Original Article

Improving musculoskeletal fitness and the performance enhancement of basketball skills through neuromuscular training program

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ABSTRACT

Ahmed, T. (2015). Improving musculoskeletal fitness and the performance enhancement of basketball skills through neuromuscular training program. *J. Hum. Sport Exerc., 10*(3), pp.795-804. The purpose of this study was to evaluate the effect of eight weeks of neuromuscular training program (NMTP) on musculoskeletal fitness and performance enhancement for basketball players. Twenty four male basketball players participated in this study and were divided into neuromuscular training group (NMT) or control group (CON). All players trained together as a team where NMT group participated 8 weeks of NMTP three times a week and CON group followed their regular protocol as guided by their coach. Musculoskeletal fitness was evaluated based on muscular strength, muscular endurance, and flexibility. Muscle strength was assessed by measuring grip strength and vertical jump test, muscular endurance was measured by push-up test and sit- up test, and flexibility was assessed using the sit-and-reach test. The basketball skills were assessed by passing test, speed spot shooting test, dribbling test, and defensive skill test. The subjects underwent all of the previously described tests before and after the training program. The results showed that the two groups demonstrated significant improvement, but the greater percentage of change is found in NMT group. The percentage of improvement in musculoskeletal fitness was ranged between 17% to 47% for NMT group versus 5% to 13% for CON, while ranged between 18% to 30% for NMT group versus 10% to 17% for CON group in skills performance. The study demonstrated that there is a significant effect of the NMTP which focused on core stability and lower extremity strength on musculoskeletal fitness and skills performance for young male basketball players. **Key words**: CORE STABILITY, DEFENSE, LOWER EXTREMITY STRENGTH, SPOT SHOOTING.

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INTRODUCTION

Musculoskeletal fitness can be operationally defined by measurements of joint flexibility, muscular strength, muscular power, and muscular endurance (Payen et al., 2000; Warburton et al., 2001). Measures of musculoskeletal fitness are often performed as part of health-related fitness tests. Basketball players must be strong, quick, and agile to effectively block, shoot, or pass the ball. They must be able to accelerate and decelerate quickly and with control, often while dribbling, shooting, or rebounding the ball. They also need to be able to repeat these actions many times with little rest between efforts throughout the game (Jackson et al., 1996). These movements could compromise joint stability by increasing the ground reaction forces and decreasing energy absorption by the musculature, resulting in musculoskeletal injury (Schmitz et al., 2007). This injury is due to a problem in musculoskeletal system which may be a reason to prevent the player to continue the game (Jackson et al., 1996). Therefore, maximal strength, power, muscle endurance, and neuromuscular control are needed to perform well and avoid injury throughout the season (Schmitz et al., 2007). Several studies support the use of interventions such as neuromuscular training (NMT) programs to prevent injury (Myer et al., 2008; Zazulak et al., 2007) and improving measures of performance (Myer et al., 2005).

Neuromuscular training program (NMTP) includes interventions that focus on increase control of center of mass, and improved ability to control of the lower extremity movement. The NMTP exercises are focused on lower limb strength and core stability. Core stability is defined as dynamic trunk control which allows for the production, transfer, and control of force and motion to distal segments of the kinetic chain (Kibler et al., 2006). The goal of the NMTP is to improve the athlete's ability to control the center of mass during dynamic activity Myer et al. (2005) found that NMTP caused significant improvements in measures of athletic performance with improvement in biomechanical measures in female athletic especially female basketball players. Kibler et al., (2006) stated that core stability controls the position and motion of the trunk over the pelvis to allow optimum production, transfer and control of force and motion to the terminal segment in integrated athletic activities. There are limited studies have done on basketball players emphasizing on skills performance and there are no studies have found to find the changes of musculoskeletal fitness after NMTP. Therefore, there is need to know the effect of neuromuscular training on musculoskeletal fitness and skills performance in young male basketball players. Hence, the purpose of this study was to determine if an 8-week NMTP that focused on core stability and lower extremity strength could improve musculoskeletal fitness and performance enhancement for male basketball players. We hypothesized that the NMT group would show significant improvements on the musculoskeletal fitness and performance of basketball skills that would not be seen in a CON group.

MATERIAL AND METHODS

Participants

Twenty four male basketball players volunteered to participate in the study and were randomly divided into two equal groups: neuromuscular training group (NMT) (age=18.04±0.68 years, height =179.91±1.67 cm, body mass=67.58±1.31 kg, sport experience=3.9±0.39 years), and control group (CON) (age=18±0.47 years, height =179.58±1.62 cm, body mass=67.41±0.99 kg, sport experience=3.95±0.33 years). All testing and training procedures were fully explained, and a written consent was taken from the participants. The subjects were informed about the possible risks and benefits of the study. Before the study, no statistically significant differences were found in musculoskeletal fitness or basketball skills between the CON group and the NMT group.

Measurements

Musculoskeletal fitness tests

Indicators of musculoskeletal fitness include sit-ups, push-ups, combined left and right hand grip strength, vertical jump and sit-and-reach trunk flexibility. In this study the grip strength and vertical jump were used as indicators of muscular strength. Grip strength was measured with a portable digital hand dynamometer (Jamar, EN-120604). Participants held the dynamometer at the level of the thigh in line with the forearm and were instructed to squeeze vigorously as to exert maximum force. The maximum grip strengths of three trials for each hand were summed to provide a single measure of grip strength (kg) (Ross and Rosblad, 2002). Vertical jump height, defined as the difference between standing reach height and the maximal jump height to the nearest centimeter in all subjects at baseline. Each subject performed three trials with 1 min of rest in between each jump. And the highest jump was used in the data analysis (cm) (Maffiuletti et al., 2002). The test- retest reliability for vertical jump test was (r = 0.92).

The number of push-ups completed without time limit (n) and the number of sit-ups performed in 60 s (n·min1) were used as indicators of muscular endurance. Sit-ups were performed from the supine position, with knees flexed 90°. One complete sit-up entailed curling the trunk from the supine position to touching the elbows to the knees and returning to the start position. The test- retest reliability for Sit-ups test was (r = 0.83). For push-ups, subject balanced from the toes. One complete push-up entailed straightening the elbows and returning to touch the nose to the floor, while keeping the back straight. The test- retest reliability for push-ups test was (r = 0.90). Finally, a sit-and-reach test was used to assess trunk and low-back flexibility. In a seated position with the knees extended and the feet placed firmly against a vertical support the subject reached forward along the measuring line as far as possible with the arms at the same level, the score was recorded to the nearest centimeter as the distance reached by the hands, using the level of the feet as recording zero, so that any measure that did not reach the toes was negative and any measure beyond the toes was positive. The test was repeated twice, with the maximum value recorded (Katzmarzyk and Craig, 2002). The test- retest reliability for sit-and-reach test was (r = 0.81).

The aahperd basketball skills test

The AAHPERD-BST was selected as it contains important all-around components of the basketball, including dribbling, passing, defense, and speed spot shooting skills (Hopkins et al., 1984). The AAHPERD-BST is also a well constructed, norm-referenced basketball skills test. The participants were familiar with the skills involved.

Basketball passing test

The test required a smooth wall surface of 30 feet. A restraining line 26 feet long was marked out on the floor 8 feet from and parallel to the testing wall. On the testing wall six boxes measuring 2 feet by 2 feet were marked out all 2 feet apart. Moving from the left side of the testing wall, targets A, C and E have their base 5 feet from the floor while B, D and F have their base 3 feet from the floor. Each participant performed a chest pass to the first target square (A), recovered the ball while moving to the second target square (B), performed a chest pass to the second target (B). The participant then continued this action until he reached the last target (F). The test was continued for just thirty seconds. Only chest passes were allowed. Each chest pass that hit the target or on the target lines was awarded 2 points and one point was awarded for each pass that hit between the targets. The test result was obtained by totaling all the points scored over 30 s. The test- retest reliability for passing test was (r = 0.92).

Speed spot shooting

Each subject performed 2 trials of a speed spot shooting skills test. The gym floor was marked with 5 spots at a distance 15 feet measured from the center of the backboard. Each subject was instructed to shoot from each of the 5 spots at least once and as many times as possible throughout a 60-second period. The subject retrieved her own ball and dribbled to a subsequent spot. Each made basket was awarded 2 points, and one point was awarded for an unsuccessful shot that hits the rim. Final score were recorded the total points from the two trials. The test- retest reliability for speed spot shooting test was (r = 0.89).

Dribbling skill test

Each subject performed three trials the first as a practice trial and the last two scored for the record. An obstacle course marked by the six cones was set up in the free throw lane of the court. Participant dribble around 6 cones using fingertips until the finish line was crossed by both feet. Scores was recorded to the nearest 0.10 of a second for each trial and the final score will be the sum elapsed time of the two trials. The test- retest reliability for dribbling skill test was (r = 0.81).

Defensive skill test

The test perimeters was marked by the free throw line, the boundary line behind the basket, and the rebound lane lines, which was marked into sections by a square and two lines. Only the middle line was a target point for this test. Additional spots outside the four corners of the area were marked with tape at points A, B, D, and E. The participant was started at point A and face away from the basket and slide to the left without crossing his feet and continue to point B. Participant touched the floor outside the lane with the left hand, executed a drop-step and slide to point C to touch the floor outside the lane with the right hand. The participant was continued the course to the end point. Each subject performed 2 trials. Scores was recorded for each trial and the final score was the sum elapsed time of the two trials. The test- retest reliability for defensive skill test was *(r* = 0.82).

Procedures

The neuromuscular training principles and exercises chosen for this study were derived from a previously published training program (Bhargava et al., 2013; Alyson et al., 2010). The NMT group participated in 8 weeks of NMTP three sessions per week and other days they followed regular exercises recommended by their coach. Each session lasted approximately 90 minutes and consisted of 20- minutes warm-up exercises which intended to prepare muscles and joints for exercise to decrease any risk of injury, followed by 60-minute increments of lower extremity strength and core stability training, and finished with 10-minute cool-down that include static and dynamic stretches for calf, quadriceps, hamstring, inner thigh and hip flexors. The core stability component was divided into 5 phases of progressive exercises (Table 1). The lower extremity strengthening program consisted of 2 groups of exercises which were performed on alternating training sessions (Table 2). The NMTP was designed to gradually progress lower extremity strength and core stability by incorporating exercises that increase lateral trunk perturbations, to increase demands on lower extremity strength and core stability. The subjects were required to maintain proper technique, while external perturbations (ball toss, unanticipated movement to the base of support) were applied to increase difficulty of the task. The program at an intensity of 80–85% of 1 RM, 8–12 repetitions and 3 sets of exercise with rest period of 160 sec after each set were performed. The subjects in CON group followed their regular protocol of training exercises as guided by their coach who included knee and hip flexibility exercises, stretching exercises and plyometrics.

Table 1. Five Phases of the Core Stability Portion of Neuromuscular Training Program.

core stability exercises				
Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 5**
- Lateral jump and hold	-Lateral jumps	-Lateral hop and hold	-Lateral hops	-X-hops
- Step-hold	-Jump single-leg hold	-Hop-hold	-Hop-hop-hold	-Crossover-hop-hop- hold
- Single-tuck jump soft landing	-Double-tuck jump	-Repeated-tuck jump	-Side-to- side barrier tuck jumps	-Side-to-side reaction barrier tuck jumps
- Front lunges	-Walking lunges	-Walking lunges unilaterally weighted	-Walking lunges with plate crossover	-walking lunges with unilateral shoulder press
-Lunge jumps	-Scissor jumps	-Lunge jumps unilaterally weighted	-Scissor jumps unilaterally weighted	-Scissor jumps with ball swivel
-Swiss ball back hyperextension	-Swiss ball back hyperextension	-Swiss ball hyperextensions with back fly	-Swiss ball hyperextensions with ball reach lateral	-Swiss ball hyperextensions with lateral ball catch

Table 2. Lower Extremity Strengh Training Component of the Neuromuscular Training Program.

Strength training	
Day 1	**Day 2**
- Dumbbell hang snatch	- Barbell hang cleans
- Barbell squat	- Sumo squat dumbbell pick-up
- Barbell bench press	- Dumbbell incline press
- Assisted Russian hamstring curl	- Gluteal/hamstring raise
- Dumbbell shoulder press	- Dumbbell back fly
- Hamstring curls	- Band ankle inversion/eversion
- Latissimus pull-down	- Walking lunges
- Lateral lunges	- Dumbbell Ys and Ts
- Seated row	- Dumbbell lateral raise

Statistical analyses

All statistical analyses were performed using the SPSS version 11.0 software (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL, USA). All data were normally distributed (Kolmogorov–Smirnov test), and therefore, a 2-tailed paired sample t-test was used to detect differences for each test between the pretest and posttest to determine statistical significance. Independent t-test has been used to evaluate the difference between groups before and after training for each parameter. The level of significance was set at $P \leq 0.05$.

RESULTS

No subject sustained an injury as a result of the training program. All subjects completed at least 20 of the 24 training sessions. There were no intergroup differences in the musculoskeletal fitness and performance skills before the program but after the NMTP there were significant differences between groups as shown in (Table 3). The two groups demonstrated statistically significant improvement between pretest and posttest in the musculoskeletal fitness components, which include hand grip strength, vertical jump, push-ups, sit-up and sit-and-reach test (p<0.05), and skills performance in basketball which tested by the skills of dribbling, passing, defensive, and speed shooting (p<0.05) as shown in (Table 4). The NMT group demonstrated significant improvement better than the CON group after the NMTP in the musculoskeletal fitness and skills performance in basketball. Figure 1 shows the percentage of improvement in musculoskeletal fitness for the two groups which ranged between 17% to 47% for NMT group and 5% to 13% for CON group. These results indicate that the NMTP had an effect on the musculoskeletal fitness. Figure 2 shows the percentage of improvement in performance skills which ranged between 18% to 30% for the NMT group and 10% to 17% for the CON group. These results indicate that the NMTP had an effect on the performance skills in basketball.

Table 3. Means, standard deviations (SD) and significant differences between the two groups in pre and post-measurement of musculoskeletal firness and skills performance in basketball.

	Variables	Pre-Test		T value	P value	Post-Test		T value	P value
		CON group	NMT group			CON group	NMT group		
Musculoskeletal fitness	Right Grip strength(kg)	21.83±1.52	21.91±1.50	0.13	0.89	23.83±1.58	28.33±1.55	7.01	0.00
	Left Grip strength(kg)	20.00±1.59	20.08±1.37	0.13	0.89	21.08±1.78	24.25±1.42	4.81	0.00
	Vertical Jump(cm)	38.91±2.15	39.08±2.31	0.18	0.85	42.25±2.63	48.50±3.06	5.36	0.00
	Sit-ups (n-min1)	20.58±1.31	21.58±1.24	1.91	0.06	23.25±2.05	30.58±2.39	8.06	0.00
	Push-up (n)	18.08±2.15	19.58±1.50	1.97	0.06	19.58±2.27	28.75±1.28	12.14	0.00
	Sit and reach (cm)	12.41±1.16	12.25±1.54	0.29	0.76	13.08±1.44	14.66±1.30	2.82	0.01
performance skills	Passing (points)	39.41±1.92	39.25±2.00	0.20	0.83	44.16±2.44	48.00±1.41	4.70	0.00
	Speed spot shooting (point)	20.41±1.31	20.25±1.42	0.29	0.76	22.41±1.50	23.83±1.19	2.55	0.01
	Dribbling (sec)	12.33±0.98	12.08±1.08	0.59	0.56	10.25±1.05	9.16±0.71	2.94	0.00
	Defensive (sec)	12.50±1.00	12.58±0.99	0.20	0.84	10.50±1.00	8.75±0.75	4.84	0.00
* P< 0.05									

Table 4. Means, standard deviations (SD) and significant differences between pre and post-measurement for the two groups in musculoskeletal firness and skills performance in basketball.

	Variables	CON group		T value	P value	NMT group		T value	P value
		Pre-Test	Post-Test			Pre-Test	Post-Test		
Musculoskeletal fitness	Right Grip strength(kg)	21.83±1.52	23.83±1.58	5.74	0.00	21.91±1.50	28.33±1.55	12.85	0.00*
	Left Grip strength(kg)	20.00±1.59	21.08±1.78	2.72	0.02	20.08±1.37	24.25±1.42	7.41	0.00*
	Vertical Jump(cm)	38.91±2.15	42.25±2.63	6.15	0.00	39.08±2.31	48.50±3.06	10.99	0.00*
	Sit-ups (n-min1)	20.58±1.31	23.25±2.05	5.06	0.00	21.58±1.24	30.58±2.39	15.95	0.00*
	Push-up (n)	18.08±2.15	19.58±2.27	2.28	0.04	19.58±1.50	28.75±1.28	13.63	0.00*
	Sit and reach (cm)	12.41±1.16	13.08±1.44	2.60	0.02	12.25±1.54	14.66±1.30	5.80	0.00*
performance skills	Passing (points)	39.41±1.92	44.16±2.44	9.61	0.00	39.25±2.00	48.00±1.41	11.51	0.00*
	Speed spot shooting (point)	20.41±1.31	22.41±1.50	7.26	0.00	20.25±1.42	23.83±1.19	10.01	0.00*
	Dribbling (sec)	12.33±0.98	10.25±1.05	9.10	0.00	12.08±1.08	9.16±0.71	7.70	0.00*
	Defensive (sec)	12.50±1.00	10.50±1.00	5.41	0.00	12.58±0.99	8.75±0.75	11.91	0.00*

* P< 0.05

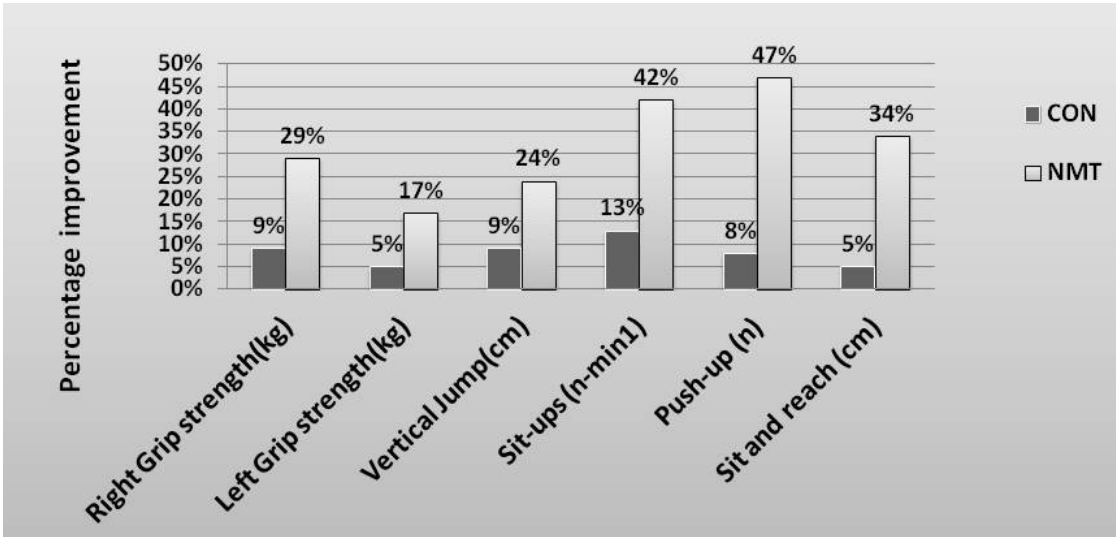

Figure 1. Percentage of improvement in musculoskeletal fitness component.

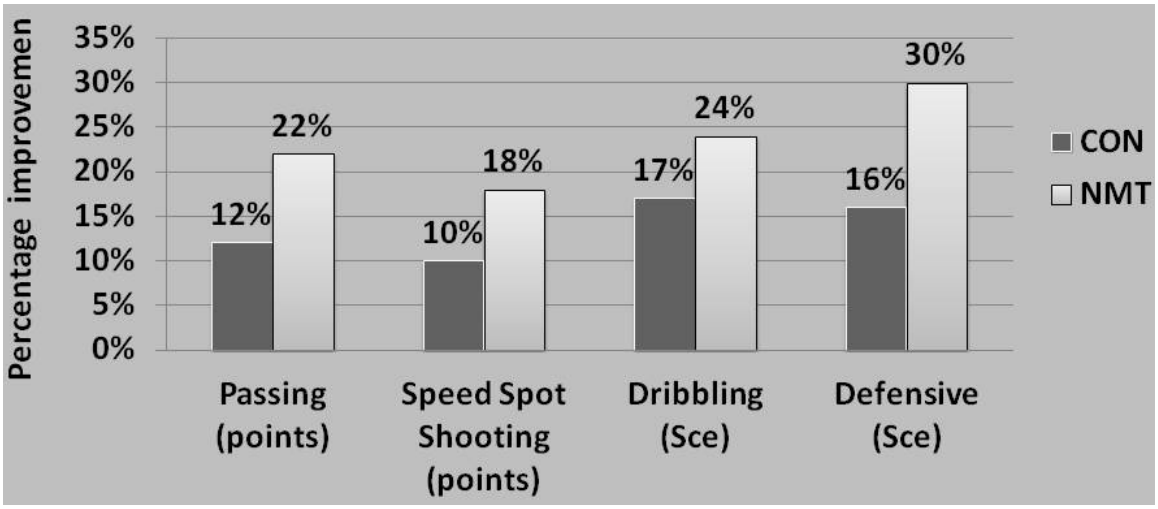

Figure 2. Percentage of improvement in the skills performance in basketball.

DISCUSSION

The present study assessed the effect of a neuromuscular training program in improving the musculoskeletal fitness and performance enhancement of basketball skills for young male basketball player. The results showed that the NMT group had greater percentage of improvement on musculoskeletal fitness and skills performance in basketball than CON group who received only regular exercises, the results also showed that there was a significant difference between the post measurements of the two groups.

In control group the improvement in musculoskeletal fitness components could be due to the influence of the regular exercises which strengths the core muscle and lower limbs, and improved knee hip flexibility. The improvement in skills performance in basketball could be due to the coach advised regular basketball training program which included training sessions as warming up (up to 20 min), exercises for the improvement of individual technical actions (up to 40 min., ball dribble for 10 min., shooting for 20 min., and passing for 10 min), tactical training (up to 30 min).

In NMT group, there were significant improvements in musculoskeletal fitness components which assessed by measuring muscular strength, endurance, and flexibility. This could be due to the effect of NMTP and regular exercises performed by the athletes. In NMTP the exercises are focused on lower limb strength and core stability that makes the neuromuscular system more efficient. Core stability exercises improve dynamic trunk control which allows for the production, transfer, and control of force and motion to distal segments of the kinetic chain (Kibler et al., 2006). Poor core stability and decreased muscular synergy of the trunk and hip stabilizers leads to decrease performance in power activities and increases the incidence of injury due to lack of control of the centre of mass (Alyson et al., 2010; Hewett et al., 2005). The effect of NMTP on musculoskeletal fitness has not been previously studied. Therefore not found on previous studies to compare our results. Chappell and Limpisvasti (2008) found that a 6-week neuromuscular training program demonstrated significant improvement in vertical jump height in the female collegiate athletics. Sue et al. (2010) reported that 6-week of neuromuscular training program improved abdominal endurance in junior tennis players. This finding is in line with our study. The NMT group shown significant improvement

in skills performance which assessed by measuring dribbling, passing, defense, and speed spot shooting skills. The improvement in performance scores after training was approximately 18% to 30%. This could be due to improve of lower limb strength and core stability that is important part can lead to improvements in athletic performance. Furthermore, the musculoskeletal fitness were improved which may be also important part of improving athletic performance. The NMTP improves the athlete's ability to control the centre of mass during dynamic activity and enhance neuromuscular control of the trunk which influence on dynamic stability of the lower extremity during high-speed athletic maneuvers (Zazulak et al., 2007). It helps to maintain balance and improving body flexibility, strength and the fitness levels, thus contributing to the improvement of skills performance. The results of this study are supported by previous studies. Myer et al. (2005) studied the effect of NMTP on measures of athletic performance and lower-extremity movement biomechanics in female athletes' especially female basketball players and they found significant improvements in measures of athletic performance. Many authors suggested that muscular performance gains after training are attributed to a neural adaptation located in the nervous system (Maffiuletti et al., 2002; Potteiger et al., 1999). According to these authors, neuromuscular factors such as increasing the degree of muscle coordination and maximizing the ability to use the muscles' stretch-shortening cycle appear to be more important for the improvement in musculoskeletal fitness and enhance skills performance.

The results show that greater percentage of change is found in NMT group. This could be due to 8 weeks NMTP that focused on lower extremity strength and core stability found added effect along with regular exercises that significantly improved musculoskeletal fitness and skills performance than the control group who relieved only regular exercises. Based on the finding in this study found that there is a significant effect of NMTP along with regular exercise on musculoskeletal fitness and skills performance for young male basketball players. The main findings of this study suggest that this kind of NMTP can improve musculoskeletal fitness and performance enhancement for male basketball players.

CONCLUSION

The results of this study highlight the potential of using neuromuscular training along with regular exercise to improve musculoskeletal fitness and the performance enhancement of basketball skills especially in young male basketball players. It is recommended that, coaches sometimes design NMTP to be incorporated into the athlete's normal fitness routine for young athletes, because this type of training is effective for improving performance level.

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