EDITORIAL

THE DECELERATION INDEX - IS IT THE MISSING LINK IN REHABILITATION?

Chris Wolfe PT, DPT, OCS, Cert MDT
Assistant Professor, Doctor of Physical Therapy Program – Belmont University

Phil Page PT, PhD, ATC, CSCS, FACSM
Associate Professor, Doctor of Physical Therapy Program – Franciscan University

Michael Voight PT, DHSc, SCS, OCS, ATC, CSCS, FAPTA
Professor, Doctor of Physical Therapy Program – Belmont University

Connor Norman PT, DPT, ATC, SCS, NREMT
Director of Sports Medicine-Football, University of Georgia Athletic Association

Peter Draovitch PT, MS, ATC, CSCS
Athletic Performance Specialist/Associate Athletic Trainer, Jacksonville Jaguars

ABSTRACT

The ability to decelerate is a key component of any successful rehabilitation program, yet it is often overlooked in favor of more traditional forms of rehabilitation and training. Deceleration, which is defined as the ability to reduce speed or momentum and stop or change direction, can be a key component of successful rehabilitation. The deceleration index is a new metric being used by some physical therapists and rehabilitation specialists to improve patient outcomes. The index is based on the principle that deceleration forces should match those created with acceleration. When patients can quickly and efficiently decelerate during physical activity, they are less likely to experience pain or injury. While the deceleration index is still in its early stages of development, there is promising evidence that it could be the missing link in effective rehabilitation. In this editorial commentary, we'll explore what the deceleration index is and why it is important to the rehabilitation process.

Key Words: Rehabilitation, momentum, deceleration, deceleration index, acceleration.

Rehabilitation providers know that the ability to change direction quickly is essential for the success of any athlete. Performance relies heavily on athletes' ability to react quickly in sports-specific situations, especially with regards to agility, coordination, and change of direction (COD). Higher intensity accelerations and decelerations are fundamental components of COD movements and are integral to successful performance of COD.
To date, change of direction speed (COD-S) tests are commonly used to identify an athlete's performance capability and potential risk of injury. To fully assess an athlete's ability to quickly change direction, a measurable evaluation tool should be used. Unfortunately, change of direction has been measured as a time-to-completion to perform the task. When using the total time for a change of direction test, one assumes that the COD is simply one measure of the athlete's ability. While this measure can grossly compare left and right COD ability and asymmetry, it gives very little insight into the component parts of COD. COD incorporates key qualities associated with athletic performance such as acceleration, deceleration, and directional changes.[1] In addition to these key qualities, the demands of deceleration are increased in athletes that have a greater body mass. This is related to the fact that these athletes achieve a higher level of momentum (mass x velocity) before initiating a deceleration maneuver.

Nimphius et al[1] proposed that the change of direction deficit (COD-D) may better distinguish an athlete's COD ability compared to a simple time-to-completion in a COD-S test. Specifically, the COD-D is calculated as the difference between COD-S test time and the time taken to cover the same total distance in a linear sprint.[2,3] Some investigations have reported that athletes with faster sprint times displayed a larger COD-D,[4-8] while others have found the contrary.[3,9,10] It is possible that sprint momentum, which is a function of velocity and body mass, may be more closely linked to COD-D because momentum better represents the mechanical

demands associated with the COD than velocity alone.[11]

While most research and training have been directed at increasing an athlete's power or ability to accelerate, the ability to decelerate may be more important and the missing link in rehabilitation. Deceleration refers to the ability to slow down quickly and efficiently from one activity or movement to another, thereby allowing the individual to adjust their momentum and reduce the risk of injury. The ability to decelerate is a key component of any successful rehabilitation program, yet it is often overlooked in favor of more traditional forms of increasing power and speed. In this paper, we will examine the role deceleration plays in rehabilitation and how the change of direction deficit can impact patient outcomes.

What is Deceleration and Why is it Important for Rehabilitation

Deceleration can be defined as the ability to reduce speed or momentum with respect to time. Harper[12] has defined deceleration as a player's ability to proficiently reduce whole body momentum, within constraints, and in accordance with the specific objectives of the task (i.e., braking force control), while skillfully attenuating and distributing the forces associated with braking (i.e., braking force attenuation). Deceleration is vital in change of direction, and a deficit in this category can have a major impact on the patient's performance. Therefore, deceleration is a fundamental skill that must be developed in order for an athlete's to successfully complete their rehabilitation program. In addition to having an impact on the athlete's performance, a decrease in the ability to quickly decelerate or quickly reduce momentum could lead to injury.[11] Poor deceleration capability has been identified as a potential mechanism associated with non-contact ACL injury due to the high forces generated during the deceleration.[13,14] Additionally, due to the high eccentric braking demands associated with deceleration, this may have the potential to induce muscle damage.[15] High deceleration forces may be linked to eccentric induced muscle damage. Researchers have reported elevated levels of indirect muscle damage biomarkers such as creatine kinase (CK) during the 72 hour period following repeated sprints with intense decelerations.[16,17]

Similar findings have been reported between the number of high-intensity deceleration actions and CK levels post-competitive match play in team sports, such as soccer.[18,19] In these instances, the eccentric braking force requirements of deceleration can impart damage on soft-tissue structures through high muscular tensions that can disrupt the structural integrity of the muscle fibers and result in myofibrillar degeneration, which may leak CK into the blood plasma.[15,20] If the muscular system has a decreased capacity to attenuate high eccentric loading forces, it may lead to loading beyond the tissues structural capability, causing muscle strain or tearing.

Introducing the Deceleration Index - What is it and why is it important for athletes.

Measuring an athlete's ability to decelerate and accelerate quickly is essential for assessing their performance. Using motion capture devices, force plates, and wearable technology, a clinician can observe changes in speed throughout the movement. The deceleration index is a measure of the rate at which an object slows down relative to its ability to accelerate. This measure has typically been used to describe the braking performance of a vehicle. In the automotive industry, the deceleration index is usually expressed in terms of gravitational-force, where 1 g is the acceleration due to gravity. For example, if a car has a deceleration index of 0.5 g, it means that it can slow down at a rate of 0.5 times the acceleration due to gravity. The higher the deceleration index, the faster the vehicle can stop. The deceleration index can be used to compare the braking performance of different vehicles and to determine whether a vehicle's brakes are operating properly.

In both performance and rehabilitation, it is important to focus on both acceleration and deceleration to ensure that the body is able to move efficiently and safely. Acceleration time is the time it takes for the same athlete to reach their maximum speed from a standing start or a slower pace. In this case, both acceleration and deceleration are determined using speed difference and time. The basic formula for calculating acceleration is the change in velocity (Δv) over the change in

time (Δt), represented by the equation a = Δv/Δt. This allows you to measure how fast velocity changes in meters per second squared (m/s^2). Deceleration can be described as the opposite of acceleration and is the time it takes for an athlete to come to a complete stop after sprinting or performing another high-speed activity. Deceleration can be calculated by dividing the final velocity minus the initial velocity, by the amount of time taken for this drop in velocity. Much like acceleration, deceleration plays a key role in an athlete's change of direction speed. Athletes can increase their COD-S by improving deceleration techniques and learning how to properly use deceleration throughout their movement. Ideally, an individual should be able to create a deceleration force equal to or better than the acceleration force.

By dividing the deceleration time by the acceleration time, the deceleration index provides a measure of how quickly athletes can slow down relative to how quickly they can speed up. The deceleration index refers to the ratio of deceleration (or braking) force to acceleration force in the body's movement patterns. This measurement is important in rehabilitation because it can indicate how well an individual is able to control their movements and prevent injury. A high deceleration index suggests that an individual is able to effectively control their movements and reduce the risk of injury, while a low deceleration index suggests a lack of control and a potential for increased risk of injury. Therefore, tracking the Deceleration Index can help athletes maximize their performance and safety in competition.

The Deceleration Index (DI) offers a straightforward measure of how an athlete's deceleration compares to their acceleration. The deceleration index can be useful in a number of contexts. For example, in team sports, such as basketball or soccer, the ability to quickly decelerate and change direction is often critical for success. A high deceleration index indicates that an athlete is able to slow down quickly and efficiently, which may give them an advantage on the court or field. To improve an athletes' change of direction speed or deficit, employing the DI as a measurable metric ensures that their COD-S development is monitored through both acceleration and deceleration phases. This can lead to increased performance, improved safety, and higher quality training for athletes.

The DI can be used to monitor an athlete's progress over time. By tracking changes in an athlete's deceleration index, rehabilitation providers can assess the effectiveness of rehabilitation and training programs, thereby identifying identify areas for improvement. For example, if an athlete's DI is consistently low, it may indicate that they need to focus more on eccentric training and deceleration drills in their training. Therefore, the DI can be used as a tool to track progress in rehabilitation and identify areas that need improvement.

With rising numbers of sports injuries, there is growing interest in finding solutions through training and rehabilitation. Going beyond just focusing on power and acceleration in training, deceleration training can be a useful tool in the rehabilitation program. COD-S is an integral aspect of an athlete's performance and having an effective measure of deceleration is key to injury prevention and efficient rehab. The Deceleration Index provides a comprehensive understanding of an individual's ability to decelerate versus their acceleration speed. Using this metric, clinicians are able to observe and measure an individual's ability to slow down as well as speed up, thus providing insight into the risk for injury. While research into its efficacy is still ongoing, initial findings suggest that the Deceleration Index has the ability to improve rehabilitation and may reduce the risk for further injury. The use of this metric could have significant implications for those working in the fields of sports medicine and physical therapy. As such, the Deceleration Index is poised to be the missing link in rehabilitation, allowing practitioners to make informed decisions with regards to an individual's training. With further research, athletes may soon reap the benefits of a reliable way to measure progress during rehabilitation exercises and reduce injury risk.

REFERENCES

1. Nimphius S, Callaghan S, Spiteri T, et al. Change of direction deficit: A more isolated measure of change of direction performance than total 505 time. *J Strength Cond Res*. 2016;30:3024–3032.
2. Nimphius S, Geib G, Spiteri T, et al. "Change of direction deficit" measurement in division I American football players. *J Aust Strength Cond.* 2013;21:115–117.
3. Nimphius S, Callaghan SL, Bezodis NE, et al. Change of direction and agility tests: Challenging our current measures of performance. *Strength Cond.* 2018;40(1):26-38.
4. Loturco I, Nimphius S, Kobal R, et al. Change-of direction deficit in elite young soccer players. The limited relationship between conventional speed and power measures and change-of-direction performance. *German J Exerc Sport Res.* 2018; 48:228–234.
5. Pereira LA, Nimphius S, Kobal R, et al. Relationship between change of direction, speed, and power in male and female National Olympic Team handball athletes. *J Strength Cond Res.* 2018;32:2987–2994.
6. Dos'Santos T, Thomas C, Jones PA, et al. Assessing asymmetries in change of direction speed performance: application of change of direction deficit. *J Strength Cond Res.* 2019;33(11):2953–2961.
7. Freitas TT, Alcaraz PE, Bishop C, et al. Change of direction deficit in national team rugby union players: is there an influence of playing position? *Sports.* 2018;7:2, 2018.
8. Freitas TT, Alcaraz PE, Calleja-González J, et al. Differences in change of direction speed and deficit between male and female national rugby sevens players [published online ahead of print May 24, 2019]. *J Strength Cond Res.*
9. Cuthbert M, Thomas C, Dos'Santos T, et al. Application of change of direction deficit to evaluate cutting ability. *J Strength Cond Res.* 2019; 33:2138–2144.
10. Dos'Santos T, Thomas C, Comfort P, et al. Comparison of change of direction speed performance and asymmetries between team-sport athletes: application of change of direction deficit. *Sports.* 2018;26:174.
11. Dos'Santos T, Thomas C, Comfort P, et al. The effect of angle and velocity on change of direction biomechanics: an angle-velocity trade-off. *Sports Med.* 2018;48:2235–2253.
12. Harper DJ, McBurnie AJ, Santos TD, et al. Biomechanical and neuromuscular performance requirements of horizontal deceleration: A review with implications for random intermittent multi-directional sports. *Sports Med.* 2022; 52(10):2321-2354.
13. Boden BP, Torg JS, Knowles SB, et al. Video analysis of anterior cruciate ligament injury: abnormalities in hip and ankle kinematics. *Am J Sports Med.* 2009; 37:252–259.
14. Brophy RH, Stepan JG, Silvers HJ, et al. Defending puts the anterior cruciate ligament at risk during soccer: agender-based analysis. *Sports Health.* 2015; 7:244–249.
15. McBurniel AJ, Harper DJ, Jones PA, et al. Deceleration training in team sports: Another potential 'vaccine' for sports−related njury? *Sports Med.* 2022;52:1–12.
16. Howatson G, Milak A. Exercise-induced muscle damage following a bout of sport specific repeated sprints. *J Strength Cond Res.* 2009;23:2419–2424.
17. Faulkner J. Multiple sprint exercise with a short deceleration induces muscle damage and performance impairment in young, physically active males. *J Athl Enhanc.* 2014;3:2.
18. Russell M, Northeast J, Atkinson G, et al. Between-match variability of peak power output and creatine kinase responses to soccer match-play. *J Strength Cond Res.* 2015;29:2079–2085.
19. Varley I, Lewin R, Needham R, et al. Association between match activity variables, measures of fatigue and neuromuscular performance capacity following elite competitive soccer matches. *J Hum Kinet.* 2017; 60:93–99.
20. Gastin PB, Hunkin SL, Fahrner B, et al Deceleration, acceleration, and impacts are strong contributors to muscle damage in professional Australian Football. *J Strength Cond Res.* 2019;33:3374–3383.