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MUSCLE ACTIVATION DURING THE ABDOMINAL EXERCISES PERFORMED ON DIFFERENT SUPPORT BASES

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SUMMARY
The EMG intensity of the trunk and thigh muscles was compared across three abdominal exercises (floor, ball and bosu). The rectus abdominis showed similar activation across exercises, but other muscles (extensor lumbar spinae and gluteus maximus), working as postural muscles, presented different levels of activation across the same exercises. The results suggest that the unstable support increases the participation of postural muscles during the abdominal exercises.

INTRODUCTION
The variety of abdominal exercises is to two fold: increase of the motivation during fitness training and to offer different levels of difficult to the performer.

Although there is not clear evidence that different types of abdominal exercises really induces more or less abdominal muscles effort, is common to hear during muscle training sessions that some types of abdominal exercises are harder than others.

We suggest that the increase on instability on the basis of support does not affect the focal muscles, but changes the muscle activation related to the postural control. The aim of this study is to compare the muscle activation of trunk and thigh muscles during abdominal exercises performed on different basis of support.

METHOD
Nine young women (21-25 years old) participated in this study. The inclusion criteria were 1) to be physically active, not to be overweight, and to have experience with abdominal exercise. The exclusion criteria were to have any disease, injury or orthopedic trauma that would not allow the participant to perform abdominal exercises, not to be fit enough to perform the series of abdominal exercise without fatigue, not to be able to perform the abdominal exercise on the experimental conditions. The activation of six muscles was recorded with surface EMG. The EMG signals were recorded at 2 kHz sampling frequency. The participant performed three sets of 5 repetitions of the abdominal exercise. The abdominal exercise was performed on three different support bases: floor, ball and bosu. The order of support basis was randomized across participants. They performed this exercise at the same pace (15 repetition/minute). We use a metronome with sound signals as feedback to control the frequency of the movement. Between each set of exercises, the participant took a minute rest.

The EMG signals were demeaned, filtered (low-pass Butterworth filter, 200 Hz frequency) and full wave rectified. An accelerometer attached over the xiphoid process was used to track the movement of the trunk during the exercise. The acceleration peak during the upward phase was used as reference (T_{peak}) to calculate the integral of the processed EMG during three time windows: before the peak (from 0.3 s before T_{peak} up to 0.1 s before T_{peak}), around the peak (from 0.1 ms before T_{peak} up to 0.1 s after T_{peak}) and after the peak (from 0.1 s. after T_{peak} up to 0.3 s after T_{peak}). For those three time windows, the integral of the processed EMG (iEMG) was calculated. This process was repeated for each muscle (rectus femoris, RF; biceps femoris, BF; psoas major, PS; gluteus maximus, GM; rectus abdominis, RA; and erector lumbar spinae level T4-T5, EL).

For the statistical analysis, three-way (phase: before, around and after the peak; task: floor, ball and bosu; and muscle: RF, BF, PS, GM, RA, EL) analysis of variance was run. The pos hoc Tukey HSD was applied when necessary. Only $p<0.001$ were accepted as significant result.

RESULTS AND DISCUSSION
The results are presented in Table 1. The three-way ANOVA found that iEMG was affected by the task ($F_{(2,3420)}=27.3$ $p<0.001$) and the muscle ($F_{(5,3420)}=12.3$ $p<0.001$). Also, the interaction between task versus muscle affected the iEMG ($F_{(10,3420)}=22.6$ $p<0.001$). The highest iEMG occurred during the abdominal exercise performed on the floor and for the RF and EL. For the interaction muscle versus task, only the GM and EL were affected by the where the abdominal exercise was performed. In this condition, the GM showed the highest iEMG when the abdominal exercise

was performed on the floor or on the bosu; while the highest EL iEMG occurred during the abdominal exercise performed on the ball or on the bosu.

The RA activation was not affected by the support basis where the abdominal exercise was performed. In general, the RA activation does not change across different types of abdominal exercises [1]. Nevertheless, we show that the PS and BF did not change their level of activation across the three different abdominal exercises.

The most activated muscle was the RA. When the knee angle does not change, the main action of this muscle is to assist the hip flexion. However, the instruction for the abdominal exercise was not to move upward and forward the trunk until the end of hip range of movement. Thus, this thigh muscle was highly activated to ensure that the hip and the knee angular positions were locked.

On an unstable basis of support, such as the ball or the bosu, the EL was more active. Although no changes on the RA activation were observed due to the instability on the basis of support, its antagonist did. It suggests that the EL increases the activation for the postural control of the trunk during the task. In this condition, it is important to outline that this muscle showed the same level of activation during the phases of the movement, like all other muscles.

The GM increased its activation when the hip was partially flexed. In this position, the femur is medially rotated and during isometric conditions, the GM can assist the stability of the hip and the knee. On the other hand, when the participants performed the abdominal exercise on the ball, this muscle showed its lowest activation. During this condition, the hip is not in a flexion position, reducing the effect of the GM on the knee joint.

CONCLUSIONS

The activation of the RA was not different among three types of abdominal exercise and it was no affected by the increase of the instability on the basis of support.

The results suggest that the instability at the basis of support increases the activation of postural muscles, not the muscles responsible for the focal movement.

REFERENCES

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Table 1: Averages and standard error of the iEMG (a.u.) of sis muscles (rectus femoris, RF; biceps femoris, BF; psoas major, PS; gluteus maximus, GM; rectus abdominis, RA; and erector lumbar spinae level T4-T5, EL) during the abdominal exercise on the floor, on the ball and on the bosu, before, around and after the peak of upward acceleration phase.

		Before	Around	After
Ball	**RF**	37.0 ± 9.7	40.2 ± 9.7	46.6 ± 9.7
	BF	9.0 ± 9.7	9.5 ± 9.7	12.0 ± 9.7
	PS	11.2 ± 9.7	12.4 ± 9.7	15.6 ± 9.7
	GM	26.6 ± 9.7	58.5 ± 9.7	55.6 ± 9.7
	RA	15.0 ± 9.7	18.3 ± 9.7	21.9 ± 9.7
	EL	7.4 ± 9.7	7.3 ± 9.7	7.8 ± 9.7
Bosu	**RF**	28.6 ± 9.4	31.4 ± 9.4	30.0 ± 9.4
	BF	11.3 ± 9.4	13.1 ± 9.4	14.5 ± 9.4
	PS	17.6 ± 9.4	24.0 ± 9.4	23.9 ± 9.4
	GM	6.8 ± 9.4	7.5 ± 9.4	9.0 ± 9.4
	RA	19.0 ± 9.4	24.1 ± 9.4	25.0 ± 9.4
	EL	8.2 ± 9.4	7.6 ± 9.4	8.2 ± 9.4
Floor	**RF**	34.9 ± 10.2	34.2 ± 10.2	35.1 ± 10.2
	BF	18.3 ± 10.2	18.1 ± 10.2	18.4 ± 10.2
	PS	22.1 ± 10.2	21.5 ± 10.2	21.6 ± 10.2
	GM	24.9 ± 10.2	24.8 ± 10.2	24.9 ± 10.2
	RA	23.1 ± 10.2	20.6 ± 10.2	31.2 ± 10.2
	EL	119.0 ± 10.2	118.0 ± 10.2	121.0 ± 10.2