and power stages have significant effect on the explosive power ($p=0.00$) karate players [39]. El-Sayed et al. (2010) investigated the effects of pilates exercises on muscular ability and jumping in athletes and observed significant improvements in vertical jump with young volleyball players [40]. In contrast to this, Da Cruz et al. (2014) found that 6 weeks of Pilates training were not sufficient to cause significant changes in physical fitness and body composition in young basketball athletes. Thus, the study has suggested that a longer training period (>6 weeks) is necessary to detect physical fitness changes in athletes [41].

Our study found that at the end of 4^{th} week of training program, the differences were 6.58% in plyometric training group, 0.29% pilates training group and 0.17% in control group. And at the end of 8^{th} week of intervention the differences were 13.86% in plyometric training group, 8.65% pilates training group and 0.17% in control group. It was found that Plyometrics Training group (Group A) had shown better performance than Pilates Training group and Control in 40m speed test. A previous study by Renfro et al. (1999) outlined of the summer conditioning program for athletes. In that study, coaches observed that 8 week plyometric training improved speed (40 m speed test) and agility of athletes [42]. Similarly, Rimmer and Sleivert (2000) investigated the effects of 8 weeks sprint specific plyometric training in rugby players and found improvement in 40m sprint performance of athletes [43]. It was found in the evidences [44,45] that competitive karate athletes showed that elite karate practitioners differ from junior level karate athletes (national level) in terms of explosive lower extremity power and maximum speed [45]. Explosive speed is required in many sports and physical activities; coaches and athletes should therefore consider a plyometrics training program for improvement in sports specific performance.

Limitations

The study was conducted on male players only. Therefore, the gender specific differences were not studied. The shorter duration of pilates and plyometric training may not be sufficient to achieve physical fitness for longer duration.

Conclusion

In modern age, athletes are trained scientifically to improve their sports performance. Based on findings of the present study it can be concluded that the Indian karate players were showed significant improvement in dynamic balance and core strength after 8 weeks of plyometric training which was very encouraging and demonstrated the better response on performance. Therefore, to improve these sports specific skills, a systematic training program is required to improve specific performance abilities. It is

recommended that coaches and trainers should incorporate this training protocol with conventional training to improve sports performance of karate athletes.

Further recommendations

- Further studies should extend these observations in other combat sports also with different intensities; volumes and methods of Pilates and plyometric training are needed to better understand the effectiveness of these training methods on the sports performance.
- Further researches are needed to provide more evidence about the most important training methods and factors which are responsible for improvement of sports performance of athletes.
- Furthermore the effects of plyometric training on cardiopulmonary fitness of karate athletes can be studied.

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Conflict of interest

None

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