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Efficacy of 6 Weeks Pilates Training on Physical Parameters and Sports-Specific Skills of Volleyball Players: A Randomized Controlled Trial

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Abstract: *Volleyball is a game of high aerobic capacity, power, speed, agility, strength, flexibility, and jumping. Pilates exercise helps in improving muscle strength and flexibility thus providing a player with skills of jumping, high aerobic capacity, and better offense and defense capabilities. The study aimed to evaluate the effect of Pilates exercises on various fitness parameters and volleyball sports-specific skills in volleyball players. University-level male volleyball players (n=30) aging between 18-25 years were included and randomly allocated into two groups i.e. control group (n=15) who performed only regular volleyball training, and the experimental group (n=15) who were given Pilates training in addition to their regular volleyball training 3 times per week for 6 weeks. The outcome measures: balance, upper and lower abdominal strength, agility, explosive power, and volleyball-specific skill tests, assessed at baseline and post-intervention. The results showed significant improvement within the control group for balance (In posterior reach and medial reach) and volleyball-specific skills (Brady's test), but other parameters did not revealed any statistical significance difference. Whereas, in the experimental group, significant improvement was found for all tested parameters except balance in lateral, anterior, posterior, anterolateral, anteromedial, and posterolateral directions. Also, there existed a statistically significant difference between both the groups for all tested parameters ($p \leq 0.05$). The study concluded that Pilates training helps in improving physical parameters such as agility, explosive power, balance, upper and lower abdominal strength, and sports-specific skills of volleyball players.*

Keywords: *Mat exercise, agility, balance, strength, explosive power.*

Introduction

Volleyball is considered as the game of high aerobic capacity, power, speed, agility, strength, flexibility and jumping activities like blocking and spiking while maintaining a higher level of performance. Volleyball games have 12 players and can be categorized as setters, hitters, middle blockers and liberos, where all play their significant and specific role (Paz et al., 2017). The players require a variety of dynamic movements and techniques while playing volleyball game. For optimal performance during the game, the players must be in excellent physical and mental condition because volleyball games have no predetermined time limit and, if the teams are evenly matched, might go for many hours (Yapici, 2019). To maintain ball contact from a maximum height during jumping activities, athletes must use the extreme explosive power of legs to jump vertically (Kumar, Goswami & Kumar, 2016). Power is a crucial component in volleyball since it allows players to jump while spiking or blocking throughout the game (Taware, Bhutkar & Surdi, 2013). Furthermore, strength (upper and lower body muscular strength) and speed are also necessary during different sprinting, jumping and high intensity movements which repeatedly occur during the play (Gabbett, Georgieff, Anderson, Cotton, Savovic & Nicholson, 2006), whereas agility is needed during the game in a way like quick and precise change in the movement of the entire body, in response to stimuli or to stop quickly (Sajjan, 2019). Additionally, the ability of the body to accurately land after jumping activity on the playing surface makes balance an important necessary component of this game. The balance control demands the integration of a flexible movement pattern design as well as the integration of sensory input (Genc, 2020). All these physical parameters such as balance, power, strength, agility, and speed contribute to the skillful play of volleyball players. There have been different sports-specific skill tests developed for the volleyball game, such as Brady's volleyball skill test, North Carolina State University volleyball skills test, AAHPER volleyball skill test, SAI volleyball skill test, Russell-

Lange volleyball skill test, and Brumbach volleyball test to evaluate the various skills that are important in volleyball, such as volleying, passing, serving, spiking or killing, and returning over the net. Brady's volleyball skill is designed to evaluate the overall playing ability of volleyball players. The Brady's test is used to measure the real number of volleys in one minute which examines the attacking ability of a player (Kansal, 2021).

Several training protocols have been developed and explored for improvement in physical fitness parameters and game specific skills thereby enhancing the performance in different sports players. The Pilates training is a highly practiced approach among players and other population which enhances the muscle strength and flexibility, thereby improving the physical fitness of sports person and it also alleviates the risk of injury risk (Manshouri, Rahnama & Khorzoghi, 2014; Greco et al., 2019). Pilates is referred to as a modern exercise method with sport specific training (Greco et al., 2019). These exercises can be performed on mat or by using different equipments like spine corrector, wunda chair, trapeze table, cadillac, reform and barrel (Owsley, 2005; Greco, Patti, Cataldi & Lovane, 2019). Pilates works on the six principles which involve concentration, control, centering, precision, proper breathing, and flow. The exercises are meant to increase the strength and flexibility by focusing on repeated movements which further causes coordinated motion in between muscle group and body organs (Panchal, Panchal, Panihar, Joshi & Pawalia, 2022). Pilates consists of various forms of stretching and strengthening exercises (Shah, 2013). It has been found to increase the muscle strength and flexibility thus providing a player with skills of jumping, improvement and enhancement in aerobic capacity, enhanced offense, and defense skills (El-Sayed, Mohammed & Abdullah, 2010). Pilates training have been found to enhance the abdominal muscle strength, neuromuscular coordination, agility, and dynamic balance in badminton players (Yeole, Kad & Singhamoney, 2018). Similarly, in cricket players it improved core muscle strength, agility, power, hamstring muscle flexibility, and speed (Panchal et al., 2022). However, the previous research on volleyball players only evaluated effect of Pilates on hamstring flexibility and serving ability and suggested strong evidence of enhanced flexibility and improved serving ability after Pilates training (Manshouri et al., 2014; Greco et al., 2019). There is paucity of studies on efficacy of Pilates on abdominal strength, agility, power, balance, and volleyball specific skills. Hence, this study aimed to determine its effects on various other physical parameters such as abdominal strength, agility, explosive power, balance, and sports-specific skills in volleyball players.

Methods

Study Design

It was a randomized, parallel group, controlled and single blinded (participants blinded) clinical trial conducted on university level volleyball players at University Sports Complex, Hisar. The ethical approval was obtained from the Departmental Ethical Committee (vide letter no. PTY/2022/155). The study was also registered under Clinical Trial Registry-India (CTRI) with the registration no. CTRI/2022/06/043132. The study was conducted from June 2022 to August 2022.

Participants

The study included total 30 male volleyball players with age group of 18-25 years, those practicing volleyball at least 3 days in a week and experience of no less than two years. The exclusion criteria consisted of any history of neurological, metabolic disease, cardiovascular, and musculoskeletal disorder as well as any existing surgery, players not practicing volleyball, involved in other sports along with volleyball, practicing Pilates presently and who are not willing to participate. Beside this, the players who had a history of drug abuse and alcohol consumption were also excluded.

Procedure

A total of 41 players were screened in accordance with the study's inclusion and exclusion criteria. Out of 41 subjects, only 30 students who satisfied the selection criteria were considered for inclusion in the study (Figure 1). All the included players were given a full explanation of the trial's procedures, and each player gave their informed consent. The players were divided randomly into two groups, i.e. control group (CG) and experimental group (EG) using lottery method with 15 players in each group. The total duration for protocol was six weeks.

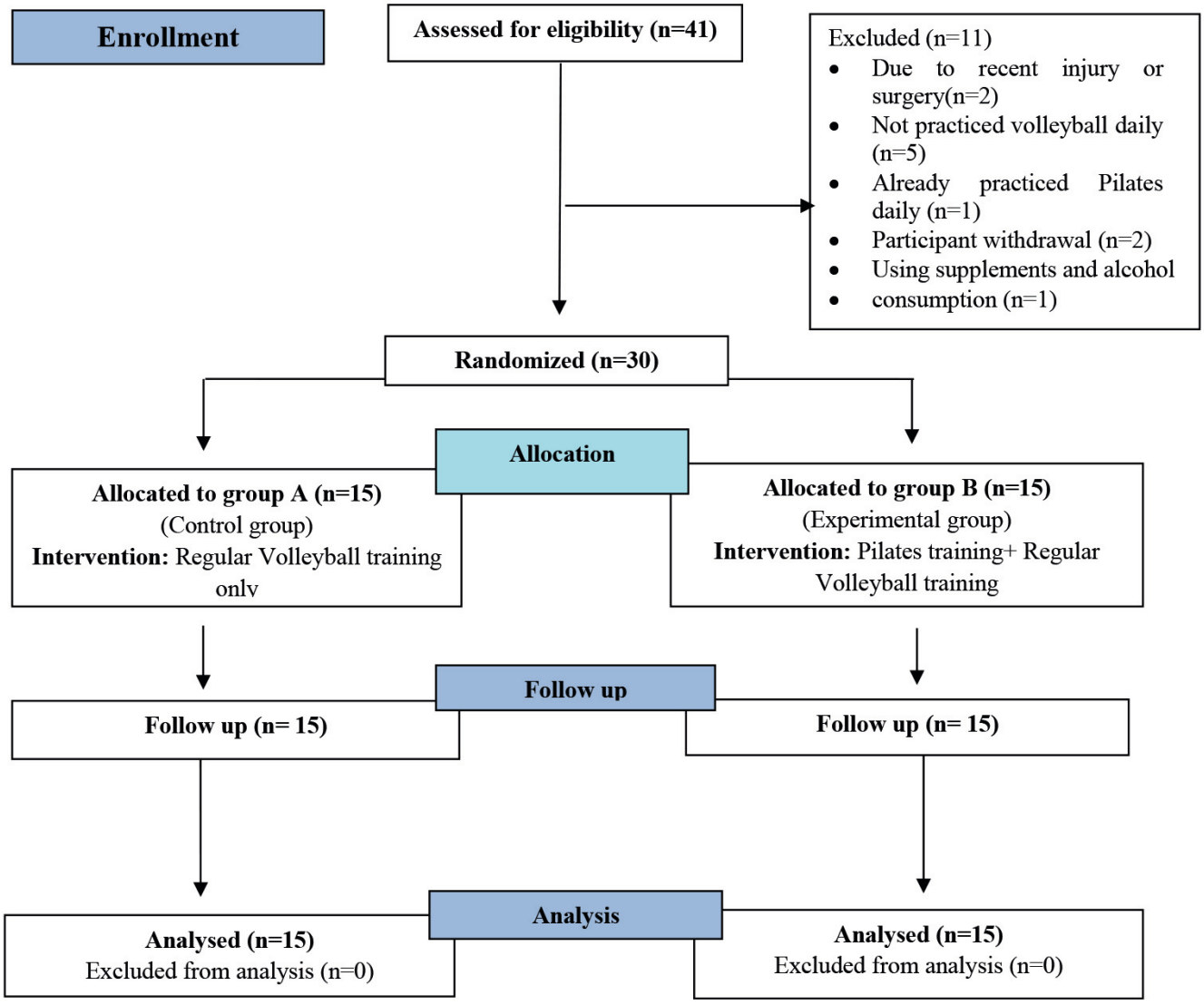

Figure 1: *Consort Flow Diagram.*

Intervention

The participants in the control group (Group-A) followed the standard volleyball training programme, but those in the experimental group (Group-B) also engaged in pilates exercises. Standard volleyball-specific exercises were included in both groups' regular training regimens, which were given to the players by coaches. For a period of six weeks, these were carried out five days a week.

The players in both groups performed regular volleyball training under the supervision of their concerned coaches which included standard volleyball game practice on routine basis such as jogging, running, general stretching exercises and volleyball matches.

Pilates exercises, such as leg circle, scissors, sidekicks, the saw, spine stretch, single leg stretch, heel squeeze, roll over, pushup, side stretch and leg pull fronts exercises (Lindsay, 2001; Segal, Hein & Basford, 2004), were performed by the participants for three days a week for six weeks. The players in the experimental group (Pilates group) completed 10 minutes warm-up before intervention, including breathing exercise, hip rotation, head movement, shoulder stretch, shoulder elevation, thoracic muscle stretch, leg stretching and cat stretch exercises, and cool down for 10 minutes at the end of training session. The protocol for Pilates training was structured in 3 phases, where each phase was followed for 2 weeks. The session length was initially 30 minutes, but by the end of week 6, it had been gradually extended to 45 to 55 minutes.

The Pilates training protocol included several exercises and progression was made from week I to week VI in terms of no. of repetitions and sets (Table 1). In Ist and IInd week, 2 sets of exercises with 10 repetitions were performed

where rest period was provided in between each exercise (i.e. 30 sec) and between the different set of exercises (i.e. 60 sec) from phase I to phase VI during 6-week Pilates training. After the second week of training, the repetitions for each exercise were raised from 10 to 15, and roll-over exercise was added from IIIrd week. After the fourth week, the number of sets was raised to three, with each exercise being performed ten times. Pushups and shoulder bridge exercises were introduced to the training regime early in the fifth week (Manshouri et al., 2014; Greco et al., 2019).

Table 1. *Pilates training protocol during Phase-1 to Phase-3 (Ist to VIth week).*

Exercises	Ist & IInd week	IIIrd & IVth week	Vth & VIth week
Leg circle	2x10	2x15	3x10
Scissors	2x10	2x15	3x10
Sidekicks	2x10	2x15	3x10
The saw	2x10	2x15	3x10
Spine stretch	2x10	2x15	3x10
Single leg stretch	2x10	2x15	3x10
Heel squeeze	2x10	2x15	3x10
Roll over		2x15	3x10
Shoulder bridge			3x10
Push ups			3x10

Outcome measures

Upper and lower abdominal strength, balance, explosive power, agility, and a volleyball-specific skill test are among the outcome variables in the study. Both at the beginning and conclusion of the six-week period, measurements were obtained. When measuring lower abdominal strength, the double leg lowering test (DLLT) was used (Kamatchi, Arun, Tharani, Yuvarani, Vaishnavi & Kaviraja, 2020), whereas the curl-up test was used to assess upper abdominal strength (Ahearn et al., 2018). Star excursion balance test (SEBT) was used to evaluate balance (Bressel, Yonker, Kras & Heath, 2007). The Illinois Agility Test (IAT) was used to measure agility (Kutlu, Yapici & Yilmaz, 2017). Vertical jump height (VJH) was used to determine the explosive power (Dave, Sharma, Patel, Prajapati & Varma, 2019). Brady's volleyball skill test (1945) was used to assess a volleyball-specific skill test. The double leg lowering test and curl up, star excursion balance test, Illinois agility test, vertical jump test and Brady's volleyball skill test, all have been rated as good to excellent on reliability test (ICC= 0.93 to 0.98, 0.995, 0.35 to 0.93, 0.98, 0.995, 0.92) (Plisky, Gorman, Butler, Kiesel, Underwood & Elkins, 2009; Kutlu et al., 2017; Rosell, Marquez, Custodio & Garcia, 2017; Ahearn, Greene & Lasner, 2018; Kansal, 2021; Rathod, Vyas & Sorani, 2021). All participants were given instructions to warm up their body before each test while the outcome measures were being assessed. The players completed three trials for each test, with the best outcome from those three being considered for the analysis.

Statistical analysis

To conduct the statistical analysis for all of the outcome measures, the paired t-test and the independent t-test were used, respectively, for the comparisons within and between groups. The criterion for statistical significance was set at $p \leq 0.05$.

Results

The characteristics of all the players such as age (years), weight (kg), height (cm), and body mass index (kg/m^2) and all outcome variable before intervention were recorded and checked for any statistical significance to look for baseline similarity between the groups. The results indicated that there was baseline similarity among the participants for majority of outcome variable except SEBT in anterior direction (Table 2).

Table 2. *Comparison of control group and experimental group before intervention.*

Characteristics	Control group (CG)	Experimental group (EG)	t-value	p-value
	Mean±SD	Mean±SD		
Age (years)	19.67±1.11	20.33±1.63	-1.3	0.202
Weight (kgs)	57.53±6.59	69.20±11.43	-0.91	0.002
Height (cm)	169.0±6.59	171.27±6.98	-3.42	0.368
BMI (kg/m^2)	20.10±1.72	23.51±3.09	-3.72	0.001
Hours of training (hours)	2.37±.87	2.40±.60	-0.12	0.904
Practicing year (years)	2.30±.92	2.63±.81	-1.05	0.302
Curl up (counts)	4.33±.97	4.40±.73	-0.21	0.83
DLLT (degree)	21.00±26.26	21.33±18.56	-0.04	0.96
Illinois agility test (sec)	14.87±.83	14.80±1.20	0.17	0.86
Vertical jump test (cm)	40.40±5.39	49.27±9.41	-3.16	0.04
Brady's test (numbers)	9.00±2.13	8.80±1.61	0.28	0.77
SEBT Anterior (cm)	73.53±5.93	83.60±7.45	-4.09	0.000
SEBT Posterior (cm)	77.07±5.21	82.00±9.04	-1.83	0.078
SEBT Medial (cm)	76.60±5.86	79.27±9.26	-0.94	0.35
SEBT lateral (cm)	77.53±6.30	82.47±10.676	-.1.54	0.13
SEBT Anteromedial (cm)	77.73±7.77	75.07±7.713	-0.94	0.35
SEBT Anterolateral (cm)	79.13±5.48	81.27±5.470	-1.06	0.29
SEBT Posteromedial (cm)	79.33±6.44	83.47±11.03	-1.25	0.22
SEBT Posterolateral (cm)	81.93±7.73	83.27±10.59	-0.39	0.69

DLLT- Double leg lowering test, SEBT- star excursion balance test. The critical value of t test was 2.048. The results were statistically significant at $p<0.05$ and non-significant at $p>0.05$.

The findings for the volleyball skill test (Brady's test) and SEBT (in posterior reach, medial reach, and lateral reach) in the control group showed statistically significant improvement. However, Curl up (p=0.164), DLLT (p=0.082), VJT (p=0.499), IAT (p=0.433), and SEBT in other directions (anterior (p=0.486), antero-lateral (p=0.546), antero-medial (p=0.189), and postero-lateral (p=0.334)) did not demonstrate any statistically significant change (p>0.05) after a period of 6 weeks from baseline. Brady's test, the DLLT, the VJT, the IAT, and the SEBT (in the medial, posterior-medial direction) all showed statistically significant improvements in the Pilates group, but SEBT in the anterior (p=0.228), posterior (p=0.094), lateral (p=0.878), anterolateral (p=0.076), anteromedial (p=0.232), and posterolateral (p=0.641) directions did not. These results signify that all outcome variables considerably improved in the experimental group but failed to do the same in the control group.

However, after completion of training i.e. after six weeks, comparisons across groups showed significant differences in all of the tested parameters, including upper (Curl up, p=0.043*) and lower (DLLT, p=0.01*) abdominal strength, lower limb explosive power (VJT, p=0.000*), agility (IAT, p=0.000*), volleyball-specific-skill test (Brady's test, p=0.000*) , and balance i.e. SEBT in all directions (Table 3). These results demonstrated that Pilates training is an effective means to improve volleyball players' performance since the experimental (Pilates) group showed better improvement than the control group.

Table 3. *Outcome variables comparison within the groups (paired t test) and between groups (independent t test).*

Outcome Variables	Groups	Pre-intervention	Post intervention	(Within group) t-value (p-value)	Pre-post difference	(Between group) t-value (p-value)
		Mean±SD	Mean±SD		Mean±SD	
Curl up (counts)	Control group	4.33±.97	4.47±.83	-1.46 (0.164)	-0.13±0.35	2.12 (0.043*)
	Experimental group	4.40±.73	4.93±.258	-3.22 (0.006*)	-0.53±0.64	
DLLT (degree)	Control group	21.00±26.26	17.00±19.53	1.87 (0.082)	4.00±8.28	-2.76 (0.01*)
	Experimental group	21.33±18.56	6.00±7.60	4.38 (0.001*)	15.33±13.55	
Illinois agility test (sec)	Control group	14.86±.83	14.73±.96	0.8 (0.433)	0.13±0.64	-12.42 (0.000*)
	Experimental group	14.80±1.20	11.86±1.24	19.13 (0.000*)	2.93±0.594	
Vertical jump test (cm)	Control group	40.40±5.39	40.26±5.37	0.69 (0.499)	0.13±0.74	10.6 (0.000*)
	Experimental group	49.26±9.41	52.66±9.02	-12.47 (0.000*)	-3.40±1.05	
Brady's test (numbers)	Control group	9.00±2.13	10.00±2.00	-3.09 (0.008*)	-1.00±1.25	4.32 (0.000*)
	Experimental group	8.80±1.61	11.60±2.13	-10.69 (0.000*)	-2.80±1.01	
SEBT Anterior (cm)	Control group	73.53±5.93	73.33±6.19	0.71 (0.486)	0.20±1.08	10.08 (0.000*)
	Experimental group	83.60±7.45	82.00±9.04	1.26 (0.228)	3.87±1.12	
SEBT Posterior (cm)	Control group	77.07±5.21	76.60±5.24	3.5 (0.004*)	0.47±.516	10.58 (0.000*)
	Experimental group	79.27±9.26	82.47±10.67	-1.79 (0.094)	3.87±1.47	
SEBT Medial (cm)	Control group	76.60±5.86	76.00±5.79	3.64 (0.003*)	0.60±0.63	13.62 (0.000*)
	Experimental group	75.07±7.71	81.27±5.470	-4.74 (0.000*)	3.53±0.99	
SEBT lateral (cm)	Control group	77.53±6.30	77.00±10.64	2.25 (0.041*)	0.53±0.91	10.37 (0.000*)
	Experimental group	83.47±11.03	83.27±10.59	0.15 (0.878)	3.60±1.24	
SEBT Anteromedial (cm)	Control group	77.73±7.77	77.53±7.87	1.38 (0.189)	0.20±0.561	11.48 (0.000*)
	Experimental group	87.47±7.511	85.80±9.44	1.25 (0.232)	4.20±1.37	
SEBT Anterolateral (cm)	Control group	79.13±5.48	78.86±5.95	0.61 (0.546)	0.27±1.66	8.38 (0.000*)
	Experimental group	82.80±9.38	86.06±10.18	-1.91 (0.076)	3.67±0.72	
SEBT Posteromedial (cm)	Control group	79.33±6.44	78.80±6.28	2.08 (0.056)	0.53±0.99	12.08 (0.000*)
	Experimental group	79.26±6.92	84.93±5.58	-5.24 (0.000*)	3.93±1.03	
SEBT Posterolateral (cm)	Control group	81.93±7.73	81.73±7.90	1 (0.334)	0.20±0.77	11.5 (0.000*)
	Experimental group	87.40±10.61	86.80±10.32	0.47 (0.641)	3.53±0.99	

*DLLT- Double leg lowering test, SEBT- star excursion balance test. The critical value of t test for within group was 2.14 and between groups was 2.048. * Significant at p ≤0.05.*

DISCUSSION

The outcomes of this study indicated that individuals in the control group significantly improved their balance (posterior and medial direction) and volleyball sports specific skills. However, in participants of experimental group, upper and lower abdominal strength, explosive power of lower limb, agility, balance (medial and posterior direction) and volleyball specific skills improved significantly at the end of 6-weeks of Pilates training. Moreover, all the

outcome variables have improved considerably in the Pilates group compared to the control group. These findings indicated that regular Pilates exercises combined with volleyball training would benefit volleyball players' different physical attributes and sport-specific skills.

The improvement of these physical characteristics with Pilates training may be attributable to the improved capacity of the neuromuscular system to accomplish various dynamic, eccentric, and isometric stabilization contractions to counteract gravity and motion. Adequate core stability facilitates enhanced inter-body movement, sustained contraction of the deep spinal stabilizer muscles, and stability for the movement of distal segments. Additionally, it improves motor unit coordination and lessens neutral inhibitory reflexes which further lead to improvement of various physical parameters (Panchal et al., 2022).

The results of our study coincide with those of a study conducted by El-Sayed et al. (2010), which concluded that the addition of Pilates mat-work training to specialized volleyball training had a substantial impact on vertical jump performance in young volleyball players. The development of trunk muscular strength, which improves limb motor coordination, motor function, and the amount of oxygen delivered to the lungs, was found to benefit from Pilate's training. Therefore, the Pilates training regimen is beneficial for improving biological efficiency, lower limb strength, and jump performance.

Similar results were found in badminton players by Yeole et al., (2018), who found that a 4-week Pilate's exercise program significantly increased abdominal muscle strength, neuromuscular coordination, agility, and dynamic balance. Likewise, research by Panchal et al., on cricket players in 2022 found that 6 weeks of Pilates training had a positive impact on several physical traits, including core muscle strength, agility, power, hamstring muscle flexibility, and speed. Additionally, the findings of the present study are consistent with those of a study conducted by Johnson, Larsen, Ozawa, Wilson & Kenedy (2007) on healthy adults, which found that implementing a 5-week Pilate's exercise program improved kinesthetic awareness, core stability, and reduced inappropriate movement patterns, which in turn improved motor control in study participants.

The findings of our study are also consistent with findings from a study on badminton players, which found that five weeks of Pilates exercises significantly improved participants' agility, lower-limb explosive power, and dynamic balance compared to the control group (Preeti, Kalra, Yadav & Pawaria, 2019). Furthermore, according to Yadav et al. (2019), five weeks of Pilates training proved beneficial for improving the badminton players' agility and coordination.

Pilates exercises contribute to improved neuromuscular coordination and enhanced control of trunk movement. The findings of our study and other studies clearly demonstrate that Pilates exercises are beneficial for improving numerous physical parameters and sports-specific skills in volleyball players. However, the study had several limitations including small sample size, inclusion of only male university volleyball players and lack of follow up. Future studies can assess the impact of Pilates training on female volleyball players and competitive volleyball players, and they might also include follow-up.

Conclusion

This clinical trial concluded that Pilates training is an efficient kind of exercise that enhanced the physical parameters such as agility, balance, upper and lower abdominal strength, explosive power of lower limb and sports specific skill of volleyball players. The research has provided an insight into the significance of Pilates for volleyball players, indicating that sports physiotherapists may guide the coaches and players about beneficial effects of Pilates exercises in sports players so that it can be included in their routine practice. The results of the study may be applied to general practice of players in a way that these exercises if given in combination with the regular volleyball training to the players may reduce injuries and improve overall performance of the players with improvement in their physical parameters and volleyball sports specific skills.

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