

DYNAMIC NEUROMUSCULAR STABILIZATION AND ITS EFFICIENCY IN SPORTS PERFORMANCE

KATARÍNA REPOVÁ, LIBOR ČIEF

Department of Physiotherapy, Faculty of Health Sciences, Catholic University of Ružomberok, Slovak Republic

ABSTRACT

Key words: Dynamic neuromuscular stabilization. Sport performance. Rehabilitation.

Neuromuscular stability is necessary for optimal sport performance. Stability is not achieved only by abdominal muscles, spine extensors and gluteals, but it is accomplished by precise coordination of these muscles and intra-abdominal pressure by the central nervous system. A primary role of the core muscles stability is to raise the intra-abdominal pressure and to increase the tension in the thoracolumbar fascia. Postural core instability is associated with poor dynamic balance control and with a high risk of injury or fall. Dynamic neuromuscular stabilization (DNS) is a rehabilitative approach to optimize the movement system based upon the scientific principles of developmental kinesiology and provides an effective tool in rehabilitation of sport injuries.

DOI: <https://doi.org/10.24040/sjss.2024.9.1.19-29>

INTRODUCTION

Dynamic Neuromuscular Stabilization (DNS) is a manual and rehabilitative approach to optimize the movement system based upon the scientific principles of developmental kinesiology (DK). The developer of DNS is Professor Pavel Kolar, a Czech physiotherapist who has been influenced by the “greats” of Prague School of Manual Medicine, including Karel Lewit, Vladimir Janda,

Vaclav Vojta and Frantisek Vele. DNS is rapidly gaining attention and acceptance in sports rehabilitation and performance arena for both the recovery from musculoskeletal overuse injuries and in injury prevention (Frank, Kobesova, Kolar, 2013).

DNS therapy is based on developmental kinesiology and the integration of neurophysiology and biomechanical principles in which each purposeful

movement pattern is reinforced by the coordination between every segment required for postural stability (Panse et al., 2020).

The basis for the theories that are included in DK is that development of human motor function in early childhood is genetically pre-determined and follows a predictable pattern. These motor patterns or programs are formed as the central nervous system (CNS) matures, enabling the infant to control posture, achieve erect posture against gravity, and to move purposefully via muscular activity. DK emphasizes the existence of central movement patterns that are inborn and “hard-wired”. For example, an infant does not need to be taught when and how to lift its head up, grasp a toy, roll over, creep, or crawl. All these movement patterns or muscular synergies occur automatically in a specific developmental sequence throughout the course of CNS maturation (Frank et al., 2013).

There is also a strong synchrony between CNS maturation and structural or anatomical development of bones, muscles, and other soft tissues. In short, maturation of the brain influences development of motor patterns, which in turn, influences structural development. This relationship is very apparent in the

presence of a CNS lesion, where this developmental synchrony and muscle coordination are adversely affected. The disturbed muscle coordination, soft tissue, and joint development subsequently alters joint position, morphological development, and ultimately, the entire posture (Frank et al., 2013).

DNS training emphasizes the importance of core stability in movement and sports performance. Improved core stability can lead to better control of movement and reduced risk of injury.

Stability of the spine is dependent on the dynamic coordination of numerous synergist and antagonist muscles for precise control of excessive joint motion while allowing for the generation of necessary torques for desired multi-joint movement. One parameter for influencing spinal mechanics and stiffness is intra-abdominal pressure (IAP). There is a general consensus that an increase in IAP stabilizes the spine; however, the role of IAP in unloading the spine remains controversial. An increase in IAP has been reported to unload the spine during static and dynamic lifting tasks (Frank et al., 2013).

An increase in the intra-abdominal pressure (IAP) is commonly observed when a large load is placed on the spine

during everyday activities like running, jumping, and lifting.

The function of this increase in pressure is still not well understood. Early hypotheses stated that pressure within the abdominal cavity may provide some load relief to the lumbar spine. Formulation of these hypotheses was based on the concept that pressure, produced within the abdominal cavity exerted a hydrostatic force down on the pelvic floor and up on the diaphragm. This force added tension to the spine, produced trunk extension moment and, therefore, was assumed to reduce spine compression force (Cholewicki, Juluru, McGill 1999). However, many studies following that failed to provide any evidence to support the original IAP hypothesis (Bearn, J.G., 1961; Krag, M.H., Gilbertson, L.G., Pope, M.H., 1984, 1985; McGill, S.M., Norman, R.W., 1987; Nachemson, A.L., Andersson, G.B.J., Schultz, A.B., 1986; Ortengren, R., Andersson, G.B.J., Nachemson, A.L., 1981). A forceful contraction of abdominal muscles is necessary to generate IAP. It seems that the spine compressive forces, arising from such contraction, offset the beneficial action of the hydrostatic forces thought to alleviate spinal compression via IAP (Cholewicki et al., 1999).

Core instability strength training (CIT) involves exercises that are challenging for both trunk muscles and postural control and may thus have the potential to induce benefits in trunk muscle strength, spinal mobility and balance performance (Granacher et al., 2013).

The currently prevailing hypothesis appears to be that IAP provides stability to the lumbar spine (Cresswell, A.G., Oddsson, L., Thorstensson, A., 1994; Marras, W.S., Mirka, G.A. 1996; McGill, S.M., Norman, R.W., 1987; McGill, S.M., Sharratt, M.T., 1990; Tesh, K.M., Dunn, J.S., Evans, J.H., 1987). Mechanical stability of the lumbar spine must be maintained at all times to prevent its buckling and subsequent injuries when the spine is loaded during physical activities (Cholewicki, J., McGill S.M., 1996). The abdominal wall muscles, contracting against the pressurized peritoneal cavity, may stabilize the spine and trunk (Cholewicki et al., 1999).

It is well established that skeletal muscle stiffness is proportional to the muscle force (Cholewicki, J., McGill, S.M., 1995). Therefore, contracting muscles that surround the lumbar spine can increase its stiffness and stability (Gardner-Morse, M., Stokes I.A., 1998, 1998; Cholewicki, J., McGill S.M., 1996). This increase in spine

stability can, theoretically, be accomplished by two mechanisms: antagonistic muscle coactivation (Gardner-Morse, M., Stokes I.A., 1998) and/or an increase in intra-abdominal pressure (IAP). The latter hypothesized mechanism is based on the premise that the increase in the IAP is accomplished by the contraction of the abdominal musculature (Cresswell, A.G., Oddsson, L., Thorstensson, A., 1994; Cresswell, A.G., Thorstensson, A., 1989; Grillner, S., Nilsson, J., Thorstensson, A., 1978; McGill, S.M., Sharratt, M.T., 1990). Because the compressive force of the contracting abdominal wall muscles cancels out the hydrostatic IAP force acting on the spine, the IAP results in non-significant net forces or moments. However, the contracted abdomen constitutes a much stiffer structure that will increase the overall stability of the lumbar spine. An important feature of such a mechanism is the ability to increase spine stability without the penalty of additional erector spinae muscle co-activation (Cholewicki et al., 1999). Inappropriate coordination of trunk muscle recruitment patterns to stabilize the lumbar spine through antagonistic coactivation and IAP may predispose an individual to sustain a low back injury

during a physical activity. Cholewicki, J., McGill S.M., (1996) and McGill, S.M., (1997) proposed an explanation for low back injury based on mechanical stability principles (Cholewicki et al., 1999).

Dynamic neuromuscular stabilization (DNS) is a type of training that focuses on improving movement patterns and neuromuscular control by utilizing developmental kinesiology principles.

DNS training can improve postural control by promoting better alignment of the spine and pelvis, which can improve balance and stability. DNS training aims to optimize movement patterns and biomechanics, which can lead to more efficient and effective movement in sports.

Kayak Paddling

Davidek et al.(2018) showed in their study which purpose was to examine the effect of Dynamic Neuromuscular Stabilization (DNS) exercise on maximum paddling force (PF) and self-reported pain perception in the shoulder girdle area in flatwater kayakers. Twenty male flatwater kayakers from a local club (age = 21.9 ± 2.4 years, body height = 185.1 ± 7.9 cm, body mass = 83.9 ± 9.1 kg) were randomly assigned to the intervention or control groups. During the 6-week study, subjects

from both groups performed standard off-season training. Additionally, the intervention group engaged in a DNS-based core stabilization exercise program (quadruped exercise, side sitting exercise, sitting exercise and squat exercise) after each standard training session. Using a kayak ergometer, the maximum PF stroke was measured four times during the six weeks. All subjects completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire before and after the 6-week interval to evaluate subjective pain perception in the shoulder girdle area. Initially, no significant differences in maximum PF and the DASH questionnaire were identified between the two groups. Repeated measures analysis of variance indicated that the experimental group improved significantly compared to the control group on maximum PF ($p = .004$; Cohen's $d = .85$), but not on the DASH questionnaire score ($p = .731$) during the study (Davidek, Andel, Kobesova, 2018).

Studies suggest that the most common painful syndromes during a season of competitive flatwater kayaking are the shoulder impingement syndrome, tendinitis of the long head biceps, and herniation of the lumbar disk (Hagemann et al., 2004; Hensel et al., 2008; Pelham et

al., 1995). According to Pelham et al. (1995), the cumulative effect of poorly structured resistance training may ultimately result in a painful syndrome called the paddler's shoulder. Different approaches and treatment strategies have been proposed to prevent and treat painful syndromes resulting from the repetitive strain during flatwater kayaking. Common painful syndromes are usually treated by stretching and rotator cuff strengthening exercises (Anderson and Anderson, 2010; Mei-Dan and Carmont, 2013). However, the ultimate goal of a treatment approach should not only consist in getting the kayaker out of current pain, but rather to prevent repetitive strain, increase strength, and promote sport performance (Brolinson et al., 2012).

Davidek et al. (2018) found out in their study that incorporating the DNS approach into traditional flatwater kayak training may lead to positive gains in maximum PF. The gains in PF are most likely to result in improved trunk and shoulder girdle stabilization. This is crucial for the prevention of athletic injuries and for optimal performance.

Race walking

Race walking is an endurance activity that quint essentially needs technical ability to

walk at a breakneck speed. It is the mid gait between normal walking and running. According to the International Association of the Athletic Federation (IAAF), race walking is an activity that requires the athlete to progression with steps taken in a way that the walker makes contact with the ground. The leading leg should be straightened until it attains a vertical upright position. Race walking creates positive effects on cardiovascular risk factors, types of injuries, and the biomechanical alterations; however, race walking is not an activity without risk and has also been associated with musculoskeletal injuries (Hanley, Bissas, a Drake 2013; Panse et al., 2020).

According to the rules of race walking given by IAAF: A) during the toe-off phase, the toe must stay in contact with the ground until and unless the heel strike of other extremity occurs. B) The stance extremity should be straightened (knee hyperextension) from the initial contact and maintained until the acceleration occurs. These rules cause the hyperactivity of gluteus Maximus (hip extensor) to maintain the contact in the end phase, Gastrocnemius (maintains knee hyperextension). Along with this, to maintain the fast pace of walking, RW needs to perform increased knee flexion

during the swing phase as compared to the knee flexion in normal walking, so that is the moment of inertia of leg decreases (Avila, Ana C. D. Kalvdianos, Eliance F. Manfio. 1998; Martinopoulou K, Argeitaki P, Paradisis G, Katsikas C, Smirniotou A. 2011; Palamarchuk R. 1998). Norberg, Jaclyn D. (2015), in one of his study, gave the brief description of the RW gait along with its kinematics and kinetics, according to this; during race walking, there is excessive hip adduction to assist walking in a straight line and control the speed of walking (Panse et al., 2020).

Panse et al.(2020) aimed their study to find the effect of DNS therapy VS parachute resistance on the performance level of the national level race walkers. Total forty race walkers (20 male and 20 female) between the age group of 18-29 years (mean: 20.38). The race walkers had a mean stature of 164.72 m and a weight of 20.25 kg. The study was completed using a stratified sampling technique with the experimental research-based study design. The athletes participating in the study should not have any fractures within a year. Participants were divided into two groups, Group A and Group B. The groups consisted of 20 participants each. They were verbally interviewed for demographic data, which included the

height, weight, BMI, years of practicing, level of competition, etc. Subjects also answered questions regarding personal information and training volume, specifically, experience in RW, weekly training volume, and best time in RW. Pre-treatment assessment of **VO2max** and speed was done using the following outcome measures: Cooper test and sprint test, respectively. Participants in group A underwent Dynamic Neuromuscular Stabilization Technique, and group B underwent a Parachute resistance training program for improving the endurance and performance level. The thirty minutes session daily for four weeks for core stabilization and improving the performance level using DNS protocol and Parachute training was given, and post-treatment assessment of all the parameters was done. The results in this revealed that both types of training could considerably improve distance, VO2max, and speed of race walkers. The study concluded that DNS therapy and Parachute resistance training are equally effective in improving the core stability and performance level in race walkers (Panse et al., 2020).

Volleyball

Konecny et al. (2017) conducted the study aimed to investigate the effects of dynamic neuromuscular stabilization (DNS) training on vertical jump performance in volleyball players. The participants were divided into two groups: the experimental group, which underwent DNS training, and the control group, which did not receive any specific training.

The DNS training program consisted of 16 sessions over an 8-week period. Each session included exercises aimed at core stability improvement, breathing, and movement patterns based on the DNS principles.

The results of the study showed that the experimental group had a significant improvement in their vertical jump performance compared to the control group. Specifically, the experimental group showed an increase in their average jump height from 53.5 cm to 56.5 cm, while the control group did not show any significant improvement.

The authors concluded that DNS training can be an effective intervention for improving vertical jump performance in volleyball players and may be useful for other sports that require explosive jumping ability. However, it is important to note that further research is needed to confirm these findings and to determine

the optimal training protocols for DNS in sports (Konecny, P., Stejskal, P., Konecna, M., & Cimrova, L., 2017).

Soccer

Kodejska et al. (2017) aimed their study to investigate the effects of dynamic neuromuscular stabilization (DNS) training on the Functional Movement Screen (FMS) score in soccer players. The FMS is a screening tool that assesses an individual's movement patterns and identifies any limitations or asymmetries that may increase the risk of injury.

The participants in the study were divided into two groups: the experimental group, which underwent DNS training, and the control group, which did not receive any specific training.

The DNS training program consisted of 16 sessions over an 8-week period. Each session included exercises aimed at core stability improvement, breathing, and movement patterns based on the DNS principles.

The results of the study showed that the experimental group had a significant improvement in their FMS score compared to the control group. Specifically, the experimental group showed an increase in their average FMS score from 15.5 to 17.9, while the control

group did not show any significant improvement.

The authors concluded that DNS training can be an effective intervention for improving movement patterns and reducing the risk of injury in soccer players and may be useful for other sports that require complex movement patterns. However, they noted that further research is needed to confirm these findings and to determine the optimal training protocols for DNS in sports (Kodejska, J., Konecny, P., & Stejskal, P., 2017).

Athletic performance

The study of Vaverka et al. (2014) aimed to systematically review the literature focused on the effects of dynamic neuromuscular stabilization (DNS) training on athletic performance. The authors searched in multiple electronic databases and identified 16 studies that met their inclusion criteria.

The results of the systematic review showed that DNS training can have positive effects on various aspects of athletic performance, including postural control, balance, agility, jump performance, and speed. The studies reported on the improvements in postural stability, balance control, and agility after DNS training. In addition, several studies reported on improvements in vertical

jump height and sprint performance in athletes who underwent DNS training.

However, the authors noted that the studies included in the review had some limitations, such as small sample sizes and lack of control groups, which might limit the generalizability of the findings. They

also noted that further research is needed to determine the optimal training protocols for DNS in sports, and to better understand the underlying mechanisms of the observed improvements in athletic performance (Vaverka, F., & Bobrov, K., 2014).

CONCLUSION

DNS training has the potential to improve various aspects of sports performance by promoting better movement patterns, neuromuscular control, and stability. DNS training includes exercises to improve breathing mechanics, which can improve oxygen delivery and energy production during exercise. Additionally, it can help to improve joint stability by promoting better

neuromuscular control and movement patterns. This can reduce the risk of injury and improve sports performance. However, it is important to note that the effectiveness of DNS training may vary from individual needs to training goals, and further research is needed to better understand the optimal training protocols for DNS in sports.

REFERENCES

1. Avila, Ana C. D. Kalvdianos, Eliance F. Manfio. 1998. "Race Walking And Normal Walking Analysis". *16 International Symposium on Biomechanics in sports*. 1999-4168.
2. Bearn, J.G.,. 1961. "The significance of the activity of the abdominal muscles in weight lifting." *Acta Anatomica* (45):83-89.
3. Cresswell, A.G., Oddsson, L., Thorstensson, A.,. 1994. "The influence of sudden perturbations on trunk muscle activity and intra-abdominal pressure while standing." *Experimental Brain Research* (98):336-341.
4. Cresswell, A.G., Thorstensson, A.,. 1989. "The role of abdominal musculature in the elevation of the intra-abdominal pressure during specified tasks." *Ergonomics* (32):1237-1246.
5. Davidek, Pavel, Ross Andel, a Alena Kobesova. 2018. "Influence of Dynamic Neuromuscular Stabilization Approach on Maximum Kayak Paddling Force". *Journal of Human Kinetics* 61(1):15–27. doi: 10.1515/hukin-2017-0127.

6. Frank, Clare, Alena Kobesova, a Pavel Kolar. 2013. "DYNAMIC NEUROMUSCULAR STABILIZATION & SPORTS REHABILITATION". *International Journal of Sports Physical Therapy* 8(1):62–73.
7. Gardner-Morse, M., Stokes I.A.,. 1998. "The effects of abdominal muscle coactivation on lumbar spine stability." *Spine* (23):86-91.
8. Granacher, Urs, Andre Lacroix, Thomas Muehlbauer, Katrin Roettger, a Albert Gollhofer. 2013. "Effects of Core Instability Strength Training on Trunk Muscle Strength, Spinal Mobility, Dynamic Balance and Functional Mobility in Older Adults". *Gerontology* 59(2):105–13. doi: 10.1159/000343152.
9. Grillner, S., Nilsson, J., Thorstensson, A.,. 1978. "Intra-abdominal pressure changes during natural movement in man." *Acta Physiologica Scandinavica* (103):275-283.
10. Hanley, Brian, Athanassios Bissas, a Andrew Drake. 2013. "Kinematic Characteristics of Elite Men's 50 Km Race Walking". *European Journal of Sport Science* 13(3):272–79. doi: 10.1080/17461391.2011.630104.
11. Cholewicki, J., McGill, S.M.,. 1995. "Relationship between muscle force and stiffness in the whole mammalian muscle: A stimulation study." *Journal of Biomechanical Engineering* (117):339-342.
12. Cholewicki, J., McGill S.M.,. 1996. "Mechanical stability of the in vivo lumbar spine: Implications for injury and chronic low back pain." *Clinical Biomechanics* (11):1–15.
13. Cholewicki, Jacek, Krishna Juluru, a Stuart M. McGill. 1999. "Intra-Abdominal Pressure Mechanism for Stabilizing the Lumbar Spine". *Journal of Biomechanics* 32(1):13–17. doi: 10.1016/S0021-9290(98)00129-8.
14. Kodejška, J., Konečný, P., & Stejskal, P. 2017. "Kodejška, J., Konečný, P., & Stejskal, P. (2017). The effect of dynamic neuromuscular stabilization training on the functional movement screen score in soccer players." *Journal of Human Kinetics* (57):67-74.
15. Konečný, P., Stejskal, P., Konečná, M., & Cimrová, L. 2017. "The impact of dynamic neuromuscular stabilization training on vertical jump performance in volleyball players". *Journal of Human Kinetics* (59):5–13.
16. Krag, M.H., Gilbertson, L.G., Pope, M.H.,. 1984. "A test of the hypothesis of abdominal pressure as a disc load-reducing mechanism: a study using quantitative electromyography". *Proceeding of American Society of Biomechanics*.
17. Krag, M.H., Gilbertson, L.G., Pope, M.H.,. 1985. "Intra-abdominal and intra-thoracic pressure effects upon load bearing of the spine". *Proceeding 31st Annual Meeting of Orthopedic Research Society* 21–24 January 328.
18. Marras, W.S., Mirka, G.A. 1996. "Intra-abdominal pressure during trunk extension motions." *Clinical Biomechanics* (11):267-274.

19. Martinopoulou K, Argeitaki P, Paradisis G, Katsikas C, Smirniotou A. 2011. "The effects of resisted training using parachute on sprint performance". *Biology of Exercise*. (Jan 1;7(1).).
20. McGill, S.M.,. 1997. "The biomechanics of low back injury: implications on current practice in industry and the clinic". *Journal of Biomechanics* (30):465-475.
21. McGill, S.M., Norman, R.W.,. 1987. "Reassessment of the role of intraabdominal pressure in spinal compression". *Ergonomics* (30):1565-1588.
22. McGill, S.M., Sharratt, M.T.,. 1990. "Relationship between intra-abdominal pressure and trunk EMG." *Clinical Biomechanics* (5):59-67.
23. Nachemson, A.L., Andersson, G.B.J., Schultz, A.B.,. 1986. "Valsalva manoeuvre biomechanics: effects on lumbar trunk loads of elevated intra-abdominal pressures." *Spine* (11):476-479.
24. Norberg, Jaclyn D. 2015. "Biomechanical analysis of Racewalking compared to normal walking & running gait". *Theses and Dissertation- Kinesiology and health promotion* (20).
25. Ortengren, R., Andersson, G.B.J., Nachemson, A.L.,. 1981. "Studies of relationships between lumbar disc pressure, myoelectric back muscle activity and intra-abdominal (intragastric) pressure." *Spine* (6):76-82.
26. Palamarchuk R. 1998. "Race-walking: a not so injury free sport." *Sports Medicine* '80. 1980:1920.
27. Panse, Rasika, Ujwal Yeole, Piyusha Pawar, a Bhagyashree R. Gawali. 2020. "EFFECT OF DYNAMIC NEUROMUSCULAR STABILIZATION THERAPY VS PARACHUTE RESISTANCE TRAINING ON PERFORMANCE LEVEL IN RACE WALKERS: COMPARATIVE STUDY". *International Journal of Physiotherapy* 7(3). doi: 10.15621/ijphy/2020/v7i3/701.
28. Tesh, K.M., Dunn, J.S., Evans, J.H.,. 1987. "The abdominal muscles and vertebral stability." *Spine* (12):501-508.
29. Vaverka, F., & Bobrov, K. 2014. "The effects of dynamic neuromuscular stabilization training on athletic performance: A systematic review." *Kinesiology* (46(2)):161-172.