Research Paper

Comparison of the Effect of Core Stability and Dynamic Neuromuscular Stabilization Training on Knee Valgus and Motor Function in Students

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ABSTRACT

Purpose: This study aimed to compare the impact of core stability and dynamic neuromuscular stabilization (DNS) training on knee valgus and motor function in 11- to 14-year-old students.

Methods: This study used a quasi-experimental design. Therefore, 60 female students from Tehran Province, Iran (mean age, 11.5 years) were selected as participants in this study and were randomly divided into three groups: core stability training, DNS training, and control. Knee valgus and movement function were measured using the Q angle and the functional movement screening (FMS) before and after the intervention. The participants in the experimental groups performed exercises for 6 weeks, with three sessions per week, each lasting 60 minutes. One-way analysis of variance and the least significant difference post hoc test were utilized to compare the groups, while the paired t-test was employed to assess within-group effects.

Results: The present study demonstrated a significant difference between the FMS test scores and knee valgus angle in the two experimental groups (DNS and core stability exercises) and the control group. However, no significant difference was observed in scores between the two experimental groups.

Conclusion: Overall, both DNS and core stability training significantly improve FMS test scores and decrease the knee valgus angle.

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Highlights

● Based on the research, it is important to highlight that one of the latest techniques in exercise rehabilitation is the DNS method. This approach not only focuses on muscle strengthening but also incorporates the nervous system.

● There is insufficient evidence to evaluate the effect of core stability training and DNS on knee valgus and motor function.

Plain Language Summary

In various studies, core stability training and dynamic neuromuscular stabilization (DNS) training methods have been used for injury prevention, to improve deformity, and to increase motor and sports performance. However, the effects of these two methods on valgus angle and motor function screening have been studied less, and fewer accurate comparisons have been made between their effectiveness. This study aimed to assess how core stability and DNS methods affect knee valgus and motor function in children between 9 and 14 years old.

Introduction

When the foot is aligned straight in the lower limb, the axis of body weight connecting the hip joint center to the ankle joint center runs directly through the center of the knee joint. Thus, body weight is transferred into the knee joint by joint surfaces, where it is distributed equally between the two sides of the joint [1]. Abnormalities and injuries of the lower limbs disrupt human movement biomechanics and can hurt them, leading to instability symptoms. Some studies have shown that lower limb alignment is one of the factors influencing posture maintenance and function [2]. The knee joint bears weight and absorbs loads during both static and dynamic movements, playing a crucial role in the balance and function of the lower limbs. Genu valgum is a common orthopedic issue among children and adolescents [3, 4]. Increasing the angle of the knee joint (valgus) is accompanied by changes in the normal direction of the lower limb posture, in turn, causing changes in the location of the center of gravity relative to the base of support, limiting the control of balance and function of the individual [5].

Today, a mechanical and sedentary lifestyle not only causes skeletal abnormalities but also leads to movement disorders in students. Researchers have developed tools to evaluate more comprehensive movement patterns and to assess a comprehensive motor pattern for injury prevention. One of these methods is the functional movement screening (FMS) test, which can demonstrate the quality of performance of functional movement patterns and identify at-risk individuals [6]. Many studies have shown that people with scores of 14 or less have a high risk of injury [7]. This evaluation method can reveal the strengths and weaknesses of exercise programs and movement disorders.

One of the best active therapies is the use of exercises and activities, which can be effective in improving postural deformities and motor function [8, 9]. Studies involving students showed that various training and treatment methods were used, including core stability exercise training. In the past few years, the significance of core stability in lower-limb biomechanics has gained more attention. A new theory suggests that weakness or lack of muscular endurance of the core stabilizer muscles can be considered a factor contributing to kinetic instability in the lower limbs [10]. When the strength of the core stabilizing muscles is low, it leads to less effective movement patterns. This weakness causes the body to adopt compensatory movement patterns, which can lead to muscle strain and overuse. It also reduces the lower limbs' dynamic stability and increases stress on their ligaments, greatly affecting a person's ability to move [11]. It has also been reported that children have lower core muscle strength than adults [12]. Core stability exercises are used to improve motor control and muscle capacity in the central area of the body, as they maintain the strength of this area against various conditions and external forces. Core stability exercises strengthen muscles and improve motor function and control posture [13, 14]. Studies that have previously examined the effects of core stability exercise training on motor functional improvement [15, 16] and improving knee deformity [17, 18] have emphasized the effects of these exercises on increasing motor function and reducing postural deformity.

Conversely, it is worth highlighting that one of the latest techniques in exercise rehabilitation is the DNS technique, which incorporates the nervous system alongside enhancing the muscular system [19]. The DNS technique is a rehabilitation and manual therapy approach aimed at optimizing the motor system. It is grounded in the scientific principles of developmental kinesiology. Increasingly recognized in the realms of rehabilitation and sports performance, DNS is effective in addressing overuse injuries and preventing further harm. This overview explores the foundations of DNS and illustrates how it can be applied in rehabilitation settings to enhance recovery from overuse injuries, ultimately helping athletes regain peak performance. In various studies, both core stability training and DNS training have been used for injury prevention, to improve deformity, and to increase motor and sports performance. However, the effects of these two methods on valgus angle and motor function screening have been studied less, and fewer accurate comparisons have been made between their effectiveness. This research aimed to investigate and contrast the effects of core stability exercises and the DNS method on knee valgus and motor function in students between the ages of 9 and 14.

Materials and Methods

The current study was quasi-experimental and included two experimental groups (DNS training and core stability training) and a control group. Sixty female school students from Tehran (aged 11 to 14 years old) were selected as samples and randomly assigned into three groups of 20 participants: the experimental group, which included core stability (n=20) and DNS (n=20), and the control group (n=20). The inclusion criteria included the age range of 11 to 14 years, having genu valgum, and studying at schools in Tehran. The exclusion criteria were failure to complete the measurement steps and pre-test and post-test processes, irregular participation in training sessions, absence from more than two sessions, pain at rest, injury during treatment or training activities, insufficient cooperation, and withdrawal during the research [8].

The FMS kit was also used to assess students' movement functions. The test consists of seven steps, including the full squat (deep squat) test, hurdle steps, in-line lunges, shoulder mobility, active straight-leg raise, trunk stability push-up, and rotary stability, along with three cleaning tests. The necessary explanations and instructions for implementing each movement pattern were provided to each test participant before the test was performed, and the test was administered once. The scoring method was a 0-3 scale for each movement pattern: performance without compensatory movement receives a score of three; performance with compensatory movement received a score of two; inability to perform and return to the initial state received a score of one; and performance with pain received a score of zero. Total scores across seven performances were considered the individual's score on the screening test [6]. The Q angle was found by drawing a line from the middle of the patella to the front upper part of the anterior superior iliac spine and a second line from the tibial tubercle that connects through the center of the patella. The point where these two lines intersect represented the Q angle. AutoCAD software was used to measure the Q angle after taking images with a digital camera [20].

Once the pre-test phase concluded, both the core stability and DNS groups followed their designated training plans for six weeks, meeting three times a week. In brief, the exercises that the DNS group performed included diaphragmatic breathing, baby rock (lying on the back with knees bent), movements while on the stomach, rolling, exercises while lying on the side, sitting at an angle, tripod stances, kneeling, squats, and the Czech get up. During the initial week, the emphasis was on training and mastering basic DNS exercises. Each week, a new challenge was introduced to an already familiar movement, gradually increasing the difficulty of the exercises while building on the skills learned in the prior weeks. This step-by-step escalation in task difficulty helped the participants make their performance more automatic. We utilized the dual task approach to determine if the exercises had become automatic (for example, ensuring that adding new tasks did not interfere with diaphragmatic breathing). In essence, the overload principle in DNS training was implemented through increased exercise complexity, whereas traditional fitness training applied it by increasing weights, repetitions, duration, distance, and so forth [18, 21].

The core stability group was trained using the program proposed by Jeffrey [18, 21]. The exercises used included rotational sit-up, front and one-side plank, Superman movement, both leg raise, single leg bridging, sit-up, upper limb and trunk body raise. In this group, similar to the DNS group, the number of repetitions and the exercise intensity during the research period were increased to perform the overload principle. Participants in the intervention groups conducted core and DNS exercises for weeks (Table 1).

Table 1. Core strength training program

Program	Weeks 1-6
Warm-Up, 1.3-Km jogging	15 min
Leg raise	1 set: 12 repetitions
Crunch	1 set: 60 s
Superman	3 sets: 60 s
Plank hip twist	1 set: 60 s
Prone-plank	3 sets: 60 s
Side-plank (both sides)	3 sets: 60 s
Supine bridge	30 s
Stretches	
Quadriceps	30 s
Hamstring	30 s
Calf stretches	30 s
Latissimus dorsi	30 s
Hip muscles	30 s
Pectorals/biceps	30 s

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Finally, after completing the six-week core stability training and DNS training protocols in the experimental groups, the post-test phase was implemented, during which the knee valgus angle was re-examined by students using Q-angle measurement and motor function using FMS.

Statistical methods for both description and inference were used to review the collected data. To check if the data followed a normal distribution, the Shapiro-Wilk test was conducted. A one-way analysis of variance (ANOVA) was used to look at differences among the groups. The least significant difference (LSD) post hoc test was then carried out to compare the means between pairs. Furthermore, a paired t-test was applied to examine changes from the pre-test to the post-test, with a significance level established at ($P\leq0.05$).

Results

Table 2 presents the demographic data of the participants. The Shapiro-Wilk test indicated a normal distribution. The findings from the paired t-test indicated a significant difference between pre-test and post-test in the knee valgus variable ($P=0.001$) in both the DNS and core stability groups, and motor function ($P=0.001$). However, no significant difference was observed between the pre-test and post-test results in the control group (Table 3).

Tables 4 and 5 present the ANOVA and subsequent post hoc test results. The results of the one-way ANOVA indicated a statistically significant difference among the groups (core stability training, DNS, and control groups) regarding the valgus variable and motor function ($P\leq0.05$). However, no significant differences were observed between the two experimental groups ($P\geq0.05$). The LSD post hoc test revealed a significant difference between the DNS training and core stability groups compared to the control group ($P\leq0.05$). In contrast, no significant difference was found between the DNS training group and the core stability training group.

Discussion

The findings indicated that six weeks of core stability exercises and DNS effectively enhanced motor function quality, as assessed by FMS scores, and reduced knee valgus angle. However, the inter-group comparison revealed no significant differences between the two groups

Table 2. Demographic information of the subjects (n=20)

Variables	Groups	Mean±SD	F	Sig.
Age (y)	DNS	12.1±1.88	1.209	0.305
	Core stability	11.05±2.54		
	Control	11.5±1.93		
High (cm)	DNS	142.95±4.05	0.131	0.878
	Core stability	143.55±7.45		
	Control	142.55±6.65		
Weight (kg)	DNS	44.85±5.76	0.129	0.879
	Core stability	45.4±5.44		
	Control	44.5±5.72		
Body mass index (kg/m²)	DNS	20.65±2.73	0.648	0.655
	Core stability	21.15±2.23		
	Control	20.45±2.41		

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regarding the research variables. The similarities in the characteristics of these two exercise methods likely contributed to the comparable results. The findings of this study, which aimed to enhance the FMS test scores after a six-week program of core stability exercises, align with the outcomes of research conducted by Chang et al. [22], Rahimi et al. [15], and Daneshjoo et al. [23]. Chang et al. assessed the effects of a six-week core stability training program, implemented as a warm-up in physical education classes, on the physical fitness, motor abilities, and balance of schoolchildren. The study's results indicated that incorporating core stability exercises into the warm-up routines significantly improved the motor function scores on the FMS. Therefore, the authors proposed that these exercises should be integrated into the regular warm-up routines of physical education classes for children [22]. Rahimi et al. conducted a study to examine the impact of central and neuromuscular stability exercises on the FMS of male wrestlers aged 11 to 14. The findings indicated that both forms of exercise significantly improved the FMS results for the wrestlers, though no substantial differences were observed between the two groups. Consequently, it is recommended that coaches incorporate these exercises into wrestlers'

Table 3. Differences from pre-test to post-test

Variables	Groups	Mean±SD		Mean Differences	T	df	Sig.
		Pre-test	Post-test				
Functional movement	DNS	13.10±1.41	17.80±1.47	4.7	-11.261	19	0.001*
	Core stability	12.95±2.32	17.35±1.95	4.4	-8.148	19	0.001*
	Control	12.90±2.3	13.55±1.19	0.65	-1.285	19	0.214
Knee valgus	DNS	19.80±3.76	15.05±4.16	-4.75	9.667	19	0.001*
	Core stability	20.6±2.79	17.05±2.7	-3.55	13.330	19	0.001*
	Control	19.75±2.95	19.55±2.39	-0.2	0.677	19	0.507

*Significance.

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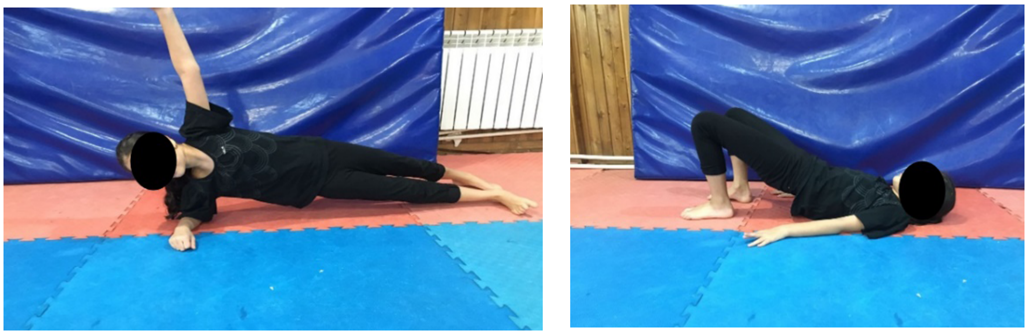

Figure 1. Examples of core stability exercises

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conditioning programs, given the crucial role of the FMS in pre-season evaluations and in preventing sports injuries [15]. Daneshjoo et al. investigated how core stability exercises affect balance and motor performance test scores of teenage soccer players. The study found that these exercises led to substantial improvements in both static and dynamic balance and improved FMS among football players [23].

Our findings suggest that DNS training, due to its comprehensiveness, simultaneous involvement of the lower and upper limbs and trunk, increased muscle strength of the lower limbs, including the thigh muscles and around the knee, the use of appropriate recruitment patterns to perform functional tasks, improving the range of motion of the hip, knee, and ankle joints, and increased neuromuscular coordination have been able to have more impact on FMS test scores and decreased knee valgus angles than core stability method; however, this difference was not statistically confirmed. With a focus on factors, such as valgus control of knee dynamics, increased knee and thigh flexibility during functional movements can

Table 4. Results of one-way analysis of variances

Variables		Sum of Squares	df	Mean Square	F	Sig
Functional Movement	Between groups	218.033	2	109.017	44.165	0.001*
	Within groups	140.7	57	2.468		
	Total	358.733	59			
Knee Valgus	Between groups	203.333	2	101.667	10.046	0.001*
	Within groups	576.85	57	10.12		
	Total	780.183	59			

*Significance.

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Table 5. Results of post hoc LSD test

Variables	(I)Group	Group	Mean±SE	Sig.
Functional movement	DNS	Core stability	0.45±0.496	0.369
		Control	4.25±0.496	0.001*
	Core stability	Control	3.8±0.496	0.001*
Knee valgus	DNS	Core stability	-2.01±1.005	0.052
		Control	-4.5±1.005	0.001*
	Core stability	Control	-2.5±1.005	0.001*

*Significance.

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probably provide safe, desirable movement patterns that ultimately improve this imbalance, proprioception, and motor function in the long term [24]. DNS exercises involve various levels of movement in the upper and lower extremities, the core area of the body, breathing and diaphragm function, along with coordinated activation of the diaphragm, transversus abdominis, pelvic floor, and multifidus muscles to enhance postural stability [25]. It is possible that the DNS method could increase strength at the beginning of DNS exercises by improving the neuromuscular coordination within the muscles. Possible reasons for improving balance through muscle strength include increasing the neural mechanisms caused by exercise, such as the use of more efficient neuromuscular units, reorganization in the sensory motor cortex, increasing the efficiency and strength of synaptic communication, increasing the activation of the nervous system, reducing neural inhibitory reactions, reducing the resistance of neural pathways to impulse transmission, and improving and facilitating the transmission of events within each of the senses [25, 26]. DNS exercises are beneficial because they enhance strength, flexibility, range of motion, and overall physical fitness, owing to the considerable diversity in motor skills across various movement patterns. One of the limitations of the present investigation was that the participants were selected conveniently and from a district of Tehran. Based on the present study, it is suggested that core stability and DNS exercises should be performed on postural abnormalities of the lower limbs in other subjects and this study should be conducted in a larger range of people.

Conclusion

Based on the findings of this research, both training methods seem to have improved knee valgus angle and FMS scores to the same extent. Therefore, physical education teachers and elementary trainers should use these exercises during physical education programs.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them. A written consent has been obtained from the subjects. principles of the Helsinki Convention was also observed.

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Authors' contributions

Data collection and investigation: Fatemeh Nasiri and Amir Reza Gharakhanloo;Supervision: Mohammad Rahimi; Data analysis and writing: All authors.

Conflict of interest

The authors declared no conflict of interest.

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