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Relation between Different Sitting Condition and Abdominal Muscle Thickness

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Abstract: *The Transverse abdominal muscle has considered to have a protective role during activity that challenges the integrity of the lumbar spine.* ***The purpose*** *of this study was to investigate ultrasonographyically determined changes in the thicknesses of the transverses abdominal and internal oblique muscles during different sitting condition.* ***Subjects and procedures****: Thirty normally developed children with age ranged from 8-10 years participated in this study. Muscle thicknesses of transverses abdominal and internal oblique muscles were assessed by the musculoskeletal ultrasonography in four different sitting condition including (a) sitting, (b) sitting with abdominal hollowing maneuver (AHM), (c) sitting with left hip flexion, and (d) sitting with AHM and left hip flexion.* ***Results****: Transverses abdominal and internal oblique muscle thicknesses were significantly differed between sitting condition, with significantly greater thickness between conditions from (a) to (d),* ***In conclusion****: It can be concluded that the condition of sitting with AHM and left hip flexion, should be chosen for maximal activation of deep abdominal muscles.*

Key words: *Ultrasonography, Deep abdominal muscles, Sitting conditions, Abdominal hollowing.*

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I. Introduction

Sitting is an important motor milestone because it is the first instantiation of upright posture. Keeping balance in a sitting posture requires infants to coordinate the trunk and pelvis from head to hips, using their legs and buttocks as the base of support [1]**.**The transverses abdominus muscle has been considered to have a protective role during activity that challenges the integrity of the lumbar spine. Many reports have suggested a preferential ability for the TrA muscle to increase spinal stability over other muscles [2]**.**The lateral abdominal muscles including transverses abdominis (TrA), internal oblique (IO), and external oblique (EO) provide stability to the trunk in different functional activities. The assessment of the size and thickness of abdominal muscles is important during athletic training [3]**.**The study of the musculoskeletal system has always been one of the most important applications for diagnostic imaging in radiology [4]**.**Skeletal muscle tissue is a contractile material that has the capacity to adapt its internal architecture to applied stresses. The structure of the muscle is strongly correlated to its activity, therefore, its characterization can help **.**in understanding the different mechanisms involved in muscle injury, aging and neuromuscular disorders [5]**.**Ultrasound (US) imaging, which is a simple, cost-effective, and safe tool that allows us to assess the oblique external (OE), oblique internal (OI), and transverses abdominis (TrA) muscle thicknesses in different and large populations. US is also a reliable tool to assess the lateral abdominal muscle thickness in healthy adults and pediatrics[6]**.**Measurement of abdominal muscle thickness in different positions and health conditions provides useful information about the structural changes in muscle structure that can be attributed to the related positions or conditions. In addition, comparison of each abdominal muscle thickness with other muscles in the same side or the muscles on opposite side may help to determine whether there is a consistent order and relative thickness, which could be used as a guide for the assessment of imbalance within the abdominal muscle groups in both younger and older healthy adults. Normal muscle values may vary in different societies which could be affected by culture, nutritional status, and physical activities [7]**.**

II. Materials & Methods

This study was approved by ethics review committee of the Faculty of Physical Therapy, Cairo University during 2017 and parents signed a consent form authorizing the child’s participation. Thirty (normally developed) children participated in this study. Thirty children from both sexes participated in this study. They were selected from El-Fayoum governorate schools. They were initially assessed to determine Inclusion and exclusion criteria.They ranged in age from eight to ten years and their BMI was normal(18-25).The Exclusion criteria included children with spinal deformity, Athletic children and if they had any neuromuscular or musculoskeletal 4ewdisorders.

Tools and Instrumentation:
(A) For sample selection:
Weight , height scale, BMI percentile chart for children:
They were used for measuring weight, height and BMI of the children who participated in this study.

(B)For assessment:
(1)Hand goniometer: Standard goniometer (baseline) model (G100) was used to measure the angle of knees and hip**.** This goniometer was of small size (6 inch 360^{o}**)** to be suitable for children.It is composed of two arms (stationary and movable).

(2) Musculoskeletal ultrasonography: Ultrasonography device (GE Healthcare LOGIQ S8 system with the R5 software version and the C1-6-D probe**,**was used to measure the muscle architecture (muscle thickness) of the abdominal muscles.

(3) BOX: Using a box (10cm height) placed under the left foot to help the child make left hip flexion.

(4) Chair: Using an adjustable chair for all children included in this study, this chair changes in height according to every child.

Procedures The researcher position the child comfortably on the chair in unsupported sitting facing the radiologist then the researcher guide the child to cross his hands on his chest, and the researcher checked the angle of the knees and the angle of the hips with the spine to be 90 degree by hand goniometer.Then the radiologist put ultrasound probe transversely across the abdominal wall over the anterior axillary line, midway between the 12th rib and the iliac crest in order to obtain a clear image of the deep abdominal layers. The procedures were applied in 4 sitting condition as follows: A-Sitting B- Abdominal hallowing maneuver (AHM) C- Left hip flexion D- Abdominal hallowing maneuver combined with left hip flexion.

(A) Sitting:

The researcher asked the child to sit without support on the chair and cross his hands on his chest, take a normal breath and make the knee angle 90 degree and angle of the hip with spine 90 degree by using the goniometer.

(B) Sitting with AHM:

The researcher asked the child to sit without support on the chair, angles of knees and hips were 90 degree, and then the researcher asked the child to contract his abdominal muscles and sustain 10 seconds in this time the radiologist captured the image after that the child toke 5 minute rest and then he/she made the same contraction of the abdominal muscle on the left side and the radiologist captured the image on the left side (repeated the procedure).

(C) Sitting with left hip flexion:

The researcher asked the child to sit on the chair, with angles of the hip with spine was 90 degree using the goniometer, and the child cross his hands on his chest. The researcher placed the box under the left foot, and asked the child to take a normal breath. The radiologist captured image on the right side and repeated this procedure again for the left side after 5 minutes rest.

(D) Sitting with AHM combined with left hip flexion:

The researcher asked the child to sit on the chair, with angles of the hip with spine was 90 degree using the goniometer and cross his hands on his chest. The researcher placed the box under the left foot and asked the child to contract his abdominal muscles during ultrasonography measurements, the child was asked to hold the task position for 10 seconds and repeat this procedure again on the left side.

Statistical Analysis

Results were expressed as mean ± standard deviation. Test of normality, Kolmogorov-Smirnov test, was used to measure the distribution of data. Accordingly, comparison between variables measured in different positions (four positions) was performed using ANOVA test followed by LSD test if significant results were recorded. Statistical Package for Social Sciences (SPSS) computer program (version 19 windows) was used for data analysis. P value ≤ 0.05 was considered significant.

IV. Results

Table 1: Comparison between mean values of Transverses abdominal muscle measured at different positions of right side in normal children.

	Sitting	AHM	Left hip flexion	AHM + Left hip flexion	F value	P value
Mean ± SD	0.34 ± 0.08	0.38 ± 0.11	0.31 ± 0.08	0.41 ± 0.12	6.514	0.001 (S)
p value vs AHM	----	----	0.009 (S)	0.147 (NS)		
p value vs left hip flexion	----	----	----	0.001 (S)		

Data are expressed as mean ± SD, F value= ANOVA test.NS= p> 0.05= not significant.
S= p< 0.05= significant.

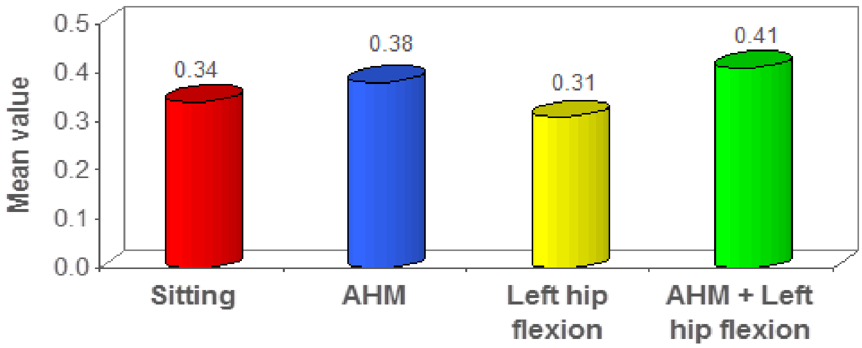

Fig. (1): Comparison between mean values of TR measured at different positions of right side in normal children.

Table 2: Comparison between mean values of IO measured at different positions of right side in normal children.

	Sitting	AHM	Left hip flexion	AHM + Left hip flexion	F value	P value
Mean ± SD	0.50 ± 0.13	0.50 ± 0.13	0.46 ± 0.10	0.53 ± 0.14	1.612	0.190 (NS)

Data are expressed as mean ± SD.F value= ANOVA test.NS= p> 0.05= not significant.

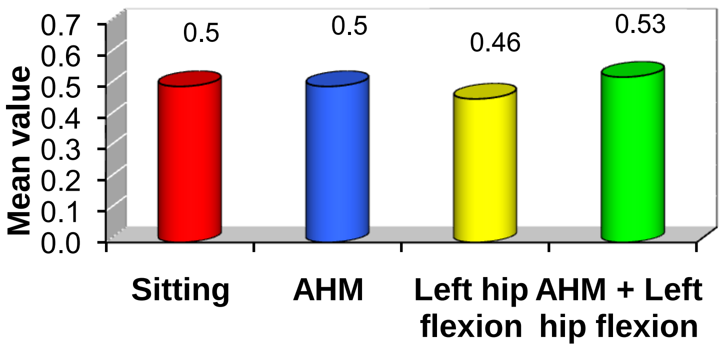

Fig. (2): Comparison between mean values of IO measured at different positions of right side in normal children.

Table 3: Comparison between mean values of Transverses Abdominal muscle measured at different positions of left side in normal children.

	Sitting	AHM	Left hip flexion	AHM + Left hip flexion	F value	P value
Mean ± SD	0.31 ± 0.07	0.37 ± 0.08	0.29 ± 0.06	0.40 ± 0.10	12.821	0.001 (S)
p value vs sitting	----	0.005 (S)	0.255 (NS)	0.001 (S)		
p value vs AHM	----	- ---	0.001 (S)	0.134 (NS)		
p value vs left hip flexion	----	----	----	0.001 (S)		

Data are expressed as mean ± SD.F value= ANOVA test.NS= p> 0.05= not significant.
S= p< 0.05= significant.

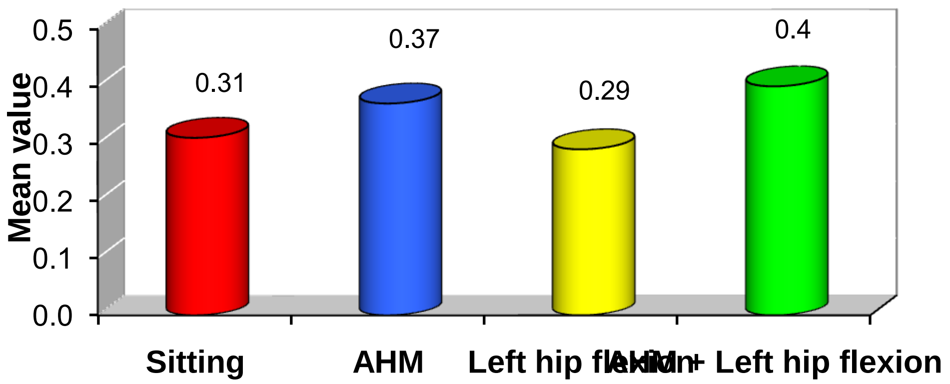

Fig. (3): Comparison between mean values of TR measured at different positions of left side in normal children.

Table 4: Comparison between mean values of IO measured at different positions of left side in normal children.

	Sitting	AHM	Left hip flexion	AHM + Left hip flexion	F value	P value
Mean ± SD	0.47 ± 0.12	0.47 ± 0.13	0.43 ± 0.09	0.48 ± 0.14	**0.959**	0.415 (NS)

Data are expressed as mean ± SD.F value= ANOVA test.NS= p> 0.05= not significant.

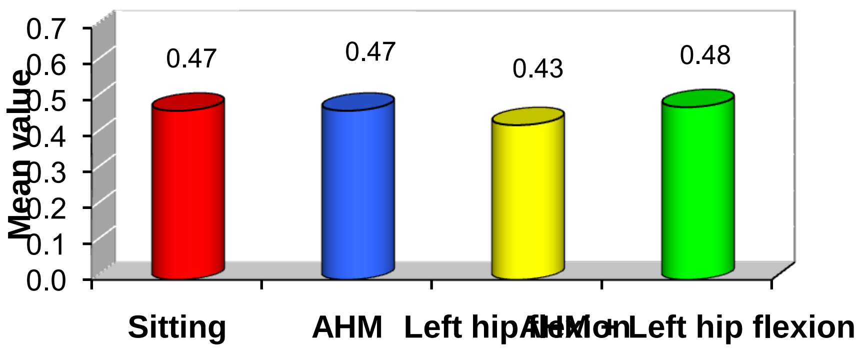

Fig. (4): Comparison between mean values of IO measured at different positions of left side in normal children.

III. Discussion

The results of this study clarified that the transverses abdominal and internal oblique muscle thicknesses were significantly differed between sitting condition, with significantly greater thickness between the four sitting conditions**.**Ultrasound (US) imaging, which is a simple, cost-effective, and safe tool that allows us to assess the oblique external (OE), oblique internal (OI), and transverses abdominis (TrA) muscle thicknesses in different and large populations. US is also a reliable tool which assesses the lateral abdominal muscle thickness in healthy adults and pediatrics [6]**.** Sitting is an important facilitator of development because it opens up new opportunities for exploration and learning. The upright posture affords new views of the world and the people who inhabit it [8]. This is supported by the findings of **Mannion et al., (2008)** [9] reported that good reliability for measurement of individual abdominal muscle thickness at rest or in contracted state. **Reeve et al., (2009**) [10] reported that TrA thickness significantly larger in erect standing than in sway-back standing and in erect sitting than in slouched sitting. In this study, the researcher used the goniometer to make the angle of the hip withe spine 90 degree (erect sitting) which may achieve the maximum thickness of the abdominal muscle.Our findings come in agreement with **Richardson and Jull, (1995)** [11] who showed that TrA muscle thickness with an AHM was almost equal to that during a 25% maximum voluntary contraction (MVC).Our results are in agreement with **Critchley, (2002)** [12] who reported that TrA thickness change during low abdominal hollowing and increased when pelvic floor contraction was added ,as in our study we found that thickness of the TrA increased in AHM combined with left hip flexion than AHM or left hip flexion alone**.** Our results agree with **Stanton et al., (2008)** [13] who reported that the TrA CSA significantly larger during both abdominal hollowing and abdominal brace than during rest**.** Our results don't agree **Rankin et al., (2006)** [14] who reported that the values (at rest) for muscle thickness for 55 men and 68 women of various ages who were moderately active. The thicknesses of both the TrA and IO muscles at rest were thicker than values during a drawing-in maneuver of the anterior abdominal wall. Also **Hides et al., (2006)** [15] reported that muscle thicknesses for young asymptomatic male elite cricketers, not unexpectedly, elite male athletes had thicker muscles at rest than the subjects of the moderately active subjects of **Rankin et al., (2006)** [14]**.** One possible explanation for this is muscle hypertrophy in the athletes due to strenuous training and competition. Also, there were females included in the current investigation and only male subjects in the study of **Hides et al (2006)** [15]**.** AHM combined with hip flexion can be considered to have a much stronger effect on TrA activation as in this position the abdominal and hip flexors are acting and this augment the force of contraction. Also any activities in upright positions (sitting) help the deep abdominal muscles to be more active to keep the lumbar spine in its neutral position. The thicknesses of the TrA and IO muscles with the AHM combined with hip flexion increased greater than those with either the AHM or hip flexion alone and this is caused by two factors: **First,** psoas major activation during hip flexion is likely to stress the lumbar spine, which is countered by the TrA. The thoracolumbar fascia and TrA have a synergic role in stabilizing the lumbar spine and sacroiliac joint [16]**.** The EO and IO muscles differ from the TrA muscle with respect to lumbar spine stability. Even though the EO and IO muscles continue to the middle portion of the thoracolumbar fascia [17].These two anatomical structures are almost perpendicular and their force is considered relatively weak [18].This explain why the TrA was recruited more readily than the EO, IO, and rectus abdominis.

A second factor is the function of the contralateral gluteus maximus muscle during the AHM and hip flexion. It has some continuity with the multifididus muscle [19]**.** Because the deep fibers of the multifidus muscle stabilizes the lumbar spine and is synchronously activated with the TrA muscle **(14).**

IV. Conclusion

Based on the result of the current study, it can be concluded that the condition of AHM combined withe left hip flexion is favorable for maximal activation of transversus abdominis without inducing overactivation of the internal oblique muscle.

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