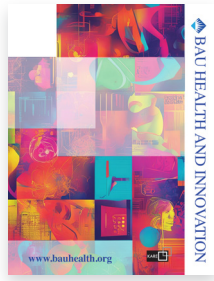
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Review

The Role of Dynamic Neuromuscular Stabilization Exercises in the Rehabilitation Process: A Traditional Review

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Abstract

Dynamic neuromuscular stabilization (DNS) is an approach based on developmental kinesiology and aims to optimize postural control, movement patterns, and musculoskeletal functions. DNS focuses on the synchronized activation of the pelvic floor, diaphragm, transversus abdominis, and multifidus muscles to provide spinal stabilization. In the literature, DNS has been shown to be an effective method for improving postural control, pain management, and motor functions in orthopedic, sports, pediatric, and neurological rehabilitation. From a developmental kinesiology perspective, DNS addresses motor control levels at spinal, subcortical, and cortical levels. Based on the developmental patterns of motor functions in early childhood, it works on the correct activation and coordination of the muscles that stabilize the spine. This provides a basis for developing postural control and motor skills in children, and for reorganizing movement patterns in neurological disorders. In orthopedic rehabilitation, DNS improves movement patterns by addressing problems such as muscle weakness and postural disorders. In sports rehabilitation, DNS reduces injury risks by increasing core stabilization and optimizing athletic performance. In pediatric rehabilitation, DNS supports children's motor control and postural stability, contributing to their social, cognitive, and emotional development. It has been reported that DNS improves musculoskeletal system functions and increases quality of life, especially in children with neurological developmental delays. In neurological rehabilitation, DNS is used to improve balance, postural control, and functional independence in neurological disorders. In conclusion, DNS exercises are a holistic approach that addresses not only the symptoms but also the root causes of movement disorders in rehabilitation processes.

Keywords: Core stabilization, developmental kinesiology, dynamic neuromuscular stabilization, rehabilitation.

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Dynamic neuromuscular stabilization (DNS), developed by Professor Pavel Kolar, is a therapeutic approach based on the foundations of developmental kinesiology.[1] All movements work with the integration of the locomotor system, and are strengthened subcortically with spinal segmental activities to ensure postural stabilization. This system, which is based on the stable movement of the spine, focuses on coordination and power.[2] This system, which uses synkinetic and subconscious activation of the pelvic floor, multifidus, transversus abdominis, and diaphragm to provide stability of the spine and create optimal intra-abdominal pressure, is rapidly gaining acceptance in musculoskeletal rehabilitation and injury prevention.[1,3]

The word core is defined in the literature as the center of the body.[4] The concept of core, which has different definitions, has been defined as a powerhouse by

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Akuthota and Nadler[5] and as a box or double-layered cylinder by Richardson et al.[6] The core region is a region consisting of 29 pairs of muscles that stabilize the pelvis and spine during movements, consisting of the abdominal muscles in the front, the gluteals and paraspinals in the back, the diaphragm above, and the hip and pelvic floor muscles below. Without the core region and the muscles located here, the spine cannot maintain its stability against resistance.[7]

Core stabilization training is a method designed to increase the strength of the core muscles and improve body balance.[8] Core stabilization training consists of two main components: static and dynamic movements.[9] Dynamic exercises increase the ability to maintain stability during position changes, resistance changes, or rotations, whereas static exercises focus on maintaining posture under resistance.[10] Golsefidi et al.[11] proved in their study that lumbopelvic stabilization increases with regularly performed core stabilization exercises, thus reducing stress on the spine and reducing the risk of injury to the lumbar muscles. Neuromuscular disorders occurring in the core region can trigger unstable behaviors and injuries at all levels of the kinetic chain.[12] Devlin[13] reported in the study that muscle fatigue occurring in the abdominal muscles causes hamstring injuries. While adequate core stabilization plays a role in maintaining balance, core strength and correct posture are very important for balance ability. In a body supported by proper posture alignment and sufficient core strength, core strength and correct posture play a therapeutic role in chronic low back pain.[14]

The aim of this study is to explain the DNS method and to contribute to future studies based on the DNS exercise studies in the literature. There is no study in the literature investigating the effects of DNS exercises in different rehabilitation areas. Our study aims to fill this gap in the literature, and it is important to shed light on future studies.

Materials and Methods

The keywords in our study were searched using Google Scholar, PubMed, and MEDLINE databases. The keywords used were DNS, developmental kinesiology, core stabilization, and rehabilitation. Our study is a review, and therefore, appropriate evidence was selected and compiled according to the flow of the study. This review was created within the scope of the Musculoskeletal Rehabilitation course of the Physiotherapy and Rehabilitation Doctorate program of Bahcesehir University Graduate Education Institute.

Research Results and Findings

Developmental Kinesiology

Developmental kinesiology is based on the fact that the development of motor functions occurs in early childhood. DNS addresses and treats the harmonious functioning of joints, posture, and respiration.[15] The foundations of developmental kinesiology are based on sensorimotor control at three levels: the spinal level, the subcortical level, and the cortical motor control level.[1] Sharma and Yadav[16] reported that while general movements occur at the spinal level, at the subcortical level, the synergistic activation of the pelvic floor, diaphragm, abdominal wall, and spinal extensors occurs before the extremity movements. At the cortical motor control level, the development of the movement pattern occurs.[16] Genetically determined motor functions present a predictable pattern in early childhood in humans. The movement pattern, which changes and develops with the development of the central nervous system, continues to form. In this way, the baby is allowed to control their posture, maintain their verticalization against gravity, and use their necessary muscles in the best way for all these purposes.[16]

DNS Exercises in Orthopedic Rehabilitation

Mascal et al.[17] reported in their study that strengthened core muscles in individuals with patellofemoral pain syndrome showed significant improvements in lower extremity functions.

Shin et al.[18] investigated the effects of isometric chin-tuck exercise and dynamic neuromuscular exercise method on muscle tension of neck flexors and posture during sitting in people with forward head posture, and as a result of the study, they proved that the group doing DNS exercises had better results. Ross[19] investigated the effects of a 12-week DNS exercise program in a case study conducted on a person with chronic low back pain. He reported that DNS exercises provided stabilization with the increase in intra-abdominal pressure and thus protected the spine with the reduced load of the lumbar region.

Cha et al.[20] investigated the effects of the DNS method on core instability with bilateral straight leg tests in young people with core instability. As a result of this study conducted with 20 people, it was proven that the tests performed at the end of the study yielded more successful results than at the beginning.[20]

DNS exercises stand out as an effective approach in orthopedic rehabilitation in terms of providing postural control, improving musculoskeletal functions, and pain management. While orthopedic problems are associated with muscle weakness, posture disorders, and instability,

DNS aims to reorganize movement patterns by getting to the root of these problems. Studies by Mascal et al.[17] on patellofemoral pain syndrome have shown that strengthened core muscles provide significant improvements in lower extremity functions. These findings emphasize the critical role of core stabilization in lower extremity control and biomechanical load distribution.[17]

As a result, DNS exercises stand out as an effective and holistic intervention method in orthopedic rehabilitation processes. Core stabilization, reducing the load on the joints, and optimizing posture are among the main goals of DNS. This method provides long-term improvement by addressing not only the symptoms but also the origin of movement disorders in the treatment of musculoskeletal disorders. DNS increases the effectiveness of orthopedic rehabilitation programs by offering a personalized and functional approach, and allows individuals to move more independently and painlessly in their daily life activities.

Neuromuscular Stabilization Exercises in Athlete Rehabilitation

Core stabilization is very important for maintaining or increasing athletic performance at an optimum level.[21] In the literature, core stabilization has been defined as the dynamic control of the hip-lumbopelvic complex, which provides torque and momentum transfer to the upper and lower extremities in movements requiring gross motor skills in daily life, sports, and during exercise. During functional tasks, the core muscles are activated before the activation of the extremities to create a stable foundation in the extremities. In addition, studies have shown that the strength of the core muscles is effective in reducing the loads on the joints and controlling the direction in the lower extremities.[22] Larwa et al.[23] reported in their systematic review that weak core stabilization, weak hip abduction, increased knee valgus, and landing on the heels may increase the risk of anterior cruciate ligament injury in young athletes.[23]

Core muscles are at the base of all kinetic chains in the body and have an impact on physical performance as they are responsible for the generation and transmission of force throughout the body. Yörükoğlu et al.[24] stated in their study that adding core stabilization exercises to rehabilitation programs can yield effective results. In addition, current publications have mentioned the importance of increasing core stability in preventing shoulder injuries, and that core stabilization is one of the factors involved in shoulder kinematics.[25,26]

In a study conducted by Jebovy et al.[27] with 20 female futsal players in sports rehabilitation, the effects of core strengthening exercises and DNS exercises were investigated, and as a result of the 6-week study, significant results were obtained in the side plank, intra-abdominal pressure, and trunk flexion measurements of DNS exercises compared to the core strengthening group.[27] In a study conducted with elite rowing athletes, it was shown that 6 weeks of DNS training caused significant increases in rowing power.[28] In another study conducted with elite baseball players, 12 weeks of DNS exercises and TheraBand exercises were examined in shoulder joint range of motion, shoulder strength, and ball throwing speed, and positive effects were observed in the ball throwing speed, shoulder internal and external joint range of motion, and shoulder internal and external muscle strength of the participants in the DNS exercises group.[29]

DNS exercises stand out as an effective approach for sports rehabilitation and performance development. Core stabilization plays a vital role in generating and transmitting force by forming the foundation of the body's kinetic chain. Strengthening the core muscles is of critical importance in optimizing athletes' performance and minimizing injury risks. It has been emphasized in the literature that core stabilization increases movement efficiency in a wide range of daily life activities to high-level athletic performance to playing an important role in transferring torque and momentum to the extremities. It has also been stated that core stabilization reduces the loads on the joints and improves directional control in the lower extremities. Weak core stabilization and biomechanical problems, especially in young athletes, can lead to serious athletic injuries such as anterior cruciate ligament injuries.

DNS exercises have been shown to be superior to traditional core strengthening programs in studies across a variety of sports. In female soccer players, DNS provided significant improvements in parameters such as side plank performance, intra-abdominal pressure, and trunk flexion strength. Similarly, in elite rowers, 6 weeks of DNS training resulted in significant increases in rowing power. In a study of elite baseball players, DNS exercises demonstrated positive effects on shoulder strength, range of motion, and ball velocity.

In conclusion, DNS is an important tool in both injury prevention and athletic performance improvement by increasing core stabilization in the sports rehabilitation process. The holistic approach of DNS not only retrains the athlete's movement patterns but also optimizes performance, providing an advantage on the field. The adaptability of these exercises to different sports branches shows that DNS has a wide range of applications and is considered an indispensable method in sports rehabilitation.

DNS Exercises in Pediatric Rehabilitation

Pediatric rehabilitation increases motor performance and provides support and development of children in terms of social, cognitive, and emotional aspects.[30] In newborns, the diaphragm plays the role of the respiratory muscle in the early postural development period.[31] As the central nervous system develops, the sagittal stabilization of the spine, pelvis, and chest matures in 4.5 months, and frontal and transverse stabilization comes next, and movements such as rolling, turning, creeping, and crawling are observed.[32] At approximately 6 months of age, the diaphragm fully fulfills its dual function of postural stabilization and respiratory muscle in coordination with abdominal breathing and the chest. In this way, upright postural stabilization is achieved, and standing, sitting, and walking occur.[33]

DNS is a holistic approach used in pediatric rehabilitation to support the child's motor skills as well as social, cognitive, and emotional development. Early motor skills of children are shaped by the harmonious interaction between the central nervous system and the musculoskeletal system. In this process, it is observed that the diaphragm in newborns plays a role not only in respiratory function but also as a basic component of postural stabilization. With the maturation of the central nervous system, the spine, pelvis, and chest area are stabilized in the sagittal plane, followed by stabilization in the frontal and transverse planes. These stages enable the emergence of motor skills such as rolling, turning, creeping, and crawling.

At approximately 6 months of age, the diaphragm's coordination of both respiratory and postural stabilization functions forms the basis for upright posture. This coordination plays a critical role in achieving developmental milestones such as sitting, standing, and walking. The primary goal of DNS is to optimize the child's motor control and postural stability by reactivating these natural developmental movement patterns. DNS stands out as an effective intervention method for improving musculoskeletal functions, especially in children with neurological or motor developmental delays.

In conclusion, DNS in pediatric rehabilitation is a comprehensive method that responds to the general developmental needs of the child as well as the acquisition of motor skills. Supporting the movement patterns acquired by the child in the early period prepares the ground for skills such as postural control, balance, and functional independence in later ages. When DNS is applied with individualized approaches, it provides a holistic effect that positively affects not only the physical rehabilitation processes but also the child's quality of life. DNS, which is approached from a multidisciplinary perspective, continues to be one of the cornerstones of pediatric rehabilitation.

DNS Exercises in Neurological Rehabilitation

Cerebrovascular diseases are the most important cause of mortality worldwide after cancer and cardiovascular diseases.[34] Stroke and cerebrovascular diseases are the third leading cause of mortality worldwide, affecting approximately 17 million people annually, and have been reported to result in the death of 6 million people.[35] Strokes cause the most functional losses and a decrease in quality of life in individuals worldwide.[36] In the literature, stroke is explained as a neurological syndrome that occurs suddenly with the cessation or decrease in blood flow to a certain area of the brain.[34] It has been observed that individuals who have had a stroke have very poor exercise capacity. The decrease in exercise capacity, together with already reduced mobility, triggers secondary immobility.[37]

In individuals who have had a stroke, balance, body movements, and muscle control are often asymmetrical due to the decreased function of the core region.[38] In these individuals, stabilization is reduced, and decreased joint range of motion, muscle strength, sensation, coordination, cognitive functions, and abnormal muscle tone lead to balance problems.[39]

In stroke patients, the better the trunk supports, the fewer abnormalities in other parts of the body. The trunk acts as a dynamic stabilizer in task-related functions, and since it is effective in contact with the support surface both while sitting and standing, trunk control is very important.[40] The transversus abdominis, multifidus, internal and external obliques, and rectus abdominus are the most important trunk muscles, but the transversus abdominis provides trunk stabilization by working together with the neural system.[41]

The DNS approach has an important place in neurological rehabilitation. While stroke and other cerebrovascular diseases can cause serious loss of motor skills and functional abilities in individuals, DNS stands out as an effective method to reduce these losses. Weak core muscle function, balance problems, and asymmetric movement patterns, which are frequently seen in individuals after stroke, are the basic problems that should be taken into the center of the physical rehabilitation process. Trunk stability and control are necessary for many functions, from daily living activities to advanced motor skills. DNS aims for the trunk stabilizer muscles, especially muscles such as the transversus abdominis and multifidus, to work in integration with the neurological system.

The DNS approach treats the body as a functional whole, based on human developmental movement patterns. This

Table 1. Studies in the field of DNS

Studies	Aim	Number of participants	Participant characteristics	Exercise attempt	Conclusion
Davidek et al.,[28] 2018	To examine the effect of DNS exercise on maximum rowing force and shoulder pain perception	20 male rowers	Elite rowers	30 min of DNS exercises daily, 5 days a week, for 6 weeks	A significant increase in rowing strength was observed after pre-, mid-, and post-tests.
Jebavy et al.,[27] 2020	Comparison of DNS and traditional core strength exercises	20 female futsal athletes	Elite futsal athletes	25 traditional core strength exercises and 6 DNS exercises	After the DNS exercise program, significant improvements were observed in IAP, trunk flexion, and side plank measurements.
Ackerman et al.,[29] 2020	To examine the effects of DNS exercises and TheraBand exercises on shoulder joint range of motion, shoulder strength, and ball-throwing velocity.	18 baseball players	Elite baseball players	TheraBand and DNS exercises 3 times a week for 12 weeks	Positive effects were observed in the ball throwing speed, shoulder internal and external joint range of motion, and shoulder internal and external muscle strength of the DNS group participants.
Son et al.,[43] 2017	To evaluate the effects of DNS application on motor functions, diaphragm movements, and abdominal muscle activation (external oblique, internal oblique, and transversus abdominis) in individuals with cerebral palsy.	15 individuals with diplegic spastic cerebral palsy	Individuals with cerebral palsy	They investigatedthe effects of a 4-week, 3-day-a-week DNS intervention on gait control, gait, and balance.	It was observed that the active muscle chain, including the diaphragm, transversus abdominals, and internal obliques, was effective in providing deep core activation; standing, jumping, and walking were improved in individuals with spastic diplegic CP.
Juehring et al.,[42] 2011	Investigating the effects of DNS in migraine	Case study	Migraine patient with hyperextension of the cervical spine	12 weeks of DNS treatment	It was observed that the head disability score decreased from 48% to 34%.
Shin et al.,[18] 2019	To investigate the effects of isometric chin stretching exercises and DNS exercise method on neck flexor muscle tension and posture during sitting.	43 participants	Patients with a forward head posture and neck pain for at least 6 months	Participants were first given three repetitions of isometric chin stretching exercises for 30 s, then three repetitions of DNS exercises for 30 s.	It has been observed that DNS exercises reduce muscle tension in the neck flexors and improve posture while sitting.
Ross,[19] 2017	To investigate the effect of a 12-week DNS program on pain in a patient with chronic low back pain.	Case study	Male participant with low back pain for at least 3 months	4 days a week, 30 min DNS workout program, for 12 weeks	It was observed that DNS exercises provided stabilization by increasing intra-abdominal pressure, thus protecting the spine by decreasing the load on the lumbar region.
Cha et al.,[20] 2018	To investigate the effects of the DNS method on core instability with bilateral straight leg tests in young people with core instability.	20 Adult Participants	Adult, healthy participants with core instability	After the first tests, all participants were given DNS exercises, and their final tests were examined.	It was observed that the tests performed at the end of the study yielded more successful results than those at the beginning.

DNS: Dynamic neuromuscular stabilization.

method aims to reactivate the individual's postural control mechanisms and increase movement efficiency through motor learning. When problems such as decreased joint range of motion, muscle strength, and coordination after stroke are systematically addressed with DNS, it is possible to improve postural stability in individuals and prevent secondary complications. Supporting neuromuscular control of the trunk muscles, in particular, not only increases balance and mobility but also contributes positively to the individual's quality of life.

In conclusion, DNS offers a complementary approach in the management of functional losses after stroke in neurological rehabilitation. Regaining trunk stabilization and postural control increases the level of independence of individuals in daily life and reduces secondary problems. The individual applicability of DNS allows it to be used in a wide range of both acute and chronic rehabilitation processes. To increase the effectiveness of DNS in post-stroke neurological rehabilitation, a multidisciplinary approach and planning appropriate to the needs of the individual are of critical importance (Table 1).

Discussion

In line with the information obtained as a result of the literature review we conducted within the scope of our study, it has been observed that the DNS exercise method has positive effects on core stabilization, neurological disorders, postural disorders, pediatric rehabilitation, and athlete performance.

In a study conducted by Shin et al.[18] it was proven that DNS exercises reduce muscle tension in the neck flexors and improve posture while sitting in individuals with forward head posture. It was understood that DNS restores postural stabilization, reduces the load on the spine, and corrects muscle imbalances. Similarly, Ross (2017) examined the effects of 12 weeks of DNS exercises in a case with chronic low back pain and stated that DNS provides stabilization in the lumbar region by increasing intra-abdominal pressure, thus helping to protect the spine.[19]

The effectiveness of DNS in improving core stability has also been demonstrated in the study by Cha et al.[20] DNS applications in young individuals with core instability provided significant improvements in bilateral straight leg tests.x These findings show that DNS has a direct effect on muscle strength, postural control, and stabilization.

Evaluating the effect of DNS on maximum rowing strength, Davidek et al.[28] proved that adding DNS-based core stabilization exercises to regular ski exercises 5 days a week for 6 weeks will support shoulder girdle and trunk stabilization. DNS is an exercise method that can increase strength in sports activities.

Juehring et al.[42] reported in a case study they conducted to investigate the effects of DNS in migraine that subjective improvement was recorded after deep neck flexors and core stability activation were applied to a patient with hyperextension in the cervical spine for 12 weeks, and the Head Disability Score decreased from 48% to 34%. Using DNS to activate the cervical muscles in people with migraine and adding core stability to this decreases the pain level of migraine patients, improves their recovery, and provides functional recovery.

Son et al.[43] investigated the effects of DNS intervention applied 3 days a week for 4 weeks on gait control, gait, and balance in their study with 15 individuals with diaplegic spastic cerebral palsy. As a result of this study, in which ultrasound and EMG were also used in the evaluation, they found that the active muscle chain, including the diaphragm, transversus abdominals, and internal obliques, was effective in providing deep core activation; and that standing, jumping, and walking improved in individuals with spastic diplegic CP.[43] This study proved that the DNS method contributes to functional recovery in individuals with CP.

Study Limitation

This study is a review examining the role of DNS exercises in rehabilitation programs. The lack of many studies in the literature on DNS exercises is seen as a limitation of our study.

Conclusion

This research shows that DNS exercises have positive effects on rehabilitation processes. As a result of the literature review conducted within the scope of this study, studies in different areas, in addition to the publications made with the DNS method, will contribute to the literature. It is thought that this review will contribute to future studies.

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