

## CHAPTER IV

### RESULTS

#### 4.1 Introduction

This Chapter presents the results of EMG activity of the three abdominal muscles (RA, EO and TrA/IO) in four positions: crook lying, prone lying, four-point kneeling, and wall support standing.

#### 4.2 Results

##### 4.2.1 Demographic data

The descriptive statistics of demographic data are shown in Table 4.1. A total of 32 participants, 14 males and 18 females participated in this study. The mean ( $\pm$  standard deviation) of age, mass, height, body mass index, abdominal skinfold thickness and supra-iliac skinfold thickness were 21.3 ( $\pm$  0.8) years, 50.2 ( $\pm$  8.2) kilograms, 1.64 ( $\pm$  0.08) meters, 18.6 ( $\pm$  1.8) kilograms/square meter, 16 ( $\pm$  4) millimeters, and 9 ( $\pm$  3) millimeters, respectively.

Table 4.1 Demographic data of participants ( $n = 32$ )

	Minimum	Mean (SD)	Maximum
Age (year)	20.0	21.3 (0.8)	23.0
Mass (kg)	36.0	50.2 (8.2)	68.0
Height (m)	1.48	1.64 (0.08)	1.78
Body mass index ( $\text{kg}/\text{m}^2$ )	15.4	18.6 (1.8)	23.5
Abdominal skinfold thickness (mm)	6	16 (4)	20
Supra-iliac skinfold thickness (mm)	4	9 (3)	16

#### 4.2.2 EMG activity

The raw data of the RMS of EMG activity of three abdominal muscles (RA, EO, and TrA/IO) during AH in four positions are presented in Appendix F. One-sample Kolmogorov-Smirnov test showed that the data was not normally distributed and the homogeneity of the variance was not satisfied ( $p < 0.05$ ) (Table 4.2). The nonparametric test was then considered.

**Table 4.2** Results from one-sample Kolmogorov-Smirnov test ( $n = 32$ )

Positions	Muscles	$p$ -value
Crook lying	RA	0.013 *
	EO	0.009 *
	TrA/IO	0.017 *
Prone lying	RA	0.053
	EO	0.210
	TrA/IO	0.370
Four-point kneeling	RA	0.006 *
	EO	0.073
	TrA/IO	0.091
Wall support standing	RA	0.010 *
	EO	0.207
	TrA/IO	0.137

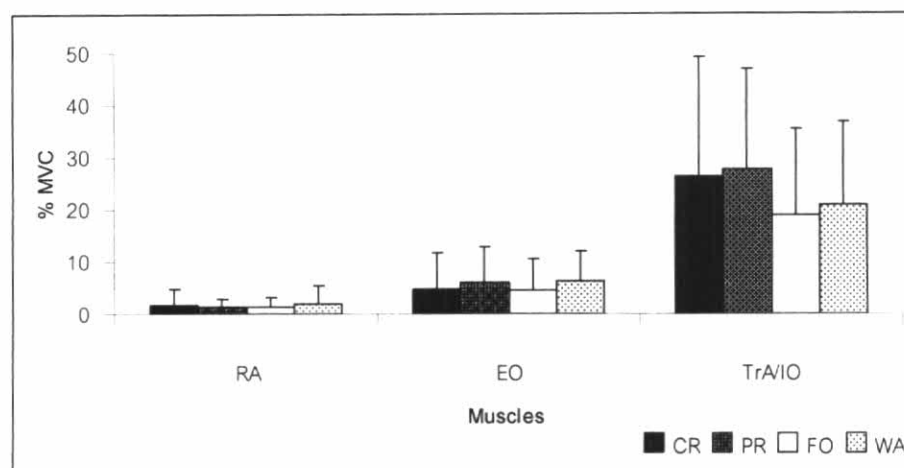
\*  $p < 0.05$ .

Mean, minimum, maximum, and standard deviation of EMG activity of three abdominal muscles during AH in four positions are presented in Table 4.3. Similar patterns of EMG activity of three abdominal muscles in four starting positions were revealed (Figures 4.1).

**Table 4.3** Descriptive statistics of electromyographic activity of three abdominal muscles (percentage of maximal voluntary contraction (MVC)) during abdominal hollowing in four positions ( $n = 32$ )

Positions	Muscles	Abdominal muscles activity (% MVC)		
		Minimum	Mean (SD)	Maximum
Crook lying	RA	0.00	1.84 (3.16)	16.67
	EO	0.00	4.82 (6.78)	34.57
	TrA/IO	4.96	26.21 (22.86)	84.00
Prone lying	RA	0.00	1.35 (1.49)	4.67
	EO	0.00	6.09 (6.87)	35.65
	TrA/IO	4.60	27.59 (19.22)	69.60
Four-point kneeling	RA	0.00	1.35 (1.93)	6.67
	EO	0.00	4.52 (6.01)	29.17
	TrA/IO	3.94	18.75 (16.68)	77.36
Wall support standing	RA	0.00	2.09 (3.40)	13.88
	EO	0.11	6.28 (5.58)	24.54
	TrA/IO	5.91	20.89 (16.01)	82.60

RA = Rectus abdominis, EO = External abdominal oblique, TrA/IO = Transversus abdominis / internal abdominal oblique.



**Figure 4.1** Mean and standard deviation of electromyographic activity of three abdominal muscles during abdominal hollowing in four positions.

RA, EO, and TrA/IO represented rectus abdominis, external abdominal oblique, and transversus abdominis / internal abdominal oblique, respectively. CR, PR, FO, and WA represented crook lying, prone lying, four-point kneeling, and wall support standing positions, respectively.

#### 4.2.3 Comparison of EMG activity of three abdominal muscles

For the assessment of the differences in EMG activity among the three abdominal muscles in each of the four starting positions, the Friedman two-way ANOVA showed significant differences in EMG activity of three abdominal muscles in all four starting positions ( $p < 0.001$ ) (Table 4.4). For the assessment of the differences in EMG activity of each abdominal muscle among four starting positions, the Friedman two-way ANOVA showed significant difference only for the TrA/IO ( $p < 0.001$ ) (Table 4.4). The EO EMG activity, however, approached significance ( $p = 0.053$ ).

**Table 4.4** Results of Friedman two-way analysis of variance for assessing the differences in electromyographic activity due to muscle or position ( $n = 32$ )

Testing conditions		<i>p</i> -value
Three abdominal muscles	Crook lying	< 0.001
	Prone lying	< 0.001
	Four-point kneeling	< 0.001
	Wall support standing	< 0.001
Four positions	RA	0.746
	EO	0.053
	TrA/IO	< 0.001

RA = Rectus abdominis, EO = External abdominal oblique, and TrA/IO = Transversus abdominis / internal abdominal oblique muscles.

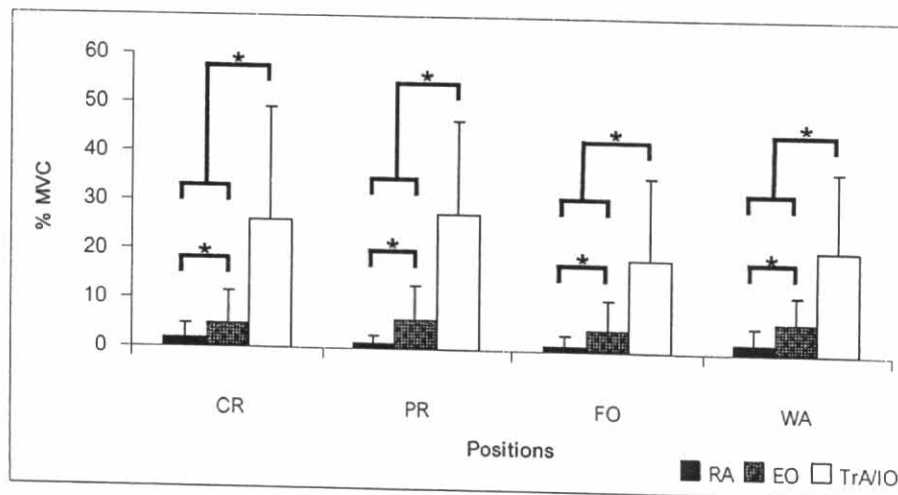
To determine in each starting position which pairwise comparisons of the EMG activity of three abdominal muscles were significantly different, the *post hoc* analysis using the Wilcoxon signed-ranks test was performed. The results showed that the EMG activity of all three abdominal muscles were significantly different from each other in all four starting positions ( $p < 0.001$ ) (Figure 4.2 and Table 4.5). According to Figures 4.1 and 4.2, the TrA/IO exhibited the highest EMG activity while the RA exhibited the lowest EMG activity.

**Table 4.5** Results from *post hoc* analysis using the Wilcoxon signed-ranks test for comparing the electromyographic activity of three abdominal muscles in each starting position ( $n = 32$ )

Positions		EO	TrA/IO
Crook lying	RA	< 0.001	< 0.001
	EO	—	< 0.001
Prone lying	RA	< 0.001	< 0.001
	EO	—	< 0.001
Four-point kneeling	RA	< 0.001	< 0.001
	EO	—	< 0.001
Wall support standing	RA	< 0.001	< 0.001
	EO	—	< 0.001

RA = Rectus abdominis, EO = External abdominal oblique, and TrA/IO = Transversus abdominis / internal abdominal oblique muscles.

$p < 0.001$ .



**Figure 4.2** Mean and standard deviation of electromyographic activity of three abdominal muscles during abdominal hollowing in four positions.

RA, EO, and TrA/IO represented rectus abdominis, external abdominal oblique, and transversus abdominis / internal abdominal oblique, respectively. CR, PR, FO, and WA represented crook lying, prone lying, four-point kneeling, and wall support standing positions, respectively.

\*  $p < 0.05$ .

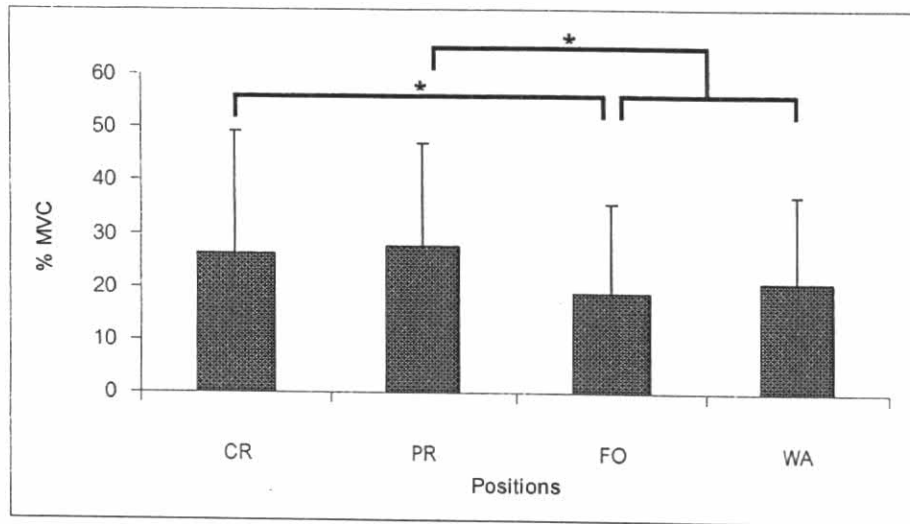
To determine which pairwise comparisons of the EMG activity of TrA/IO recorded from four starting positions were responsible for the significant difference for the Friedman two-way ANOVA, the *post hoc* analysis using the Wilcoxon signed-ranks test was performed. The significant differences were found in three pairwise comparisons (Figure 4.3 and Table 4.6). They were between crook lying and four-point kneeling ( $p = 0.010$ ), between prone lying and four-point kneeling ( $p < 0.001$ ), and between prone lying and wall support standing ( $p = 0.011$ ). The TrA/IO EMG activity was highest in prone lying, crook lying, wall support standing, and four-point kneeling, respectively (Figure 4.3).

**Table 4.6** Results from *post hoc* analysis using the Wilcoxon signed-ranks test for comparing the eletromyographic activity of transversus abdominis / internal abdominal oblique muscle among four different starting positions ( $n = 32$ )

	Prone lying	Four-point kneeling	Wall support standing
Crook lying	0.135	0.010 *	0.337
Prone lying	—	< 0.001	0.011 *
Four-point kneeling		—	0.155

\*  $p < 0.05$ .

$p < 0.001$



**Figure 4.3** Mean and standard deviation of electromyographic activity of transversus abdominis / internal abdominal oblique (TrA/IO) muscles during abdominal hollowing in four positions.

CR = Crook lying, PR = Prone lying, FO = Four-point kneeling, and WA = Wall support standing positions.

\*  $p < 0.05$ .

#### 4.2.4 Frequencies of inhibited and isolated abdominal muscle activity

The raw data of number of participants who were categorized as 'always', 'sometimes', and 'never' groups are presented in Appendix G. More participants could inhibit RA EMG activity than EO EMG activity (Figures 4.4A and 4.4B). More participants could inhibit RA EMG activity in prone lying and four-point kneeling better than in crook lying and wall support standing positions (Figure 4.4A). Fewer participants were unable to keep RA EMG activity silent in prone lying and four-point kneeling positions. The number of participants who could manage to perform AH with no RA EMG activity was similar across four positions (ranged from six to nine participants). In contrary, over 75 percent of participants could never perform AH without contribution from EO (Figure 4.4B). When considering the isolation of TrA/IO from RA and EO during AH, similar number of participants in each of the three groups to the results of inhibited EO activity (Figure 4.5). Nine participants could perform ideal AH with no contribution from RA and EO for at least one trial in four positions.



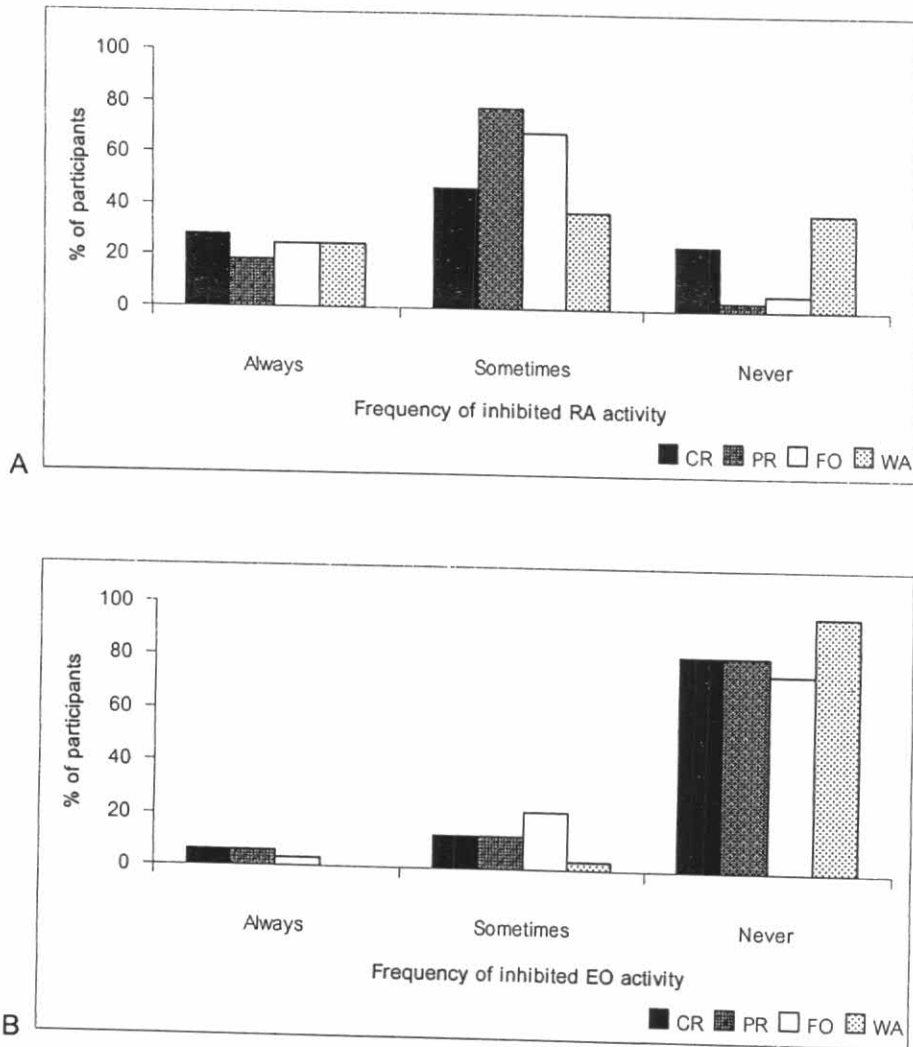


Figure 4.4 Frequency of inhibited activity of (A) rectus abdominis (RA) and (B) external abdominal oblique (EO) in four positions during abdominal hollowing.

CR = Crook lying, PR = Prone lying, FO = Four-point kneeling, and WA = Wall support standing positions.

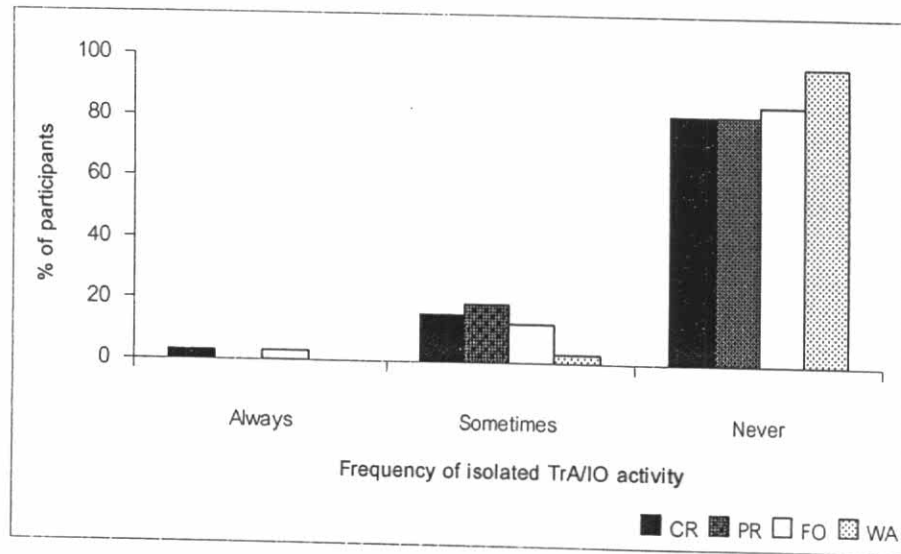


Figure 4.5 Frequency of isolated activity of transversus abdominis / internal abdominal oblique (TrA/IO) in four positions during abdominal hollowing. CR = Crook lying, PR = Prone lying, FO = Four-point kneeling, and WA = Wall support standing positions.