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Acute effects of the use of external instability generating devices on neuromuscular performance

Efeitos agudos da utilização de dispositivos geradores de instabilidade externa sobre o desempenho neuromuscular

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Abstract – Physical training with the use of instability generator devices has become popular in the health area, in sport training and clinical practice (mainly in the prevention and treatment of injuries). To understand how the process of using these devices occurs and the results of their acute effects is important to guide professionals in choosing the appropriate device. The aim of this review was to present the main features of instability devices and analyze their acute effects on core muscle activation, neuromuscular performance and activation of lower and upper limbs. Studies have shown that the main acute effects of exercises performed with these devices are: 1) increased activation / muscular recruitment (especially in the middle zone or core); 2) greater co-activation of antagonist muscles (trunk, upper and lower limbs), with increased stiffness and joint stability; 3) lower force output, power and speed in extremities.

Key words: Instability; Low pain back; Sports performance.

Resumo – *O treinamento físico com utilização de dispositivos geradores de instabilidade tem se popularizado na área da saúde, no treinamento desportivo e na prática clínica (principalmente na prevenção e tratamento de lesões). Entender como ocorre o processo de utilização desses dispositivos e quais são os resultados sobre os efeitos agudos é importante para nortear profissionais da área na escolha do dispositivo adequado. O objetivo desta revisão foi apresentar as principais características dos dispositivos desestabilizadores e analisar os efeitos agudos da utilização sobre a ativação da musculatura do core, rendimento neuromuscular e ativação das extremidades inferiores e superiores. Estudos têm demonstrado que os principais efeitos agudos dos exercícios realizados com estes dispositivos são: 1) maior ativação/recrutamento muscular (especialmente da zona média ou core); 2) maior coativação da musculatura antagonista (do tronco, membros superiores e inferiores), com aumento da rigidez e estabilidade articular; 3) diminuição da produção de força, potência e velocidade das extremidades.*

Palavras-chave: *Desempenho esportivo; Dor lombar; Instabilidade.*

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INTRODUCTION

In biomechanics, stability is represented by the sum of all forces acting on a given body, which result is equal to zero. However, stability refers to the body's ability to maintain a state of balance in relation to external and internal forces to which it is submitted[1]. In an even more dynamic concept, stability is the ability of osteoarticular and muscular structures to maintain or return to a position or trajectory of the trunk when submitted to disturbance. It is a dynamic concept that depends on a certain disturbance, whether internal or external[2].

In the training area, external stability has been stimulated in training sessions through the use of destabilizing devices, with the objective of increasing the core activation[3] (functional kinetic chain) and improving sports performance[4].

An important aspect is to consider the options that such material or device provides because such features challenge the ability to control and internal stability. Thus, these devices increase the stimulus levels, increasing the external instability as a way of progression of the proposed activities or tasks[5].

Variables such as support base, amplitude, movement pattern, execution speed, among others, directly interfere in the instability provided by these devices[6]. The effects of using these tools in different populations such as healthy individuals, athletes, and people with low back pain on different perspectives, such as the influence on the core and lower and upper limb activation, lesions and neuromuscular performance, acutely or even with longer interventions, have been evaluated[7]. Understanding how this use process occurs and what the results on acute effects serve to guide professionals in the health area in choosing the appropriate device, according to the objective, is of utmost importance.

Thus, the aim of this study was to present the main characteristics of destabilizing devices and to analyze the acute effects of their use on the activation of core muscles, and neuromuscular performance of lower and upper limbs.

METHODOLOGICAL PROCEDURES

Researches were carried out in the Scielo, Medline and Pubmed databases from January to April 2015 for papers published based on original scientific researches during the period from 1994 to 2015. Thus, only results of interventions with exercises that used such devices have been considered and are described in this review.

The present review included only articles that used some type of instability generating device and whose aim was to analyze the effects of their use on the activation of the core musculature and the lower and upper limbs, as well as the neuromuscular performance, on the prevention and treatment of low back pain and lower limb injuries.

INSTABILITY GENERATING DEVICES AND PROGRESSION VARIABLES

Stability is a dynamic concept in which it is possible to be more or less stable or unstable depending on the destabilization generated in the individual[1,2]. Instability generating devices or unstable materials are those that generate some type of destabilization in the body, that is, they reduce the degree of stability of the subject at the same time that the instability is increased. These include unstable / destabilizing surfaces / bases such as Bohler's Plate and Fit Ball, where it is possible for the subject to be on the device. In addition, there are these in which it is not possible to stay on the device, like Suspension Tape and Sliding Board (Box 1).

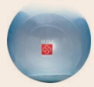
Destabilizing materials are characterized as devices designed with the purpose of promoting constant re-equilibration of the subject in order to increase the proprioceptive activity and the demands of the neuromuscular control and, in this way, to improve the physical condition[8]. The use of these materials, the combination and the manipulation of other variables such as the support base, amplitude and pattern of movement and execution speed are some of the key points to advance in progressions that optimize neuromuscular integration. The use of each of these devices requires a great knowledge about them, so that all the possibilities of progression in direction and amplitude of the movement can be explored[9].

The level of destabilization generated by these devices can be analyzed from the degrees of movement freedom that they allow, that is, the spatial axes involved during the exercise execution[6].

In this way, equipments such as the balance board, which have a single degree of freedom, generate destabilization in a single plane (frontal or sagittal) and therefore provide lower level of destabilization. On the other hand, those that stimulate two or three degrees of freedom, such as a Swiss ball will provide greater level of multidirectional instability, as they occur simultaneously in at least two spatial planes. Thus, the most instability generating devices will be those that have the three degrees of freedom simultaneously and therefore can rotate on themselves (inflatable discs and the Bohler's plate, for example)[10]. In turn, other physical characteristics of the device may increase or reduce the destabilizing potential (inflammation pressure and stiffness, support base and size)[11].

From a practical point of view, this perspective offers the possibilities of progression with the same exercises and / or distinct from those less "destabilizing" devices (one degree of freedom) to highly challenging ones, which use the three degrees of freedom simultaneously. Table 1 shows some of the main destabilizing devices used in clinical and fitness practice and whose effects are studied by the scientific community.

Box 1. Types and characteristics of main destabilizing devices

Material	Characteristics	Image
Fit-ball, Swiss ball, physio-ball	Plastic or rubber ball of large diameter	
Ballastball BOSU DSL	Fitball with heavy material inside	
Physio-roll	Fusion of two large balls (peanut shape)	
Fit-ball "hemispheri-cal"	Consists of an inflatable rubber hemi-sphere fixed to a rigid platform.	
H inchable disc	Small inflatable rubber discs	
Instability boards	Boards with a prominent central element on which slopes can be made.	
Multifunctional bow	Synthetic fiber (polyethylene) or natural wood bow with specific dimensions (70x50x17 cm), balanced and light weight that can be used on both sides.	
Destabilizing platform	Platform that rotates and produces twists in all directions in response to the user's movements (If the user moves on one side, the platform exerts a force that pushes back in the opposite direction).	
Styrofoam	Foam designed in tubular shape	
Suspension elements	Elements used to perform the suspen-sion of the subject from the upper or lower limbs.	
Sliding board	Rectangular surface that allows the body to slide sideways using socks made of sturdy fabric that facilitates the sliding of the feet on the slide. Made with side edges that limit the range of slides.	
Sliding device	Devices that allow sliding on a support-ing surface while maintaining steady and firm footing (feet, hands, or knees).	
Bohler's plate	Wooden platform that rotates on a semi-circle, moving in all planes	

ACUTE EFFECTS OF TRAINING WITH EXTERNAL INSTABILITY GENERATING DEVICES

Acute effects on the core muscle activation

The core is a complex formed by the muscles located in the hip and spine and has as main functions to stabilize the spine, keeping it in a neutral position, generating and transferring forces in an optimal way between lower and upper limbs[1,2]. It has been shown that performing exercises involving the musculature of trunk and / or limbs when working on moderately unstable surfaces tends to increase the core muscle activation more than when performing the same exercises in stable conditions[12]. It is believed that this greater muscle activation occurs due to the need to stabilize the spine and maintain postural control; however, methodologically, loads similar to those used by athletes in their training routines were not used.

In this sense, Hamlyn et al.[13] demonstrated that when performing free squats (80% of 1RM), greater activation of the erector spinae and lumbar spine erector muscles is better activated (34% and 70%, respectively) than with other calisthenics and static exercises that use unstable bases such as Superman (individual in supine position, causing spine hyperextension in such a way that feet and hands do not touch the ground, and knee and elbow are in extension) and lateral bridge (plank), with no differences in the actions of the oblique internal and rectus abdominis muscles. Nuzzo et al.[14] observed greater activation of spine erectors with deadlift and squat with free weight in the soil (with different loads: 50, 70 and 90% of 1RM), than with calisthenics exercises on Swiss ball (trunk extension in four supports with contralateral elevation and pelvic elevation in dorsal decubitus). However, these authors did not find significant differences in the activation of rectus abdominis and external oblique muscles, concluding that multiarticular exercises with free weights are more effective for the improvement of strength and hypertrophy of extensor muscles of the spine than unstable exercises without overload, which may be more suitable for the development of muscular resistance. Willardson et al.[15] also reported greater muscle activation in subjects trained in rectus, transverse abdominus and internal oblique muscles during elbow joint development and flexion (75% of 1RM) than when 50% of 1RM was used on a Bozu®. The authors concluded that, for the loads studied, the use of Bozu® does not imply any advantage to the core. Marshall and Desai[12] evaluated the electromyographic (EMG) activity of active adolescents during the performance of six exercises performed on a Swiss ball and demonstrated that in five of the exercises tested, there was insufficient muscular activation to improve the strength of core and limbs (<60% of maximal voluntary isometric contraction).

It is necessary to make clear that, not always greater muscle activation is a consequence of the use of an instability generating device[16-20]. Lehman et al.[17] did not detect greater activation of the rectus abdominis muscles when performing the bridge (pelvic elevation) in dorsal decubitus on an unstable surface compared to a stable surface. Ventricular decubitus (plank) exercise showed greater activation of these muscles with the use of an unstable surface when compared to the use of stable surface [17], which is due to the fact that the muscles responsible for stabilizing the posture act in a specific way according to the motor task to be performed. In another study, Lehman et al.[18] concluded that core muscle activation depends more on the biomechanical characteristics and exercise demands than on the use of unstable bases. Wahle and Behm[19] observed that individuals with experience in strength training may no longer activate core muscle when performing their exercise routines on moderately unstable bases.

Other studies have analyzed the muscular responses to exercises that used suspension devices to generate instability[21-23]. These concluded that the demands of the core muscles (especially the anterior rectus abdominis) on the exercises in suspension are higher compared to the same exercise performed on stable ground[21,23]. In general, these results can only be considered for exercises evaluated and the strict conditions established in each study.

According to the Canadian Society of Exercise Physiology[24], major core activation will not always occur through the use of instability generating devices. In this context, the greater activation of this muscle complex will depend on what level of instability is being generated by this device, and moderate instability is the most indicated for "optimal" activation. Another relevant aspect is who is the individual being submitted to instability. In general, in the core training of an athlete of different levels (amateur or high performance) and individuals in the fitness area, the use of instability generating devices generates an increase in the activation of this musculature, output power and causes enough sufficient stress in the system to induce or maintain health benefits; however, the maximum strength or power is compromised and should not be used with the aim of hypertrophy, increase the absolute strength or core power[3,24].

Acute effects on the muscular activation of limbs

Exercises performed on unstable bases cannot only increase the core muscle activation to stabilize the spine, but can also increase the activation and coactivation of the muscles of extremities. For example, muscle activation of triceps and deltoid muscles were greater with bench press exercise (60% of 1RM) performed under unstable conditions (Swiss ball) than when performed under stable conditions. More recently, Saeterbakken et al.[25] studied trained subjects (load corresponding to 60% of 1RM) and verified that the electromyographic (EMG) activity of the pectoralis major, anterior deltoid, triceps brachii and central muscles (anterior rectum, external oblique and spine erector) was different when working on different surfaces (stable bench, inflatable disc and Swiss ball). The most stable situation (supine on rigid bench) resulted in greater electromyographic activity of the pectoralis major and triceps brachii muscles. The load of 6RM obtained on bench press on unstable surfaces represented 92-93% of the load used in the same exercise on a stable surface. On the other hand, the greater activation of the rectus abdominis muscle was observed when exercise was performed on a more unstable surface (Swiss ball). These results support the idea that greater instability implies less ability to apply force, especially on the main agonist musculature. In addition, not all studies have shown higher EMG activity in the extremities when exercising on unstable surfaces[26].

Calatayud et al.[22], compared the muscle activation of the upper limbs during push-up exercise using different types of suspension training devices with different adjustments capable of producing different degrees of instability. The results showed that the activation of the brachial triceps, upper trapezius, rectus femoris, rectus abdominis and spine erectors muscles was greater in exercises performed in suspension than in exercises on a stable surface. However, the situations that provided more stability favored a greater activation of the pectoralis major and deltoid muscles in the same exercise.

Overall, the results seem to indicate that in order to maintain a sufficient level of muscle activation in the extremities, the degree of instability should be moderate rather than high[5].

Acute effects on neuromuscular performance

The concomitant contraction of antagonist muscles generally increases when training is performed on unstable surfaces[5]. This has been documented in exercises involving the trunk[27] and lower and upper limb muscles[6] when exercises are performed using instability generating devices.

The increase in the activity of antagonist muscles could also negatively influence the production of strength and power by opposing the movement direction. Simultaneously to the acute effect of muscle coactivation, there is also a reduction in strength production due to the increase in muscle activation of limbs and the stabilizing function of the involved musculature[28]. Thus, there is indication that the force output and the power of extremities are severely affected when exercises are performed using unstable surfaces such as support base or point [1]. The use of unstable surfaces can reduce the maximum power by 12-80% or more when compared to exercise performed on stable bases (squatting and bench press)[9,28-30].

In the study by Drinkwater et al.[29], subjects performed squats with different loads on stable ground using foam pads and Bozu®. Data showed a significant reduction associated with instability situations in the concentric and eccentric peak power, strength, speed and squat depth. The authors emphasized that while unstable-based training may improve core stability and balance, they also induce acute loss of strength and power, indicating that the training of these variables should be performed with separate protocols.

Given the above, higher levels of external instability tend to be associated with lower acute production of strength and power of the agonist musculature, a fact that is probably related to the increase in joint stiffness necessary to guarantee stability. To improve acute power / force performance, high levels of external stability[14] are required, which can only be achieved by using stable surfaces.

FINAL COMMENTS

The level of destabilization generated by instability generating devices can be analyzed from the degrees of movement freedom that they allow, the larger the number of these spatial axes the greater the destabilization generated by the device.

Exercises performed on unstable bases activate more core muscles when compared to the same exercises performed in stable situations, especially regarding the core stabilizing muscles (multifidus, lumbar square muscles); however, this ideal muscle activation depends on some factors such as the level of individual trainability and the degree of instability caused by these devices.

Training on destabilizing surfaces is associated with an acute reduction in maximal power output, strength and movement speed in the lower and upper limbs. Therefore, it could be inferred that in order to achieve maximum strength and power development, high levels of external stability (stable ground, backrests) are necessary.

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