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Interrater and Intrarater Reliability of the Intra-Abdominal Pressure Test in Young Adults

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ABSTRACT

BACKGROUND: Diaphragm is not used correctly to its fullest potential which can lead to injury provoking compensations. If recruited properly, the diaphragm aids in the production of intra-abdominal pressure, which is necessary for core and spinal stabilization. Intra-abdominal pressure is a key component of our dynamic stability system.

OBJECTIVE: The purpose of this study was to determine the interrater and intrarater reliability of the intra-abdominal pressure test in young adults.

METHODOLOGY: It is a non-experimental design of test-retest type. 80 subjects (50 women and 30 men) aged 18-28 years with the BMI of < 23.05-24.9 kg/m^2 were conveniently included. Subjects with the history of low back pain for past 3 months, any hip or knee surgery for last 1 year, thoracic or thoracoabdominal surgery, postural deformities, cardiorespiratory diseases, pregnancy and pelvic floor dysfunction was excluded. The intra- abdominal pressure test had been carried to the subjects on the same day for the interrater reliability and 1 week later for the intrarater reliability. The signs of proper stabilization with the correct and incorrect activation of the chest and abdominal movements of the subjects were documented independently between the raters and scoring had been done.

RESULTS: The results of the study showed an overall excellent interrater reliability of ICC=0.957 and intrarater reliability of ICC= 0.903 of the test.

CONCLUSION: The study concludes that there is an overall excellent interrater and intrarater reliability of the intra-abdominal pressure test in normal young adults and hence it can be used in clinical practice.

Keywords: Diaphragm, Intra-abdominal pressure, Intra-abdominal pressure test, Core stability, Spinal stability.

INTRODUCTION

Intra-abdominal pressure (IAP) is the pressure created within the abdominal cavity[1].The diaphragm, pelvic floor muscles, deep flexors of neck and all the abdominal sections, including posterior and lateral parts are proportionately activated, thus increasing the IAP, which stabilizes the thoracic segments at its lower parts and lumbar spine from front[2]. The diaphragm is the mainstay for core stabilization and to contract first and the abdominal wall, probably transverse abdominis muscle to produce IAP[3]. IAP is a key component of our dynamic stability system[4].

The diaphragm contracts and moves like a piston caudally to the abdominal cavity during inspiration which creates the negative pressure in thoracic cavity and forces air into the lungs and increases IAP simultaneously. The diaphragm is our essential muscle for breathing and many individuals have very little awareness of how to activate it properly[5].

As we age, we don't use diaphragm correctly and to its fullest potential which can lead to injury provoking compensations. If recruited properly, the diaphragm aids in the production of IAP, which is necessary for core stabilization. It can also help to increase the amount of air that we breathe in by up to 30%. Unfortunately, as humans grow they tend to breathe through chest instead of their belly causing dysfunctional diaphragm activation and it perpetuates muscle imbalances[6].

Proper core stabilization is not truly achieved without intra-abdominal pressure and does results in collapsing of the core and spine. There is a rise in IAP during inspiration proportional to the depth of inspiration. IAP role is to assure stiffness and lumbar spine stability and therefore to handle loads it is essential for lumbar spine to produce adequate IAP[7]. Intra-abdominal pressure provides stability to the lumbar spine through two mechanisms, one was IAP generation along with activation of abdominal muscle and the second is co-activation of antagonistic flexor extensor muscles and these both were effective in the lumbar spine stabilization[8].

The lumbar spine stiffness increases when intra-abdominal pressure is elevated. In order to perform daily activities and exercises it is necessary for a person to create sufficient intra- abdominal pressure. The lower back gets rounded in some individuals and it is due to insufficient IAP production[9].

IAP breathing is in attention at present. The characteristic point is that both of breathing in and out constantly increases the abdominal pressure and the abdominal muscles get hardened so the abdomen does not become concave, even when a person is in expiratory phase[10].

Professor Pavel Kolar, a Czech physiotherapist, and DNS developer has done a lot of research in Dynamic Neuromuscular Stabilization, or commonly referred to as ''DNS''[11]. He has developed various clinical tests and working on the papers of various DNS clinical tests but the reliability of intra-abdominal pressure test (IAPT) is has not been done yet. And this study has been carried out to find out the interrater and intrarater reliability of the intra-abdominal pressure test in young adults.

The intra-abdominal pressure test involves the series of 14 components which includes the correct and incorrect activation of the chest, abdominal muscles,

pelvic floor muscles, and position of the extremities. It evaluates the individual's breathing pattern as well as their ability to develop IAP. It involves the training of the postural pattern of breathing and diaphragm function for stabilization, which has a fundamental role not only for breathing, but also for physiological stabilization of the trunk[12].

MATERIALS & METHODS

STUDY DESIGN: Non-experimental design

STUDY TYPE: Test-retest type

SAMPLING METHOD: Convenient sampling

SAMPLE SIZE: 80

STUDY DURATION: 2 months

STUDY SETTING: Department of Physiotherapy SRM Institute of Science and Technology Kattankulathur

Participants

Informed consent was obtained from all the subjects to voluntarily participate in this study after screening for inclusion and exclusion criteria.85 subjects were screened for the study and there were 5 drop outs (2 subjects due to dysmenorrhea and 3 subjects were absent for test-2) and 80 subjects (50 females, 30 male) aged 18-28 years with the BMI of < 23.05-24.9 kg/m^2 were conveniently included in the study. Subjects with the history of low back pain for past 3 months, any hip or knee surgery for last 1 year, thoracic or thoracoabdominal surgery, postural deformities, cardiorespiratory diseases, pregnancy and pelvic floor dysfunction was excluded.

Outcome measures

Demographic data and information about the presenting complaints were noted. Both the expert and novice raters concluded the screening process and instructions were given independently on the same day for interrater reliability, during which no results were shared by both the raters until the whole process of data recruitment and the documentation was done by observation and palpation of the chest and abdominal movements of the subjects by assessing the test performance on 2 different occasions i.e., 1 week later for re-test for the intrarater reliability

Intra-abdominal pressure test

S.NO	CONTENTS OF THE TEST- CORRECT ACTIVATION	YES	NO
1	Balanced activity of all abdominal muscles		
2	Chest is kept in neutral position		
3	Lower chest widens		
4	Pelvic floor and diaphragm stay almost parallel		
	INCORRECT ACTIVATION		
5	Hyperactivation of rectus abdominis muscle		
6	Insufficient activation of lower abdominal wall		
7	Cranial migration of umbilicus		
8	Inspiratory position of the chest		
9	Hyperextension in the thoracolumbar region		
10	Abdominal diastasis		
11	Concavities of abdominal wall above the level of groin		
12	Shoulder protraction		
13	Cervical spine hyperextension		
14	Over activity of superficial hip flexors		

Procedure

It is an objective test, so it is essential to establish whether the same results are obtained between the raters and by the same rater on the subsequent occasion. The study involves the novice and expert raters using the screening test comprising of 14 components.

The expert rater was an Associate professor and the novice rater was a Post graduate student and both the raters have learnt and well experienced before administering the test. Each subject was scheduled to about 10 minutes. Both the expert and novice raters concluded the screening process and instructions were given independently on the same day for interrater reliability, during which no results were shared by both the raters until the whole process of data recruitment and the documentation was done by observation and palpation of the chest and abdominal movements of the subjects by assessing the test performance on 2 different occasions i.e, 1 week later for re-test for the intrarater reliability

This test requires an observational and palpational judgement regarding subject's ability to hold the position to a pass or fail benchmark standard. Prior to testing, the novice and expert raters reviewed the assessment criteria to ensure consistency. The participants were taught about the components of the test following standardised instruction, regarding how to position, to perform proper breathing and to prevent faulty positioning and breathing pattern.

Before the screening process commenced, each participant was well informed about the test because it evaluates the proper diaphragm activation and performance of a functional breathing, a period of familiarisation was necessary so as not to skew the results for the wrong reason. The scoring with yes or no had been done independently between the raters for interrater reliability and on 2 different occasions i.e, one week apart for intrarater reliability.

INTRA-ABDOMINAL PRESSURE TEST

Subjects were clearly explained about the intra-abdominal pressure test and

demonstration was done before performing test on the subjects. Subjects were instructed to assume proper starting position. Subjects were placed in 3 months old supine position The hips, knees, and ankles were placed in 90 degree flexion, hips mild abduction and external rotation. Legs supported on the chair or therapist's arm. Chest is passively taken into neutral position(expiratory) and the foot were placed apart. The 90/90 is a breathing technique that works on proper diaphragm mechanism and generation of IAP. This technique optimizes the zone of opposition and diaphragm and pelvic floor gets repositioned in a parallel alignment to each other. The optimal zone of opposition restored with 90/90 breathing helps the diaphragm fulfil its respiratory and postural dual role.

During the demonstration of the test the verbal cues were given; ''Keep your chin tuck in, can you relax your shoulders, try to prevent your upper chest breathing, take an effort to breath from your lower lateral side of your chest, do not arch your back, blow out your stomach like the balloon, prevent placing your foot closer, maintain the 90/90 position throughout the test''.

TEST PERFORMANCE:

Once the subject has learnt the test, gradually remove the support from the legs. Subject will be instructed to do diaphragmatic and lower thoracic breathing. The test will be carried as long as the subject can able to hold the position. If the subject fails to hold the position, support will be given by chair or therapist's arm. Later the support is removed and the test is carried and documentation of the correct and incorrect activation is done.

OBSERVATION AND PALPATION: Activation of abdominal muscles, movement of the chest during test performance, position of the pelvis, formation of the cylinder, movement in the shoulder girdle and position of the cervical spine and head.

IAP - CORRECT ACTIVATION is observed by balanced activity of the all abdominal muscles, chest is kept in neutral (caudal) position, widening of lower chest, pelvic floor and diaphragm stay almost parallel.

INCORRECT ACTIVATION is observed and palpated by hyper activation of rectus abdominis, insufficient activation of lower abdominal wall, cranial (cranio-lateral) migration of umbilicus, inspiratory position of the chest (chest is not maintained in neutral position), hyperextension in thoracic/lumbar junction, abdominal diastasis, concavities of abdominal wall above the level of the groin, shoulder protraction, cervical spine hyperextension and over activity of superficial hip flexors.

Figure 1

Figure 2

Figure 1 & 2 shows subject performing the intra-abdominal pressure test with and without support for interrater reliability.

Figure 3

Figure 4

Figure 3 and 4 shows subject performing intra-abdominal pressure test with and without support for intrarater reliability.

STATISTICAL ANALYSIS

Data analysis

The collected data were tabulated and analyzed using SPSS statistical analysis. The demographical data were analyzed using descriptive statistics. The interrater and intrarater reliability were analyzed using Cronbach's alpha and Intra class correlation coefficient (ICC) and Cohen's kappa statistics for determining level of agreement between the raters.

RESULTS

The results of this study include the individual components and overall reliability of the test between the novice and expert raters for interrater reliability and comparing the test 1 and test 2 for intrarater reliability.

TABLE-1 DEMOGRAPHIC DATA

Demographic variable		Intrarater		Interrater	
		Frequency	Percentage	Frequency	Percentage
Age (in years)	18	2	2.5	2	2.5
	19	13	16.2	13	16.2
	20	13	16.2	14	17.5
	21	23	28.8	22	27.5
	22	5	6.2	5	6.2
	23	11	13.8	11	13.8
	24	8	10.0	8	10.0
	25	2	2.5	2	2.5
	26	3	3.8	3	3.8
	Mean±SD	21.36±1.950		21.35±1.956	
Gender	Female	50	62.5	50	62.5
	Male	30	37.5	30	37.5

Table 1 shows the demographic variables of age and gender with the frequency and percentage with the mean and standard deviation of 21.36±1.950 for intrarater reliability and 21.35±1.956 for interrater reliability.

TABLE- 2 INTERRATER RELIABILITY OF THE INTRA-ABDOMINAL PRESSURE TEST

S.no	Components of the test	Agreement (%)	Kappa	Level of agreement
1	Balanced activity of all abdominal muscles	93.5	0.820	Excellent
2	Chest kept in neutral position	88.5	0.829	Excellent
3	Lower chest widens	91.2	0.797	Good
4	Pelvic floor and diaphragm stay almost parallel	93.5	0.793	Good
5	Hyperactivation of rectus abdominis muscle	66.7	0.794	Good
6	Insufficient activation of lower abdominal wall	81.2	0.787	Good
7	Cranial migration of umbilicus	50.0	0.661	Good
8	Inspiratory position of the chest	98.1	0.830	Excellent
9	Hyperextension in the thoracolumbar region	88.2	0.785	Good
10	Abdominal diastasis	0	-	-
11	Concavities of abdominal wall above the level of groin	100	0.882	Excellent
12	Shoulder protraction	83.6	0.674	Good
13	Cervical spine hyperextension	92.6	0.888	Excellent
14	Over activity of superficial hip flexors	57.1	0.709	Good

Table 2 shows the kappa values with agreement (%), and level of agreement for all the 14 components of which 5 components show excellent agreement and 8 components show good and 1 component show poor level of agreement between the novice and expert raters for interrater reliability.

TABLE – 3 INTERRATER RELIABILITY BETWEEN THE NOVICE AND EXPERT RATERS

Interrater	Mean	SD	N	r-value	ICC
Novice	4.56	1.413	80		
Expert	4.66	1.368	80	0.918	0.957

Table 3 shows the overall scoring for the interrater reliability with the r-value of 0.918 and ICC of 0.957 and it shows the excellent interrater reliability between the novice and expert raters.

TABLE- 4 INTRARATER RELIABILITY OF THE INTRA-ABDOMINAL PRESSURE TEST

S.no	Components of the test	Test	Mean	SD	N	ICC
1	Balanced activity of all the abdominal muscles	Test1	0.59	0.495	80	0.853
		Test 2	0.66	0.476	80	
2	Chest kept in neutral position	Test 1	0.33	0.471	80	0.905
		Test 2	0.41	0.495	80	
3	Lower chest widens	Test 1	0.45	0.501	80	0.860
		Test 2	0.50	0.503	80	
4	Pelvic floor and diaphragm stay almost parallel	Test 1	0.75	0.436	80	0.718
		Test 2	0.76	0.428	80	
5	Hyperactivation of rectus abdominis muscle	Test 1	0.03	0.157	80	0.798
		Test 2	0.01	0.112	80	
6	Insufficient activation of lower abdominal wall	Test 1	0.36	0.484	80	0.802
		Test 2	0.31	0.466	80	
7	Cranial migration of umbilicus	Test 1	0.01	0.112	80	-0.026
		Test 2	0.01	0.112	80	

Table 4 To Be Continued…						
8	Inspiratory position of the chest	Test 1	0.70	0.461	80	0.854
		Test 2	0.60	0.493	80	
9	Hyperextension in the thoracolumbar region	Test 1	0.24	0.428	80	0.528
		Test 2	0.18	0.382	80	
10	Abdominal diastasis	Test 1	0.03	0.157	80	-0.035
		Test 2	0.01	0.112	80	
11	Concavities of abdominal wall above the level of groin	Test 1	0.06	0.244	80	0.938
		Test 2	0.05	0.219	80	
12	Shoulder protraction	Test 1	0.65	0.480	80	0.813
		Test 2	0.60	0.493	80	
13	Cervical spine hyperextension	Test 1	0.34	0.476	80	0.926
		Test 2	0.28	0.449	80	
14	Over activity of superficial hip flexors	Test 1	0.05	0.219	80	0.568
		Test 2	0.01	0.112	80	

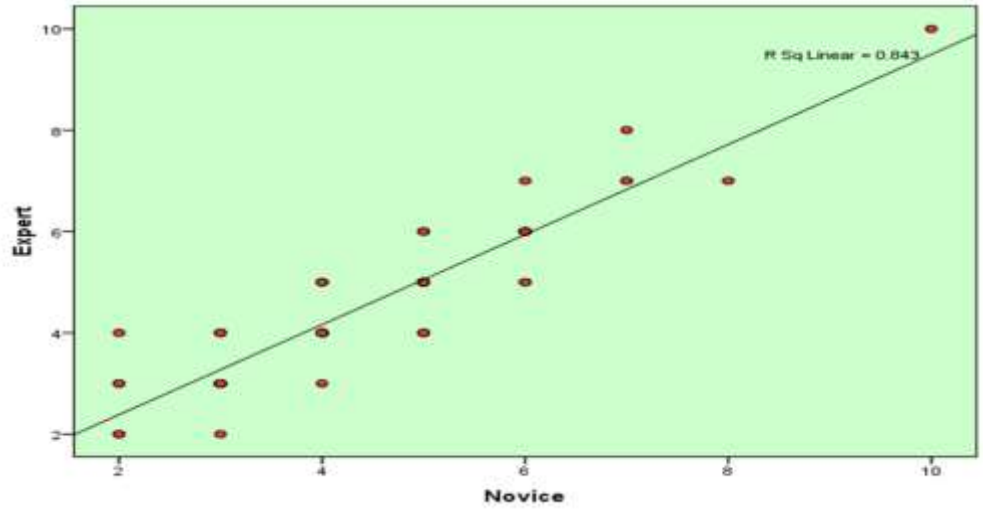
Table 4 shows the intrarater reliability for all the 14 components using the Cronbach's alpha with the 3 components show excellent agreement, 5 components show good level of agreement, 2 components are show acceptable agreement and 4 components show poor level of agreement between the test 1 and test 2.

TABLE – 5 INTRARATER RELIABILITY BETWEEN THE TEST-1 AND TEST-2

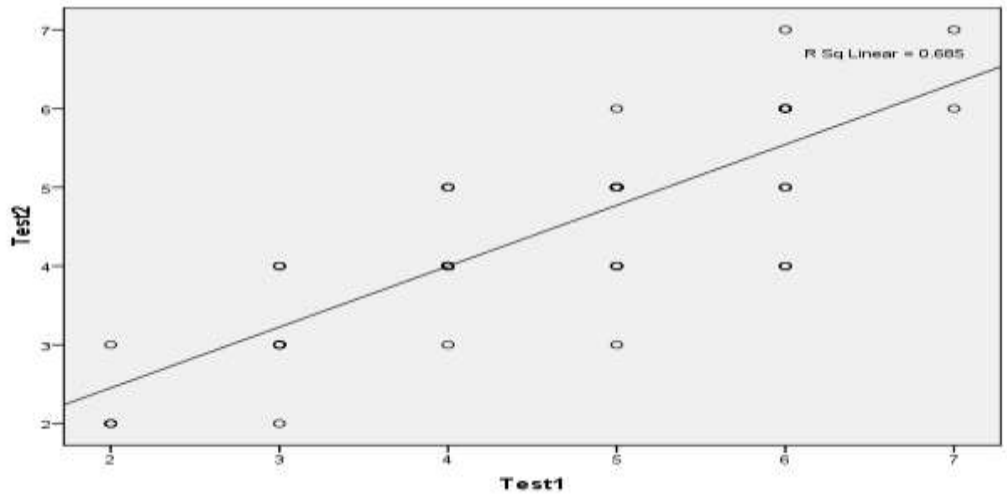
Intrarater	Mean	SD	N	r-value	ICC
Test1	4.48	1.169	80	0.826	0.903
Test 2	4.38	1.072	80		

Table 5 shows the overall intrarater reliability between the test 1 and test 2 with the r-value of 0.826 and ICC of 0.903 and shows an excellent intrarater reliability between the test 1 and test 2.

Graph – 1: Difference between the novice and expert raters for interrater reliability.



GRAPH – 2: Difference between test 1 and test 2 for intrarater reliability.



DISCUSSION

The study aimed to find out the interrater and intrarater reliability of the intra-abdominal pressure test in young adults. The intra-abdominal pressure test is the quick and inexpensive test with minimal equipment. These data clearly indicate that the IAPT can be applied confidently by trained individuals, no matter experienced or non-experienced raters, when the standardized procedure is used. The three statistical analysis has been done (ICC, Kappa and percentage agreement) and managing data (individual and group criteria) produced different levels of agreement between the novice and expert raters.

Agreement between the expert and novice raters was generally excellent overall, although agreement strength depended on the analysis used i.e, overall statistical analysis was excellent, ICC = 0.957 and kappa values indicate 14 components of which 5 components (balanced activity of all the abdominal muscles, chest is kept in neutral position, inspiratory position of the chest, concavities of abdominal wall above the level of groin, and cervical spine hyperextension) show excellent agreement and 8 components (lower chest widens, pelvic floor and diaphragm stay almost parallel, hyperactivation of the rectus abdominis muscle, insufficient activation of the lower abdominal wall, cranial migration of the umbilicus, hyperextension in the thoracolumbar region, shoulder protraction, and overactivity of superficial hip flexors) show to have good and 1 component (abdominal diastasis) show to have poor level of agreement between the expert and novice raters.

The few differences in the results may be due to the skill between the experienced and non-experienced raters, testing protocol, psychological aspect of the subjects, inability of the subjects to learn the test. The participants were asked to perform the test and the test is an evaluation of their habitual or natural breathing pattern. The criteria involve the precise observations, it is necessary to review assessment criteria by the expert and novice raters prior to the test to achieve the consistent results.

This study ensures that there is an overall excellent intrarater reliability, ICC=0.903. For all the 14 components using the Cronbach's alpha, 3 components(chest is kept in neutral position, concavities of abdominal wall above the level of groin, and cervical spine hyperextension) show excellent agreement, 5 components (balanced activity of all the abdominal muscles, lower chest widens, insufficient activation of the lower abdominal wall, inspiratory position of the chest, shoulder protraction) showing good level of agreement, 2 components (pelvic floor and diaphragm stay almost parallel, hyperactivation of the rectus abdominis muscle) show acceptable agreement. The 4 components (cranial migration of the umbilicus, hyperextension in the thoracolumbar region, abdominal diastasis and overactivity of superficial hip flexors) were found to have poor level of agreement with ICC=<0.5 which comes under the unacceptable level of agreement between the test1 and test 2. This is due to the fact that components like shoulder protraction and cervical spine hyperextension are the compensatory presentation of the faulty breathing pattern and nothing could be done with the anatomical configuration.

Intra-abdominal pressure is modulated and activated in relation with the task. IAP is the key element which organizes movement awareness and the recruitment of muscles because it happens from inside. Imagine there is a large balloon which is self-inflating that allows to know what the hips and shoulders does because of positive internal pressure[4].

In order to perform daily activities and exercises it is necessary for a person to create sufficient intra-abdominal pressure. The lower back gets rounded in some individuals and it is due to insufficient IAP production which leads to low back pain and dysfunctional breathing. The most apparent sign of proper stabilization with

adequate IAP is the filling out of the concavities at the lower lateral abdominal wall[5].

In this study some of the subjects were able to blow their abdomen like a balloon which mimics the belly breathing or balanced activity of all the abdominal walls with ICC=0.853, but with no or less lateral excursion of the diaphragm. Hanslindgren in his study stated that, diaphragmatic breathing is frequently referred to as belly breathing, which is incorrect. The intra-abdominal pressure increases when the diaphragm contracts and moves caudally into the abdominal cavity which causes abdominal wall to distend with the slight expansion in all the 3 directions[5].

The abdominal wall's opposing action is important in controlling the length tension relationship of the diaphragm. This opposing action of the abdominal muscles maintain the dome shape of diaphragm and the zone of apposition and enhances the increased force of diaphragm. Belly breathing does not produce any resistance to the diaphragm instead distends the abdomen forward, and thus reduce diaphragm's ability to contract effectively.

Some subjects could not able to activate the lower abdominal wall and unable to push the fingers placed above the level of groin by the examiner with ICC=0.802, this shows the subject could not able to generate the intra-abdominal pressure and it is assessed by asking the subject to push against examiner's fingers against resistance.

In this study most of the subjects kept their chest in inspiratory position with the ICC = 0.854 and this is the postural signs of dysfunctional breathing. In this case the rib cage becomes stiff and elevated which causes the ribs to rotate externally and pulls the diaphragm's costal fibres into more vertical and straight position and reduces diaphragm's contraction and zone of apposition. The lower lateral excursion of diaphragm is less or diminished in some subjects. During the administration of the test, the raters passively brought down the chest to the expiratory position and instructed the subjects to maintain the position throughout the test[13].

The function of the core stabilization is to maintain the increased intra-abdominal pressure throughout normal breathing cycles. This is attained by the simultaneous activity of the diaphragm, abdominal muscles and pelvic floor. To facilitate an increased intra-abdominal pressure, the diaphragm should perform its breathing at a lower position.

The pelvic floor and diaphragm are almost parallel between the 1 and 2nd test with the ICC= 0.718, The muscles of pelvic floor is the base for abdominal canister. If the pelvic floor lacks its integrity that leads to inability to sustain intra-abdominal pressure. Pavel Kolar in his study stated that when the subject presenting with inspiratory chest position often occurs with an anterior pelvic tilt so, the chest and pelvic axes becomes oblique instead of parallel. For optimal respiration and stabilization, the chest must be above the level of pelvis, with their axes almost parallel and horizontal to each other[13].

Some subjects present with the hyper activation of the rectus abdominis muscle (RA) with ICC = 0.798, which is due to unbalanced activation of the abdominal wall with decreased tone in the internal and external oblique muscles as well as transverse abdominis (TrA) and this hyperactivation of rectus abdominis can be seen in the upper sections and concavities can be seen at the lateral lower abdominal wall in supine position and this shows there is inadequate IAP generation. The RA dominant activation can be observed by the cranial migration of the umbilicus.

Anterior tilt of the pelvis, hyperextension in the thoracolumbar junctions occur due to the paravertebral muscles hyperactivity that indicates unstable spine due to inadequate IAP. This can be assessed by subjects's lumbar lordosis increase and lower back does not adhere to the table; lack of IAP and intra-pelvic pressure causes hollowing above groin.

The position of shoulder is important in stabilization with the ICC=0.813. Protraction and elevation of shoulder is the compensatory faulty breathing signs of dysfunctional breathing and can be assessed by excessive activation of the upper trapezius and pectoralis muscle. Cervical hyperextension is observed in many subjects as it is also the compensatory faulty sign of dysfunctional breathing with the ICC=0.926, and it can be assessed by the increased cervical lordosis.

Overactivity of the hip flexors are observed with ICC=0.568. Poor trunk stabilization does not anchor hip flexors properly and the subject cannot maintain neutral hip position as a result; lower extremities becomes ‘’ too heavy’’ and fall back on the table; hip abduction increases.

The inability to create insufficient intra-abdominal pressure leads to dysfunctional breathing pattern and low back pain. The respiratory function of the diaphragm is achieved when it is in lower down position to produce sufficient IAP needed for postural task. The diaphragm’s position is different in chronic low back pain sufferers thus inhibiting them to activate the core properly and no intra-abdominal pressure is produced. Both belly and chest breathing are the signs of dysfunctional diaphragm function and position. Pavel Kolar’s evidence suggests that individuals who has increased risk for low back pain have the limited capability to contract their diaphragm for stabilization.

The intra-abdominal pressure test is useful in assessing the individual’s proper use of diaphragm and checking the generation of IAP and show excellent interrater and intrarater reliability while analyzed with the individual components of the test and out of 80 subjects only 4 subjects satisfied the correct and incorrect activation criteria and passed the test in the interrater reliability and 6 subjects passed the test in the intrarater reliability.

CONCLUSION

The study concludes that there is an overall excellent interrater and intrarater reliability of the intra-abdominal pressure test in normal young adults and hence it can be used in clinical practice. The IAPT is reliable for testing the pattern of recruitment of diaphragm, pelvic floor muscles, abdominal wall and spinal extensors. This test can be used to identify the dysfunction of these groups of muscles.

List of Abbreviations:

IAP – Intra-abdominal pressure

IAPT - Intra-abdominal pressure test

Declaration by Authors

Ethical Approval: Ethical approval was obtained from Institutional Ethics Committee of SRM Medical college hospital and research Centre, Kattankulathur, India (no. 1560/IEC/2019) dated 27.02.2019. Every participant gave a written consent to participate in this research

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