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

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To appear in: ***Physical Treatments***

Received date: 2024/02/2

Revised date: 2025/03/12

Accepted date: 2025/09/28

First Online Published: 2025/10/08

Please cite this article as:

Rahimi M, Nasiri F, Gharakhanloo AR. Comparison of the Effect of Core Stability and Dynamic Neuromuscular Stabilization Training on Knee Valgus and Motor Function in Students. ***Physical Treatments.*** Forthcoming 2026. DOI: http://dx.doi.org/10.32598/ptj.2026.542.4

DOI: http://dx.doi.org/10.32598/ptj.2026.542.4

Abstract

Purpose: The objective of this research was to compare the impact of core stability and Dynamic Neuromuscular Stabilization training (DNS) on knee valgus and motor function of -۱۱-۱۴year-old students.

Methods: This research was quasi-experimental design. For this reason, ۶۰female students from Tehran (average age of ۱۱٫۵ years) were selected as the participant of this research, and they were randomly divided into three groups, core stability training, DNS training, and control. Knee valgus and movement function were measured by Q angle and functional movement screening test before and after the intervention. The subjects of the experimental groups did the exercises for ۶weeks and ۳sessions every week so that each session was 60 minutes. One-way analysis of variance, LSD post hoc test was utilized to compare the groups, while the paired t-test was employed to assess the effects within each group.

Results: The results of the present research demonstrated that there was a notable difference between the functional movement screening test scores and knee valgus angle in the two experimental groups (DNS exercises and core stability exercises) with the control group. However, no noteworthy difference was observed in the comparison of scores between the two experimental groups.

Conclusion: overall, it can be concluded that both DNS and core stability training significantly improve scores on functional movement screening tests and decrease the knee valgus angle.

Keywords: core stability training, dynamic neuromuscular training, knee valgus, functional movement screening test

Highlights

- Based on the research, it's important to highlight that one of the latest techniques in exercise rehabilitation is the dynamic neuromuscular stabilization method. This approach not only focuses on muscle strengthening but also incorporates the nervous system.
- There is not enough solid proof to evaluate how core stability training and dynamic neuromuscular stabilization affect knee valgus and motor function.

Plain Language Summary

In various studies, both core stability training and DNS training methods have been used to injury prevention and improve deformity and increase motor and sports performance. However, the effects of these two methods on valgus angle and motor function screening have been less studied and less accurate comparison has been made between the effectiveness of these two methods. This study aimed to assess how core stability and Dynamic Neuromuscular Stabilization methods affect knee valgus and motor function in children between 9 and 14 years old.

Introduction

when the foot is in aligned straight in 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 have a negative effect on 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 load during both static and dynamic movements, playing a crucial role in balancing and functioning of the lower limbs. Genu valgum, is a common orthopedic issue among children and adolescents. (4). Increasing the angle of the knee joint (valgus) is companion with changes in the normal direction of the lower limb posture, in turn, causes changes in the location of the center of gravity relative to the base of support, limiting the control of balance and function of the mankind (5).

Today mechanical and sedentary life style not only causes skeletal abnormalities, but also makes movement disorders in students. Researchers have developed tools for evaluation more comprehensive patterns of movement and focus on evaluating a comprehensive motor pattern for Injury Prevention. One of these methods is the functional movement screening test (FMS), 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 both be effective in improving postural deformities and can also improve a person's motor function (8,9). Studies in students showed various training and treatment methods were performed, 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 suggest that weakness or lack of muscular endurance of the core stabilizer muscles can be counted as a factor that cause kinetic instability on the lower limbs (10). When the strength of the core stabilizing muscles is low, it leads to less effective movement pattern s. 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 stated that children has less lower muscle strength in the core area of their body compared to adults (12). Core stability exercises are used as motor control and muscle capacity in the central area of the body, for it maintains 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 effect 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's 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 Dynamic neuromuscular stabilization (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 (DK). Increasingly recognized in the realms of rehabilitation and sports performance, DNS is effective in addressing overuse injuries and preventing further harm. This overview seeks to explore the foundations of dynamic neuromuscular stabilization and illustrate how it can be applied in rehabilitation settings to enhance recovery from overuse injuries, ultimately aiding athletes in regaining peak performance. In various studies, both core stability training and DNS training methods have been used to injury prevention and improve deformity and increase motor and sports performance. However, the effects of these two methods on valgus angle and motor function screening have been less studied and less accurate comparison has been made between the effectiveness of these two methods. The aim of this research was to investigate and contrast the effects of core stability exercises and the Dynamic Neuromuscular Stabilization method on knee valgus and motor function in students between the ages of 9 and 14.

Materials and methods

The current study was of a semi-experimental nature and had two experimental groups (DNS training and core stability training) and a control group. For this, 60 female school students from Tehran (age 11 to 14 years of old) were selected as samples and randomly assigned in three groups of 20 participants, Experimental Groups were core stability (n=20) and DNS (n=20) and control group (n=20). Inclusion catteries were age range of 11 to 14 years, having Genu valgum and studying at schools in Tehran. The exclusion criteria were failure to completing the measurement steps and the pre-test and post-test process, irregular participation in training sessions and absence of more than 2 sessions, pain at rest, injury during treatment or in training activities, insufficient cooperation and participation withdrawal during the research (8).

The FMS kit was also used to determine the movement functions of students. 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 test. The necessary explanations and instructions for the implementation of each movement pattern were given to each test before the test was carried out and the test was taken once. The scoring method is 0 to 3 scales for each movement pattern, performance without compensatory movement receives a score of three, the performance with compensatory movement of a score of two, the inability to perform and return to the initial state of a score of one, and the performance with pain receives a score of zero. Total scores in 7 performances were considered to be the individual's score on the screening test [46]. The Q angle is 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 represents the Q angle. AutoCAD software used to measure Q angle after taking images with digital camera.

Once the pretest phase concluded, both the core stability group and the DNS group followed their designated training plans over a period of six weeks, meeting three times a week. In brief, the exercises that the DNS group performed included: diaphragmatic breathing, Baby Rock (lying on 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 (CGU). During the initial week, the emphasis was on training and mastering basic DNS exercises (specific details about the movements can be found in appendices C and D). Each week, a new challenge was introduced to an already familiar movement, gradual ly increasing the difficulty of the exercises while building on the skills learned in the prior weeks. This stepbystep escalation in task difficulty helped the participants to make their performance more automatic.
We utilized the dualtask 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 applied through enhancements in exercise complexity, whereas traditional fitness training applied it by elevating weights, repetitions, duration, distance, and so forth. (18,21).

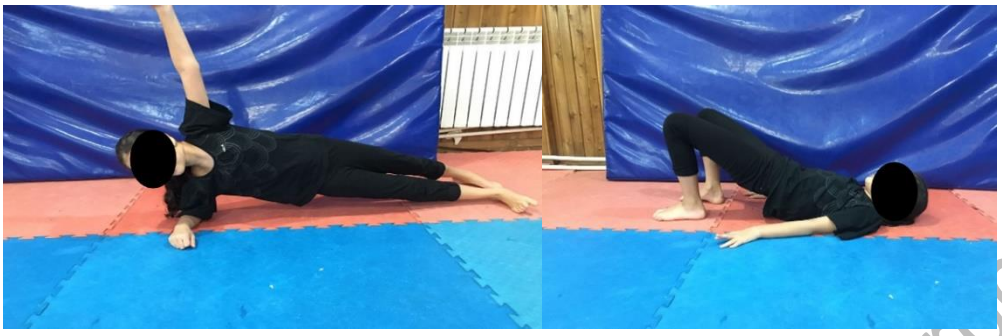
For the core stability group, the training program proposed by Jeffrey was used (18, 21). That the exercises used included rotational sit-up, front and one-side plank, Superman movement, both leg raise, single leg bridging, sit up, upper limb and trunk body raise. In this group, similar to the DNS group the number of repetitions of the exercise and its intensity during the research time were increased to perform overload principle.

Participants in the intervention groups conducted exercises of core and DNS 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 repetition
CRUNCH	1 set: 60s
SUPERMAN	3 set: 60s
PLANK HIP TWIST	1 set: 60s
PRONE-PLANK	3 set: 60s
SIDE-PLANK (BOTH SIDES)	3 set: 60s
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

Examples of core stability exercises



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

Statistical methods for both description and inference were used to review the collected data. To check if the data followed a normal distribution, the ShapiroWilk test was conducted. A oneway analysis of variance, or ANOVA, was used to look at differences among the groups. The LSD postho c test was then carried out for comparing means between pairs. Furthermore, a paired ttest was applied to examine changes from the pretest to the posttest, with a significance level established at ($P \leq 0.05$).

Results

The demographic data of the participants is presented in Table 1. The outcomes of the Shapiro-Wilk test showed normal distribution. The findings from the paired t-test indicated that there was a notable difference between pre-test and post-test in the knee valgus variable ($p=0.001$) in both the DNS group and the core stability group, and motor function ($p=0.001$). however there was no noteworthy difference between the pre-test to post-test results in the control group (table 3).

Table 2. Demographic information of the subjects

Variables	groups	numbers	mean	SD	F	sig
Age (years)	DNS	20	12.10	1.88	1.209	0.305
	Core stability	20	11.05	2.54		
	control	20	11.50	1.93		
High (cm)	DNS	20	142.95	4.05	0.131	0.878
	Core stability	20	143.55	7.45		
	Control	20	142.55	6.65		
Weight (kg)	DNS	20	44.85	5.76	0.129	0.879
	Core stability	20	45.40	5.44		
	control	20	44.50	5.72		
Body mass index	DNS	20	20.65	2.73	0.648	0.655
	Core stability	20	21.15	2.23		
	Control	20	20.45	2.41		

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

variables	groups	Pre-test (x±sd)	Post-test (x±sd)	Mean differences	T	df	sig
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±2.30	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	20.60 ± 2.79	17.05 ±2.70	-3.55	13.330	19	*0.001
	Control	19.75 ± 2.95	19.55 ± 2.39	-0.2	0.677	19	0.507

significance*

The findings from the analysis of variance and subsequent post hoc tests are presented in Tables 4 and 5. The results from the one-way ANOVA indicated a statistically significant difference among the groups (core stability training, DNS and control group) regarding the valgus variable and motor function ($p \leq 0.05$). however, there was no significant difference observed between the two experimental groups ($p \geq 0.05$). the outcomes of the LSD post hoc test revealed a significant distinction between the DNS training group and the core stability group when compared to the control ($p \leq 0.05$). In contrast, no significant difference was found between DNS training group and core stability training group.

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	140.700	57	2.468		
	Total	358.733	59			
Knee valgus	Between groups	203.333	2	101.667	10.046	*0.001
	Within groups	576.850	57	10.120		
	Total	780.183	59			

*significance

Table 5. Results of post hoc LSD test

variables	group(I)	group	Mean differences	Standard error	sig
Functional movement	DNS	Core stability	0.45	0.496	0.369
		control	4.25	0.496	*0.001
	Core stability	control	3.80	0.496	*0.001
Knee valgus	DNS	Core stability	-2.01	1.005	0.052
		control	-4.50	1.005	*0.001
	Core stability	control	-2.50	1.005	*0.001

*significance

Discussion

The findings indicated that six weeks of core stability exercises and Dynamic Neuromuscular Stabilization (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 regarding the research variables. Its likely that the similarities in the characteristics of these two exercise methods contributed to the comparable results. The findings of this study, which aimed to enhance the FMS functional movement screening 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] Daneshmandi 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 in to the warm-up routines significantly improved the motor function scores on the functional movement screening (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 and his team conducted a study to examine the impact of Central and neuromuscular stability exercises

on the functional movement screening (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 wee observed between the two groups. Consequently, it is recommended that coaches incorporate these exercises into the conditioning programs for wrestlers, considering the crucial role of the FMS in pre-season evaluations and preventing sports injuries. [15] Daneshmandi et al. investigated how core stability exercises affect balance and motor performance test scores of teenage soccer players. the study found that these exercises lead to substantial improvements in both static and dynamic balance, along with enhancing the scores on the functional movement screening (FMS) for football players. [23]

It is also likely 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, 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 focus on factors such as valgus control of knee dynamics, increased knee and thigh flexibility during functional movements can probably provide safe and 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... [25] it is possible that DNS method could increase strength at the beginning of DNS exercises by the neuromuscular coordination developed 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 convenient and from a district of Tehran. Based on the present study, it is suggested that core stability and dynamic neuromuscular stabilization exercises should be performed on postural abnormalities of the lower limbs in another subjects and it is also suggested that this study be done in a larger range of people.

Conclusion

Based on the findings of this research, both training methods seem to have improved the angle of the knee valgus and the FMS scores to the same extent. It is therefore suggested that physical education teachers and elementary trainers use these exercises during the physical education program.

Ethical Considerations

Financial support

This study did not receive any financial support from funding bodies in the public, private, or charitable sectors.

Contributions of Authors

All authors conducted data analysis and writing, which involved reviewing and editing. The data collection and investigation were done by Fatemeh Nasiri and Amir Reza Gharakhanloo. Mohammad Rahimi offered supervision.

Conflict of interest

The writers stated that there are no conflicts of interest.

Acknowledgments

This article is derived from a master's thesis conducted in the Department of Physical Education and Sports Sciences at the Tehran Science and Research Branch of Islamic Azad University. The contributions of everyone who assisted in conducting this research are greatly appreciated.

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