**Section:** Technical Report

**Article Title:** Exercise in Motor Development Positions. What Happens with the Activity of Antagonist Muscle Pairs? Pilot Study

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**Abbreviated title**: Muscle activation in development positions

**Key words**: Muscle activation, Ontogenetic positions, Surface electromiography

## ABSTRACT

**Context:** Exercises in motor development positions are employed in order to activate correct muscular patterns but the effects on the activity of antagonist muscle pairs remain unknown. **Objectives:** To determine the effect of using exercises in motor development positions on the activity of antagonist muscle pairs. Another aim was to analyze if introducing some facilitators modifies the muscle activity in the different studied positions. **Design:** Controlled laboratory study using a single-group repeated measures design. **Patients:** Twenty-one right-handed, healthy adults aged over 41 years (10 males and 11 females). **Setting:** Workers of different departments at Maz Hospital. **Intervention:** Surface electromyography activity of muscle antagonist pairs Upper Trapezius / Lower Trapezius, Serratus Anterior / Pectoralis Major and External Abdominal Oblique / Lumbar Paraspinal was measured in three positions: rest (supine decubitus), reflex turning 1 (RT1) and Modified Vöjta's first position (V1stP). **Main Outcome Measures:** Primary outcomes were mean normalized RMS (averaged over two repetitions) of EMG signals of antagonist muscle pairs in the three analyzed positions. Intraclass correlation coefficients, ICC>0.70 (model 3,2), type consistency and 95%CI was used to estimate the reliability and as exclusion criteria of measurements. **Result:** Analyzed positions had a significant effect on the activity of the muscles P<.001. There was a significant increase in the activity of the phasic musculature versus its tonic antagonists, except in the case of the external oblique / lumbar paraspinal in V1stP. Adding possible facilitators such as gaze, breathing or the combination of both did not show significant changes in the level of activation of the studied muscle groups. **Conclusion:** Ontogenetic developmental positions can be used to facilitate and improve the activation of phasic muscles.

## INTRODUCTION

Postural stabilization is defined as an active (muscular) holding of body segments against the activity of external forces controlled by CNS. This active maintenance implies a coordinated activation of the agonist and antagonist muscles (co-activation) that acts on every joint and in all possible positions it can adopt.

In rehabilitation of severe CNS pathological conditions, such as cerebral palsy or cerebrovascular accidents, different reflex methods (Vöjta [1], Brunkow [2]) have been used to facilitate muscle activity. These methods achieve coordinated activation of the antagonist musculature at the right timing, reflexively and outside the conscious control of the subject. To obtain these same results in functional pathology sports rehabilitation and exercises training, Dynamic Neuromuscular Stabilization (DNS)[3] incorporates Vöjta's principles into exercises based on ontogenetic developmental positions. However, few evidence-based studies have been conducted[4].

Another accepted way to automatically modify muscular activity is through the introduction of possible facilitators such as the use of gaze- synkinesis and abdominal breathing[5].

Using innovative exercises based on motor development, this study shows electromyographically the change in activity of antagonistic muscle groups and what happens when introducing potential facilitators.

Developmental positions may be a useful component of rehabilitation and training programs to address the right muscle co-activation.

## METHODS

### Design

A controlled laboratory study using a single-group repeated-measures design was undertaken.

**Participants**

Twenty-one right-handed, healthy volunteers (10 males and 11 females) whose ages ranged from 30 to 49 years (*mean* = 41.90 years, *SD* = 5.30) were recruited. All participants were workers of different departments at Maz Hospital and gave written informed consent prior to the experiment. None of them had previously performed any of the exercises used in this study. Participants were not included if they had any injury, pain or symptomatic orthopaedic, neurological or systemic condition at the moment of the investigation or surgery in the previous 6 months to the study.

The procedure was approved by the Ethics Committee of the Maz Hospital, in accordance with the Declaration of Helsinki

**Procedures**

Surface electromyography (EMG) activity of muscle antagonist pairs Upper Trapezius (UT) / Lower Trapezius (LT), Serratus Anterior (SA) / Pectoralis Major (PM) and External Abdominal Oblique (EAO) / Lumbar Paraspinal (LP) muscles were collected with six wireless probes, 16 bit resolution, BTS FREEEMG 1000 located at the belly of the muscles using standard electrodes with snap connectors for the connection with pre-gelled (Nuprep® gel) disposable snap electrodes (30×24.8×14 mm main electrode-∅,16×12 satellite electrode, separation 50 mm). All recordings were taken from the right (dominant) side of the body. The electrode placement procedure and skin preparation followed the description of SENIAM[6].

The electromyograph EMG SMART-DX of BTS Bioengineering has a sensitivity of 1μV, accuracy +/- 2%, differential input impedance of 100MΩ, common mode rejection ratio (CMRR) of greater than 110 Db at 50-60 Hz, and a frequency response of 10 to 500 Hz. EMG signals were digitized, sampled at a frequency of 1000 Hz, band-pass filtered from 10 to 500 Hz and stored using the software BTS SMART Analyzer.

EMG activity was analysed in three positions: supine decubitus, reflex turning 1 (RT1) and Modified Vöjta's first position (V1stP) (Figure 1).

After placing the electrodes, subjects were asked to lie supine on a table as relaxed as possible. From this position, the RAW basal activity of the different muscles was captured for 10 seconds. The first two and the last three seconds recorded, respectively, were rejected and the root-mean-square (RMS) values of EMG signals were calculated over the remaining 5 seconds. This procedure was performed for all records.

Next we recorded the EMG activity by introducing into the resting position different facilitators in the following order: looking to the right side, diaphragmatic breathing and looking to the right plus diaphragmatic breathing. The minimal RMS value obtained was used for the normalization.

First, the DNS-certified physiotherapist monitored the accurate body position and corrected mistakes before recording EMG signals in RT1 position. Subsequently, the facilitators were introduced and EMG activity registered. Facilitators were applied in the same sequence that was performed in the resting position.

The same procedure was performed in V1stP position.

The whole process was repeated the following day, under the same conditions, with each participant of the study.

**Outcome measures**

The mean normalized RMS (averaged over the 2 repetitions) was used for statistical analysis. To facilitate inter-individual comparison, the muscle activity (calculated RMS) was normalized as a percentage of the minimal measured signal at rest.

An Intra-Class Correlation Coefficient (ICC) (model 3,2), type consistency and 95% confidence intervals were calculated for each muscle to estimate the reliability of measurements.

Subjects were excluded when ICC of the RMS values of EMG signals was smaller than 0.70[7] between the two measurements of the same muscle or of its antagonist in the different positions. Another criterion to rule out participants was RMS of resting values larger than 7μV[8].



**Statistical analysis**

Signals´ processing and the statistical analysis were performed using Statistical Package for Social Sciences (SPSS) release 20.0 for Windows (IBM Corp).

A two-way analysis of variance (ANOVA) of normalized mean values for each selected muscle pairs was performed to determine if there was a significant effect on EMG activity. The level of statistical significance was set at $P < .05$. There was a significant interaction between the two factors ($P < 0.001$). Consequently, Tukey's HSD Post Hoc pairwise comparison were performed.

## RESULTS

Table 1 summarizes the two-way ANOVA analysis for the interaction between position and muscle antagonist pairs, and Figure 2 compare the mean values of each position between the phasic and antagonistic tonic muscles.

**Upper and Lower Trapezius**

14 subjects (mean = 44.00 years, SD = 4.82) met the exclusion criteria. Results show that the different positions had a significant effect on the activity of the UT and LT. LT activation was more important than UT in RT1 position, and slightly higher in V1stP (Table 1).

**Serratus Anterior and Pectoralis Major**

The exclusion criteria were achieved by 8 subjects (*mean* = 42.75 years, *SD* = 4.76). Results show that the different positions had a significant effect on the activity of SA and PM. Activation of SA was significantly higher than that of PM in RT1 position and much greater in V1st P (Table 1).

**External Abdominal Oblique and Lumbar Paraspinal Muscles**

10 subjects (*mean* = 42.20 years, *SD* = 6.06) fulfilled the exclusion criteria. Results show that the different positions had a significant effect on the activity of EAO and LP. EAO revealed higher values than LP in RT1 position. Nevertheless, activation values of EAO in V1stP were significantly lower than those of LP (Table 1).

**Facilitators**

There was no significant effect on the activity of muscle pairs when facilitators were added.

## DISCUSSION

The co-activation strategy requires interactions not only between timing, duration, force, muscle lengths of agonist, synergist and antagonist muscles, but also with joint centration (maximum joint congruence) and afferent inputs. In order to trigger these complex neuromuscular control strategies, we can use reflex methods.

Numerous studies have analysed the modification in the activity of antagonistic muscle groups, especially UT/ LT/ SA, obtaining as results the importance of conscious centration of the position of the scapula [9] and head [10], the use of quadruped position[11], or the necessity of joint centration in closed kinetic chain position[2]. These findings are consistent with the positions and results of this study.

The results of our EMG study on the muscular pair EAO / LP cannot be confirmed by earlier research. EAO activity only increases in RT1 position. We can suppose this is due to the stimulation of the oblique chain that favours turning. On the other hand, LP muscles increase their activity in V1stP position. This could be explained if V1stP position triggers the straightening towards standing.

Other methods to achieve muscular co-activation use proprioceptive inputs as "gaze-synkinesis" or respiration [12]. Some authors have claimed that eye movement facilitate movements of the head and trunk in the direction of the gaze and inhibits movements in the opposite direction and diaphragm is related to stabilizing the trunk during functional tasks, so it can be related to some changes in the activity of muscle chains. Nevertheless, in our study when facilitators were introduced results were not conclusive.

There are several reasons for not adopting Maximal Voluntary Isometric Contraction (MVIC) as normalization method in this study: (*i*) the controversies over the MVIC[13], (*ii*) the evidence that maintaining a static position requires a modest effort,(*iii*) the fact that the recordings in this study were made from muscles with a constant length and shape and (*iv*) the positions used only require the subject to offset the forces of gravity.

As a pilot study, it is limited by the small sample size and the strict exclusion criteria.

This study only analysed muscle activity of antagonistic muscle groups on the dominant side and in healthy subjects during a short period of time. Future research should focus on comparing the activity of contralateral muscle groups, symptomatic subjects or over a longer period of time.

## CONCLUSIONS

Using developmental positions on the basis of ontogenesis of human motor locomotion elicits the right muscular co-activation of antagonist muscular pairs; especially it promotes higher muscle activation of phasic muscles. Adding facilitators did not change the relative level of activation of the different muscles studied.

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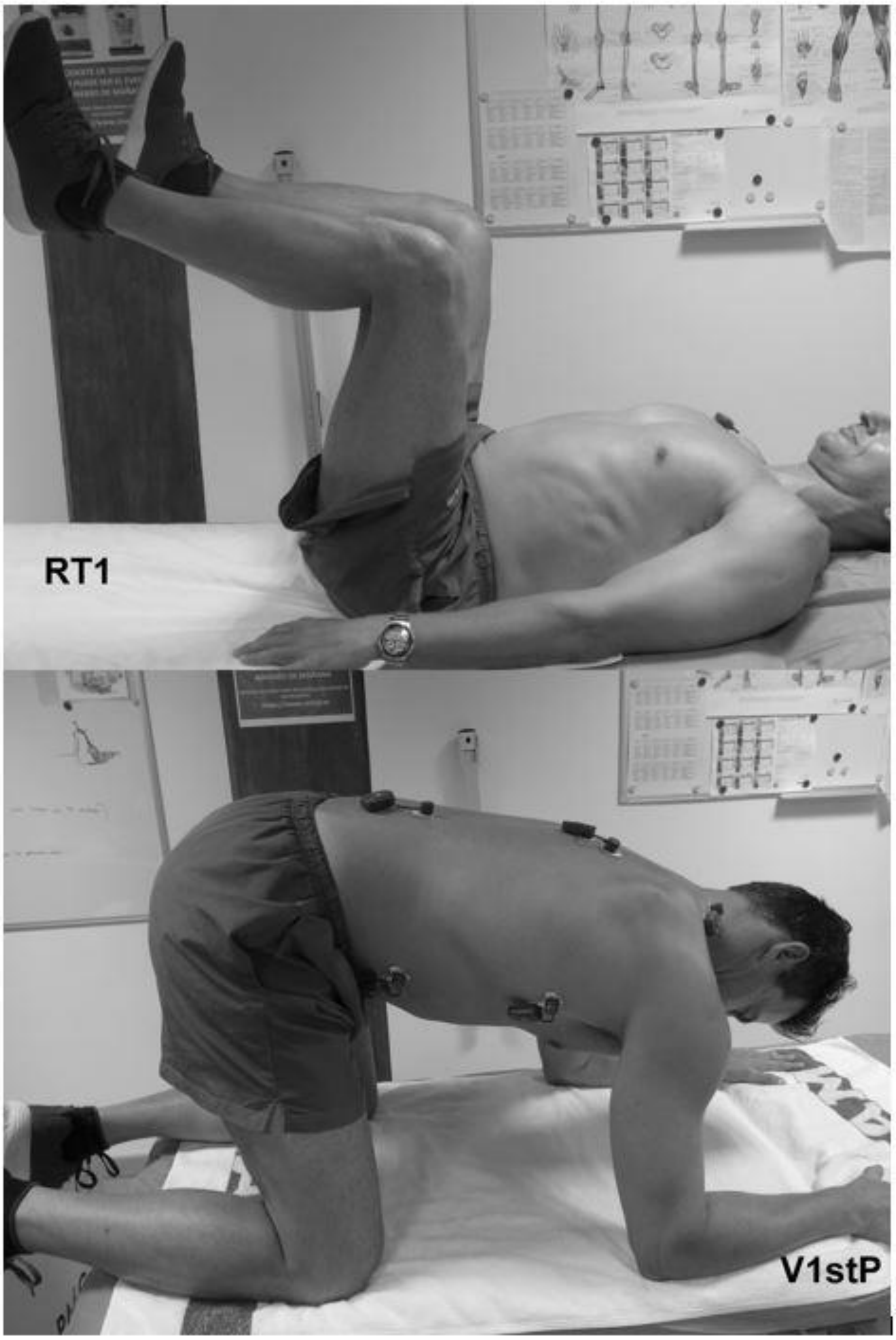


**Figure 1.**

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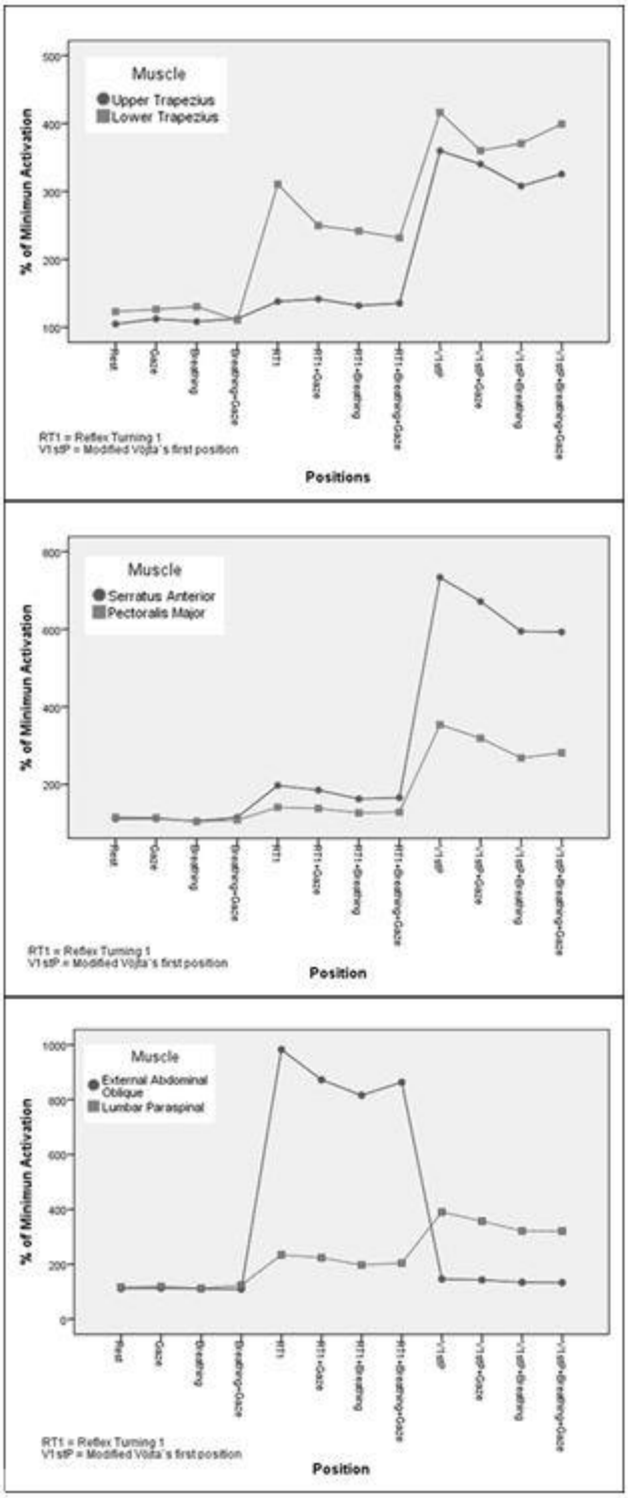


**Figure 2.**

**Table 1:** Two way ANOVA Analysis Summary.

| Source | SS | df | MS | F | *p* | Partial Eta squared |
|---|---|---|---|---|---|---|
| Upper Trapezius and Lower Trapezius | | | | | | |
| Position | 352.303 | 11 | 32.028 | 23.545 | .000 | .454 |
| Muscle | 33.029 | 1 | 33.029 | 24.281 | .000 | .072 |
| Position * Muscle | 20.796 | 11 | 1.891 | 1.390 | .176 | .047 |
| Error | 424.407 | 312 | 1.360 | | | |
| Serratus Anterior and Pectoralis Major | | | | | | |
| Position | 524.814 | 11 | 47.710 | 14.781 | .000 | .492 |
| Muscle | 80.056 | 1 | 80.056 | 24.802 | .000 | .129 |
| Position * Muscle | 112.157 | 11 | 10.196 | 3.159 | .001 | .171 |
| Error | 542.281 | 168 | 3.228 | | | |
| External Abdominal Oblique and Lumbar Paraspinal | | | | | | |
| Position | 813.152 | 11 | 73.923 | 13.862 | .000 | .414 |
| Muscle | 137.123 | 1 | 137.123 | 25.713 | .000 | .106 |
| Position * Muscle | 850.467 | 11 | 77.315 | 14.498 | .000 | .425 |
| Error | 1151.896 | 216 | 5.333 | | | |

Abbreviations: SS, Type III Sum of squares; df, degree of freedom; MS, Mean squares