Is it possible to stabilize the trunk using rhythmic stabilization in the upper limb? A cross-sectional study of asymptomatic individuals

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ABSTRACT

Objective: The study aim was to evaluate the immediate effect of rhythmic stabilization on local and distant muscles involved in a functional reach.

Method: Prospective, observational cross-sectional study. Eight right-handed and non-impaired individuals (4 females and 4 males) aged 18–24 years (21.5 ± 1.58 years) were evaluated. Bilateral electromyographic recording of the biceps brachii, triceps brachii, multifidus lumbar, and rectus abdominis muscles was performed during three different tasks. Task 1 involved functional reach, while Task 2 involved rhythmic stabilization followed by a functional reach. Task 3 was similar to Task 2, but with 3 repetitions before a functional reach.

Results: The results showed no difference between the tasks or sides. However, an interaction was observed between each side and muscles, with greater activation of the right multifidus lumbar muscle.

Conclusion: Rhythmic stabilization during the task of reaching promotes an increase of multifidus activity ipsilateral to its application. Thus, this particular technique of proprioceptive neuromuscular facilitation can be useful for improving stability of the trunk and can be used in clinical practice for this purpose.

Level of Evidence: 5.

KEYWORDS

Electromyography; functional reaches; rhythmic stabilization; proprioceptive neuromuscular facilitation

Introduction

Rhythmic stabilization (RS) is one of the original techniques of proprioceptive neuromuscular facilitation (PNF), which was described in 1950 [1]. RS comprises alternating isometric contractions against resistance without movement intention. Its various objectives include increasing the range of motion passively and actively; improving muscle strength, balance, and stability; and reducing pain [2,1]. The technique involves the use of isometric contraction with the alternating activity of agonist and antagonist muscles without the loss of tension [1].

Several studies have explored the clinical use of RS within or apart from the concept of PNF. In the 1950s, same studies had already shown that RS has positive effects on injuries or diseases affecting the central nervous system [3,4]. More recently, RS was used to improve the stability of the trunk in women [5] and children [6] with low back pain. RS resulted in the positive outcomes of better mobility, increased static and dynamic strength, and pain relief [5], as well as improved endurance and flexibility [6]. As shown in a case study of an athlete with

acute posterior dislocation of the glenohumeral joint, these effects contributed to joint stability and resulted in a successful return to competition [7]. RS has also been used in the treatment of amyotrophic lateral sclerosis, and was considered to be one of the few techniques to have a beneficial effect on spasticity, quality of life, and pain relief [8]. Lastly, RS has been used in sports training to increase strength, local blood flow, relaxation, and range of motion [9].

However, to our knowledge, few studies have reported findings of the assessment of muscle activity from the application of RS in healthy individuals. We believe that this investigation is essential before the exploration of the impact of RS in impaired individuals. The findings of the present study could contribute as an insight to the treatment of several injuries, especially to potentiate some weak muscles. Witt et al. [10] observed the use of different diagonal patterns of movement (e.g. as performed with the use of varying weights or elastic resistance) may interfere with muscle activation. Furthermore, little is known about the immediate effects of the application of RS on the involved local muscles

and on distant muscle groups. In this study, the following hypotheses were tested: (1) RS alter the muscle activation of the muscles directly and indirectly involved in the task; (2) the repeated use of the RS technique increases the amount of muscle activation. The study aim was to evaluate the immediate effect of the application of RS on muscle activation with respect to local antagonistic pairs and to distant muscles indirectly involved in the task of reaching.

Material and methods

Design

A prospective, observational cross-sectional study on asymptomatic individuals was performed using electromyography to evaluate the immediate effect of the application of RS on muscle activation in reach task. The participants were informed of the procedures used in the study and signed a consent form in accordance with the standards of the Ethics Committee under number 044/05.

Participants

The study included eight right-handed individuals (4 females and 4 males) aged between 18 and 24 years (mean $\pm$ standard deviation: 21.5 ± 1.58 years). All individuals in this convenience sample had no musculoskeletal and/or neurological impairments.

Instrumentation

The bilateral electromyographic (EMG) activity of the biceps brachii (BB), triceps brachii (TB), multifidus (MF) lumbar, and rectus abdominis (RA) muscles was recorded with bipolar surface Delsys electrodes (model DE2.2L; Delsys Inc., Boston, MA, USA) with a total gain of 2000 and a band-pass of 20–450 Hz. The impedance and CMRR were $> 10^{15} \Omega/0.2 \text{ pF}$ and -92 dB (typical), respectively; the frequency of acquisition was 1000 Hz. Electrodes were fixed following abrasion and cleaning with alcohol according to the Biomedical and Health Research Program (BIOMED II) of the European Union [11].

Procedure

After the electrodes were attached, the participants remained seated on a stretcher without support for the feet and with the EMG activity recorded at rest. The maximal voluntary isometric contraction (MVIC) for each muscle was then recorded, and the test was performed manually with the individual sitting on the stretcher (for BB and TB); in the prone position with the lower limbs stabilized fixed by straps (to test MF); and supine with hands on chest and the knees flexed off the stretcher and stabilized (to test RA).

Subsequently, the participants sat in the corner of the stretcher. Their trunks were positioned next to a rigid wooden frame and glass. A shoulder and elbow angulation of 45° and 90° , respectively, was demarcated on the glass using a goniometer and reflected the position of the common functional reach (FR; Figure 1). The common FR is a movement to reach objects in front, and thus they are often used in many activities of daily living. The starting position was with the upper limb in the side of the body (shoulder in neutral position and elbow in extension, keeping the muscles relaxed – see Figure 1). All measures were on the right upper limb (RUL) and performed by a trained physiotherapist, with five years of experience in the use of PNF.

For Task 1, the participants were instructed from the initial position to perform a normal FR holding an object positioned in front of them and then to finish the movement (Figure 1), while the EMG activity was recorded.

For Task 2, RS procedure was conducted as well. The initial position of the participants was in extension, abduction, and internal rotation of the shoulder; elbow extension; and pronation and extension of the wrist and fingers (Figure 2A). From this position, the participants were instructed to perform flexion, adduction, and external rotation of the shoulder; elbow extension; and supination and flexion of wrist and fingers (Figure 2B). These positions reflect the execution of the second functional variant of the upper limb diagonal, in accordance with PNF method. The RS was performed in half the amplitude of this diagonal (Figure 2A and 2B), and consisted of alternating isometric contractions against resistance with 4 s each. The participants subsequently returned to the starting position and performed the FR, with the EMG activity recorded (FR1).

Task 3 was similar to Task 2, with the RS was performed in three repetitions of alternating isometric contractions against resistance with 12 s each, followed by a new recording of EMG activity during the reach (FR2) from the initial position.

Task 2 and Task 3 were used to explore the existence and the behavior of co-contraction of extremity and trunk muscles, if they occur as described in the literature [12].

To all participants was allowed to practice the movements three times before data registration. All movements were executed based on the verbal commands 'ready' (an instruction to go to the starting position) and 'go' (an instruction to perform the reach).

Data analysis

The EMG signals were stored and subsequently processed offline using Microsoft Excel and KaleidaGraph software. The signals were rectified, filtered at 25 Hz, normalized to MVIC, and integrated into the envelope.

Figure 1. This figure illustrates the initial and final positions for the task of reaching. In the initial position, the shoulder is in a neutral position and the elbow extended; the final position of the shoulder and elbow is 45° to 90° of flexion.

The mean of the integral EMG activity (IEMG) of each muscle was used in 3-way analysis of variance (ANOVA) to evaluate the effects of the muscles, tasks, and sides, since the data were normally distributed. The Tukey test was used as the *post hoc* test, and the alpha was 0.05. All analyses were performed using Statistica for Windows, Version 5.0 (Statsoft, Inc., Tulsa, OK, USA).

Results

All participants were able to perform the requested tasks, and Figure 3 shows the mean IEMG for all muscles studied. As shown by ANOVA, a significant difference was observed between the activation of the muscles ($p < 0.001$), but there was no differences in the tasks ($p > 0.63$) and sides ($p > 0.88$). There was no interaction between tasks and sides ($p > 0.68$) and between tasks and muscles ($p > 0.81$). However, there was an interaction between sides and muscles ($p < 0.01$). A *post hoc* analysis identified a larger activation (around 100%) of the MF lumbar muscle on the right side compared to left side ($p < 0.03$). The other muscles showed no significant differences ($p > 0.05$).

Discussion

The present study aimed to evaluate immediate muscle activation with the use of RS for a FR task. Among its other functions, RS promotes increased stability by improving muscle co-contraction [1]. The first hypothesis was that RS alter the muscle activation of the muscles directly and indirectly involved in the task, and it was accepted in part since during the task of reaching, there was only irradiation to the most distant muscle of the trunk, the right MF. However, there was no significant increase in the EMG activity of the muscles where the RS was performed. One possible explanation is that the study was conducted in healthy individuals without any change in the muscle recruitment of the RUL. However, it is debatable whether there really is a local effect on the muscles involved in the RS.

The controversy over the effects of RS has been described by Bello et al. [13] in commenting on the limited knowledge of the effects of RS in soccer players. These authors compared RS with passive stretching in injury prevention. They found no significant differences between these techniques; however, there was a trend

Figure 2. This figure illustrates the initial position (A) to perform RS procedure: extension, abduction, and internal rotation of the shoulder; elbow extension; and pronation and extension of the wrist and fingers. B illustrates the final position used during RS: perform flexion, adduction, and external rotation of the shoulder; elbow extension; and supination and flexion of wrist and fingers (second functional variant of the upper limb diagonal of PNF method).

Figure 3. Average integrated EMG for all muscles studied, BB: biceps brachii, TB: triceps brachii, MF: multifidus lumbar, and RA: rectus abdominis in both sides, right (r) and left (l) during three tasks, common functional reach (FR), functional reach after isometric contractions against resistance with 4 s each (FR1), and functional reach after three repetitions of isometric contractions against resistance with 12 s each (FR2). A significant difference was observed between r and l sides for the MF ($p < 0.05$).

indicating that individuals in the group treated with RS had fewer injuries, suggesting this technique could be more effective. Within this context, Pereira & Gonçalves

[14] investigated a PNF-based 10-week program applied in an elderly population, a program which included the technique of RS. An improvement in balance was found, with a lower risk of falls. However, when compared to a control group, no significant changes were found in the force produced by the knee extensors or in the evaluated electromyographic variables. Similarly, in the present study, no evidence of changes in EMG activity at the site of application of RS was observed, as described in the definition of the technique.

The our second hypothesis was the repeated use of the RS technique increases the amount of muscle activation, but the results showed no differences between tasks, so that hypothesis was rejected. It was anticipated that producing more repetitions against resistance would result in greater facilitation of the muscles, increasing their activation during a functional task. In the present study, the right MF muscle showed an increase in EMG activity when the RS was performed. Lumbar stability is known to be maintained by the increased activity of erectors muscles and appropriated muscle recruitment between these muscles and the abdominal muscles (RA in this study) during functional activities like sit-to-stand [15], which ensures dynamic stability [16]. Hodges & Richardson [17] demonstrated an anticipatory activity of MF during active movements of the extremities in healthy individuals. Such activity was independent

of the direction of the external force applied during limb movement. These two previous studies reinforce that the increase in muscle activity in the present study occurred in the right MF muscle to promote proper trunk stabilization and thereby favored the task to be performed.

The number of participants can be considered a limitation of the present study; however, this number is consistent with previous studies [13,17]. The sitting position could also be considered a limitation, since the need to control the trunk could affect the activation of the MF lumbar as well as producing some compensation for the task. However, the present study helps to reveal the motor behavior in the sitting position and can provide support to future studies.

Despite these limitations, it can be speculated that the use of RS can potentially function as an indirect mechanism for improving lumbar stability [17], which could be useful in cases of low back pain. For example, several studies have shown multifidus muscle atrophy and a reduction in the cross-sectional area [18,19]. Re-training multifidus muscle improves the lumbar stability and reduces reported pain levels [18,20].

In a previous study RS training improved trunk mobility and muscle endurance in individuals with chronic low back pain [5]. Future studies should investigate if RS could be effective to improve the lumbar stability. In addition, this muscle activation is thought to be useful in cases of hemiparesis and paraparesis, conditions that exhibit impaired stability of the trunk [21]. Future studies could explore the effect of RS on hypotonic muscles. Additional studies could address other positions, movements or PNF diagonals such as in throwing movements to provide comparisons with the results presented in this study.

Conclusion

Rhythmic stabilization during the task of reaching promotes an increase of multifidus EMG activity ipsilateral to its application. Thus, this particular technique of PNF can be useful for improving stability of the trunk and can be used in clinical practice for this purpose.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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