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Effect of proprioceptive neuromuscular facilitation techniques on core muscle strength and endurance in healthy individuals

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Abstract
Core muscular network is important for function. An experimental study was conducted in 120 healthy individuals in the age group of 20 to 30 years. They were randomly assigned into 3 groups of 40 each – control, rhythmic stabilization training and combination of isotonic exercises. Core muscle strength was measured using core stability gradation and endurance with lumbopelvic stability test. There was statistically significant difference observed in post values of core muscle strength ($p = 0.000$) and endurance ($p = 0.000$) in all the three groups using one-way ANOVA test. Combination of isotonic exercises is better than Rhythmic stabilization and control group. Hence, proprioceptive neuromuscular facilitation techniques have a significant effect on core strength and endurance in healthy individuals.

Keywords: proprioceptive neuromuscular facilitation, core strength, core endurance, rhythmic stabilization, combination of isotonic exercises

1. Introduction
The term 'core' is an intricate muscular network and also denoted as the lumbo-pelvic-hip complex. It is a space lined with diaphragm on the superior aspect forming the roof, abdominal and oblique muscles on the anterior and lateral part, paraspinal and gluteal muscles in the posterior aspect and pelvic floor along with hip girdle musculature forms the floor or inferior aspect. It creates a corset-like stabilization effect on the spine and enhances the function [1]. An effective core is crucial for maintenance of proper muscle balance throughout the human kinetic system. It is essential for accurate functioning of the activities of daily living [2]. It is also referred to as the powerhouse of all limb movements [1].
The core musculature has been categorized into two aspects from a neuromuscular standpoint, with superficial muscles representing the outer global system and the deeper muscles constituting the local system. The deeper muscles include internal oblique, transversus abdominis, multifidus, quadratus lumborum and medial fibres of external oblique. Whereas, the superficial muscle group comprises of rectus abdominis, lateral fibres of external oblique and erector spinae [3]. Core muscles play an imperative role in many functional and athletic activities as it enhances core stability. For optimal core stability, both the deeper and superficial core muscles have to contract in appropriate sequence with proper timing and tension [4, 5]. The stability of pelvis and trunk is necessary for all movements of lower extremities. All local stabilizer and global mobilizer core muscles are activated while performing any extremity movement which implies that core muscles provide proximal stability for distal mobility [6,7]. If the core is not stable and weak, there is a risk for injury in the kinetic chain [8].
Proprioceptive neuromuscular facilitation (PNF) is a technique primarily designed to boost and accelerate the neuromuscular mechanism via the stimulation of the proprioceptors. A spiral and diagonal directional PNF patterns in line with the topographical arrangement of the muscles are used to facilitate the activation of muscles [9]. PNF exercises have been recommended for sensory-motor control training and stimulating lumbar muscle proprioception in chronic low back pain patients [10]. Two commonly used forms of PNF exercises are rhythmic stabilization training (RST) and combination of isotonic exercises (COI). The RST technique consists of application of alternating isometric contraction of antagonistic patterns [9]. The COI technique involves the performance of varying type of agonist muscle contraction required for function. It involves alternating concentric, eccentric and isometric contractions and is used to improve agonist strength and improve function [11]. Hence, the aim of the study is to study the effect of proprioceptive neuromuscular facilitation [PNF] technique on core strength and endurance in healthy individuals.

2. Materials and methods
An experimental study was conducted in 120 healthy individuals in the age group of 20 to 30 years. 120 healthy subjects were selected and randomly assigned into 3 groups of 40 each. Exclusion criteria included any history of low back pain, injury or trauma to spine and sacroiliac joint dysfunction. Group A was the control and no interventions

were given to this group. Group B received rhythmic stabilization training (RST). Group C received combination of isotonic exercises (COI). Institutional research review committee approval was obtained before conducting the study. Subjects were explained about the nature of the study in the language best understood by them. A written informed consent was taken from the subjects who were willing to participate in the study and the informed consent document was duly signed by the subject. Demographic data of the subject was noted.

The outcome measures used were core muscle strength and endurance. Core muscle strength was measured using a core stability gradation using pressure biofeedback. The starting position was crook lying position. The pressure was increased upto 40 mm Hg. The subject was asked to maintain the pressure as steady as possible using the deep muscle corset action while the therapist palpates the contraction throughout the test. Grade 1 is holding the contraction for 10 seconds. Grade 2 is holding the contraction and sliding of one leg with contralateral leg supported. Grade 3 is holding the contraction and sliding of one leg unsupported and with the contralateral leg supported. Grade 4 is holding the contraction and sliding of one leg supported and with the contralateral stable leg unsupported. Grade 5 is holding the contraction and sliding of one leg supported with the contralateral leg also unsupported with heel approximately 5 cm high from the surface [12].

Lumbopelvic stability test was used to measure core muscle endurance. The subject was in crook lying position. The pressure biofeedback unit was placed beneath the lumbar spine and inflated to 40mm Hg. Subjects were instructed to perform abdominal drawing in maneuver and to maintain the contraction. An ability to maintain the pressure at 40 ± 2 mm Hg during this maneuver indicated a successful performance. Holding time of contraction was measured using stopwatch in seconds and noted.

Rhythmic Stabilization Training: In this group, subjects were given alternating (trunk flexion - extension) isometric contractions of antagonists against resistance for 10 seconds, with no motion intended [9]. Subjects performed 3 sets of 15 repetitions with rest interval. Subject

assumes a seated position and faces the physical therapist. The therapist places her hands on upper part of the thoracic area, just below the shoulder level. From this position, the subject is instructed to flex the trunk against resistance provided by the therapist. The resistance slowly increases as the subject gradually increases strength. When strength exertion is stabilized, the therapist slowly moves one hand to the upper part of the back, just below the shoulder level, aiming to provide resistance to the antagonist movement of the trunk. When the subject responds to the new position, the therapist moves the other hand to the upper part of the back and instructs the subject to extend the trunk against the resistance provided [13].

Combination of Isotonic Exercises: In this group, subjects were given alternating concentric, eccentric and isometric contractions of agonists against resistance without relaxation [9]. The therapist resists the patient's moving actively through a desired range of motion (concentric contraction). At the end of motion the therapist tells the patient to stay in that position (stabilizing contraction). When stability is attained the therapist tells the patient to allow the part to be moved slowly back to the starting position (eccentric contraction). Total 3 sets of 15 repetitions with rest interval at maximal resistance were performed. All training sessions had been controlled by the same physical therapist and had a total duration of 30-45 minutes. The maximal resistance had been provided each time by the physical therapist, intensity progression through 4-week period was carried out according to PNF principles.

The training frequency was 5 times per week for total 4 weeks. The training volume per session includes 3 sets of 15 repetitions. Each treatment session was conducted for 30-45 minutes.

Statistical Analysis

Data were analyzed using SPSS version 20 (Statistical Package for Social Science). Descriptive statistics (mean ± standard deviation) were determined for all measured variables. Unpaired t test was used to analyse pre and post values of core muscle strength and endurance in all the three groups. One-way ANOVA test was used to compare post values of core muscle strength and endurance in the three groups. A 5% level of probability was used to indicate statistical significance.

3. Results

A total of 120 healthy subjects were selected and divided into three groups with 40 subjects in each group. The mean age of participants in control group, rhythmic stabilization group and combination of isotonic exercises group was 24.08 ± 2.79, 24.53 ± 2.68 and 24.25 ± 2.94 years respectively. (Table 1)

Table 1: Demographic characteristics of the participants in all three groups.

	Control group N = 40	**Rhythmic stabilization group N = 40**	**Combination of isotonic exercises N = 40**
Age	24.08 ± 2.79	24.53 ± 2.68	24.25 ± 2.94
Gender			
Male	4 (10%)	4 (10%)	4 (10%)
Female	36 (90%)	36 (90%)	36 (90%)

There was no difference observed in pre and post values of core muscle strength (p = 0.112) and endurance (p = 0.11) in control group using paired t test. There was statistically significant difference observed in pre and post values of core muscle strength (p = 0.000) and endurance (p = 0.000) in Rhythmic stabilization group using paired t test. There was statistically significant difference observed in pre and post values of core muscle strength (p = 0.000) and endurance (p = 0.000) in Combination of isotonic exercises using paired t test.

Table 2: Comparison of mean values of pre and post core muscle strength and endurance in each group.

	Core muscle strength			Core muscle endurance		
	Pre	**Post**	**p value**	**Pre**	**Post**	**p value**
Control Group	1.23 ± 0.48	1.23 ± 0.48	0.112	50.97 ± 40.96	51.9 ± 40.12	0.11
Rhythmic stabilization training	1.15 ± 0.36	2.15 ± 0.36	0.000*	61.23 ± 46.26	158.83 ± 36.49	0.000*
Combination of isotonic exercises	1.1 ± 0.31	2.9 ± 0.3	0.000*	54.02 ± 35.68	192.8 ± 42.76	0.000*

*p value less than 0.05 is significant.

There was statistically significant difference observed in post values of core muscle strength (p = 0.000) and endurance (p = 0.000) in all the three – control, Rhythmic stabilization and combination of isotonic exercises group using one-way ANOVA test. Combination of isotonic exercises is better than Rhythmic stabilization and control group.

Table 3: Comparison of mean values of post core muscle strength and endurance in each group.

	Core muscle strength		Core muscle endurance	
	Post	**p value**	**Post**	**p value**
Control Group	1.23 ± 0.48	0.000*	51.9 ± 40.12	0.000*
Rhythmic stabilization group	2.15 ± 0.36		158.83 ± 36.49	
Combination of isotonic exercises	2.9 ± 0.3		192.8 ± 42.76	

*p value less than 0.05 is significant.

4. Discussion

The present study analyzed the effect of proprioceptive neuromuscular facilitation on core muscle strength and endurance in healthy subjects. The present study revealed significant improvement in the core strength and endurance after 4 weeks of PNF exercises. Both, rhythmic stabilization and combination of isotonic exercises showed statistically significant difference in core muscle and core endurance. RST involves isometric contractions of agonist and antagonist whereas COI used all muscle action types (eccentric, concentric, and isometric) through a progressively increased range of motion.

An increase in core strength may be due to the dynamic nature of combination of isotonic exercise, which uses all muscle action types - eccentric, concentric and isometric through a progressively increased range of motion as compared to the static nature of rhythmic stabilization technique [14]. Increase in muscle strength can be attributed to a neurologic mechanism. There is an increase in recruitment of the number of motor neurons with each muscle contraction [15].

Proprioceptive neuromuscular facilitation (PNF) is a technique involving combinations of alternating contractions and stretches which leads to facilitation of the agonist muscle and increase the recruitment of supplementary motor neurons or increase the excitability of the motor neurons already in use [16]. Also, it alters fibre type distribution and mean cross sectional area of the muscle causing increase in muscle strength [13].

A recently published study demonstrated that dynamic exercises utilizing PNF patterns can increase thickness of the abdominal muscles, thereby enhancing the trunk stability and physical function by stimulating the proprioceptors of muscles and tendons [17]. The proprioceptive neuromuscular facilitation uses the resistance in order to assist in muscle contraction, augment motor control and assist movement awareness. When resistance is applied to muscle, the response of muscle to cortical stimulation increases and causes active muscle tension. Activation of proprioceptive reflexes from the contracting muscles attenuates the response of synergistic muscles at the same joint and associated adjacent joints. This leads to increases in the strength of contracting muscle [18, 19]. This technique is easy to understand and leading to facilitation of movement throughout its execution. It targets strength, coordination and balance using diagonal movement patterns.

5. Conclusions

The result of the study showed that the proprioceptive neuromuscular facilitation (PNF) techniques have significant effect on core strength and endurance in healthy individuals.

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7. References

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