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# Effect of Fatigue on Balance and Chest Expansion in Normal Adults

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***Abstract***
***The purpose*** *of this study was to investigate the effect of fatigue on balance and chest expansion in normal adults.* ***Materials and methods:*** *thirty eight normal subjects from both genders were participated in this study. They were recruited from faculty of physical therapy students and workers. Their ages were ranged between 18-25 years. They were grouped into one group. Biodex lab was used to measure balance pre-post fatigue. Maximum voluntary ventilation was measured by spirometer. Chest expansion was measured by tape measurement.* ***Results:*** *A statistical significant decrease was found in balance, maximum voluntary ventilation and upper chest expansion.* ***Conclusion:*** *Fatigue affected on balance and chest expansion.*

***Key words****: balance, fatigue, postural stability, chest expansion., maximum voluntary ventilation*

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## I. Introduction

Neutral posture is the anatomical alignment of spinal curves which is coordinated in response to change in center of gravity (C.O.G). The coordination of posture with C.O.G is called balance. Subjects with postural changes were expected to have a displaced C.OG. [1]

The maintenance of balance is important in the prevention of injuries and this ability depend on proprioceptive input from musculotendinous and capsuloligamenteous mechanoreceptors in conjunction with visual and vestibular input to central nervous system..[2, 3] .This input is used in both feedback and feed-forward loops to provide the appropriate neuromuscular response. [4, 5] Alternation in any of these inputs would disturb balance and increase the risk of injury. [6]

Fatigue alter the proprioception and kinesthetic properties of joints by increasing joint laxity and by causing sensorimotor and biomechanical deficits such as reduced muscle strength and activity therefore decreasing neuromuscular control thus increasing the risk for injury and the risk of fall[7, 8.]. The most outcomes of fatigue are minimizing the skills related to physical fitness like balance, strength, activities of daily living. [9].

Ventilation is a complex process determined by diaphragm, rib cage and abdominal muscle contraction and balance-elasticity of soft tissues surrounding rib cage and thorax. [10]. The diaphragm has been hypothesized to be a respiratory muscle with postural function [11]. The diaphragm has been found to contract prior to initiation of upper extremity movement [12]. Independently of the phase of respiration [13]. .

Core strength and stability have been found to be an important element in either prevention of injury and physical activities, moreover postural stability is subjected to the strength, coordination and modification of the core musculature .[14] and is essential for perfect biomechanical function across the kinetic chain .[15].

**Hodges et al**, found that as a respiratory demand increased the postural function of the diaphragm decreased. [16]. so that the biomechanics of respiration have been found to be with respect to abdominothoracic expansion during inspiration at rest, and cost diaphragmatic breathing is watched when the abdominal and lateral costal expansion is prevalent over the superior thoracic expansion. Although data are still limited, trends are concentrated throughout clinical consideration indicating that a process of diaphragmatic breathing may be useful for posture, core stability, upper thoracic hyper tonicity .[17]. And decreasing the percent of incidence of low back pain. [18]. so, the purpose of this study was to investigate the effect of fatigue on balance and chest expansion in normal adults

## II. Subjects And Methods

This study was conducted at the Faculty of Physical Therapy, Misr University for Science and Technology in the Biodex balance lab. In the period from September 2019 to November 2019, to investigate the effect of fatigue on balance and chest expansion in normal adults.

**Subjects**

Cross section observational study was used to investigate the effect of fatigue on balance and chest expansion in normal adults using Biodex balance system-Spirometer- Tape measurement

A sample of thirty eight normal participants out of 120 volunteers who expressed a desire to undergo the test and fulfilled the selection criteria. Every participant was subjected to a primary examination to obtain a complete picture of their health status to identify any contraindication and to determine whether the patient could participate in the study. All participants were signed a written informed consent. Participants were included if their age between 18-25 years

Measurement were performed under the following standardized conditions:(i) measurement were carried out by the same investigator and (ii) the same balance measures were assessed before and after applied fatigue for each participant using the Biodex stability system(BSS), measure maximum voluntary ventilation before and after fatigue by spirometer and measure chest expansion before and after by tap measurement. All participants were applied fatigue by treadmill.

The participants were excluded if they had history of respiratory diseases, heart disease, vascular disease, central nervous system disorder, diabetes mellitus, psychiatric disorders, hypertension, musculoskeletal problem and neurological deficit affecting balance.

**Instrumentation**
**For evaluation**

• Height measurement by Stadiometer.
• Weight measurement by weighting scale.
• Tape measurement to measure chest expansion.
• Spirometer easy one to measure maximum voluntary ventilation.
• The Biodex Balance System to measure the postural stability and the limit of stability.

**Procedures**
**Height measurement by Stadiometer:**
Ask the participant to stand straight with bared feet flat together in the center of the base of the board, push gently down the movable block until it touches the subject's head and read the measurement by cm.[19].
**Weight measurement by weighting scale:**
Ask the participant to stand over the center of the platform with the body weight equally distributed between both bared feet and read the measurement by kg.[19].
**Spirometer**
The participant sit on chair without back support and hold the spirometer device, put the mouse piece in the mouth, close the nose by nose clip, instruct the participant to make forced and deep inspiration and expiration until time over (12 sec.) [20], repeat the maneuver three times and take the average .[21]
**Chest expansion test:**
Chest expansion test made by tape measurement, instruct the participant to sit on the chair, foot on the ground, without back support. physical therapist measure upper chest expansion by putting the tape at 2nd intercostal space, middle chest expansion by putting the tape at 4th intercostal space and lower chest expansion by putting the tape at the level xiphoid process. Instruct the participant to make deep inspiration and take the reading at the end of inspiration.[22]

**Biodex balance test:**

To measure the postural stability, the Biodex Balance System uses a circular platform that is free to move in the anterior–posterior and medial - lateral axes simultaneously and allows up to 20° of foot platform tilt and calculates a medial–lateral stability index (MLSI), anterior–posterior stability index (APSI), and an overall stability index (OSI). A high score indicates poor balance. The stability of the platform can be adjusted by the level of resistance of the springs under the platform. The ranges of the platform stability is from 1–8, with 1 representing the greatest instability[23] . the participant stands with both feet and opened eyes on the platform. The subject instructed to achieve a centered position on the released platform by shifting position of foot to keep cursor centered on the screen. The participant does the test three trials while the stability level is eight..

To measure the limit of stability, the participants move the cursor to each of 8 successive targets on the display screen by leaning and returning to the center position before the next target is selected while standing on the fully unstable platform. The participant must complete all 8 targets while keeping your body in a straight line to reach the end of the test. [24]the participant does the test three trials.

**Treadmill:**
The participant walk on treadmill as fast as possible gradually for 15 min. the spirometer , chest expansion test and biodex balance test made before and after walking.

**Statistical analysis**
All statistical analyses were carried out by using the statistical package for the social sciences (SPSS, version19 for windows; SPSS Inc., Chicago, Illinois, USA). Data were screened for normality assumption, homogeneity of variance, and presence of extreme scores. Shapiro-Wilk test for normality showed that all measured variables were not normally distributed, so Wilcoxon test to for within subjects' comparison and spearman correlation coefficient test for correlation. Statistical analysis was conducted using SPSS for Windows, version 20 (SPSS, Inc., Chicago, IL). The p-value was set at < 0.05.

**General Characteristics of the Subjects:**
Data were collected from 38 subject as shown in table (1,2); study group consisted of 38 subjects 23 males and 15 females, their mean age, weight, height and BMI were (23.6±0.94) years, (74.2±14.2) kg, (168.5±11) cm and (25.9±3.1) kg/m2 respectively

**Table (1): General Characteristics of subjects**

| Study group | Mean | ±S. D. | Minimum | Maximum |
|---|---|---|---|---|
| Age (years) | 23.6 | 0.94 | 22 | 25 |
| Weight (kg) | 74.2 | 14.2 | 53 | 95 |
| Height (cm) | 168.5 | 11 | 155 | 188 |
| BMI (kg/$m^2$) | 25.9 | 3.1 | 21 | 30.8 |

**Table (2): Sex distribution of the subjects.**

| Sex | Male | Female |
|---|---|---|
| Frequency | 23 | 15 |
| Percent | 60.5% | 39.5% |

**Table (3) Comparison between the mean values of pre and post-walking of postural stability, limits of stability, chest expansion and Maximum voluntary ventilation.**

| Variables | | Pre-fatigue | Post-fatigue | Percentage of change (%) | Z-value | P-value |
|---|---|---|---|---|---|---|
| Postural stability | Overall | 1.54±0.47 | 1.26±0.43 | -18.2 | -3.01 | 0.003* |
| | A/P | 0.95±0.34 | 0.9±0.29 | -5.3 | -0.455 | 0.640 |
| | M/L | 0.94± 0.30 | 0.69±0.27 | -26.6 | -3.93 | 0.001* |
| Limits of stability | Overall | 11.3 ±3.4 | 13.9 ±4.7 | 23 | -4.59 | 0.001* |
| | Forward (F) | 14.3±7.6 | 14.8±6.9 | 3.5 | -0.563 | 0.573 |
| | Backward(B) | 19.7 ± 8.2 | 20.4±6.4 | 3.6 | -0.312 | 0.755 |
| | Left (L) | 13.5 ± 5.4 | 15.7±5.7 | 16.3 | -3.64 | 0.001* |
| | Right (R) | 11.8±4.9 | 16.2±6.7 | 37.3 | -3.92 | 0.001* |
| | F/L | 15.7±8.9 | 18.3±8.6 | 17.6 | -1.08 | 0.276 |
| | F/R | 14.1±6.8 | 15.1±5.7 | 7.1 | -1.46 | 0.143 |
| | B/L | 16.1 ± 5.3 | 16.9±6 | 5 | -0.970 | 0.332 |
| | B/R | 12.4±3.9 | 18.1±8.1 | 46 | -4.67 | 0.001* |
| Chest expansion | Upper | 4.8 ±1 | 4.1±1.5 | -14.58 | -2.78 | 0.005* |
| | Middle | 4.9±1.5 | 4.84±1.52 | -1.2 | -0.123 | 0.902 |
| | Lower | 4.7 ±1.5 | 4.9±2.7 | 4.3 | -0.705 | 0.481 |
| Max. voluntary ventilation | | 127.8±45.2 | 123.2±36.1 | -3.6 | -0.457 | 0.647 |

Level of significance at p<0.05, *= significant, Plus-minus(±)values are mean standard deviation (SD)

Statistical analysis using the results of Wilcoxon test in the Table (3) revealed that there was no a significant difference between pre and post fatigue in the antero-posterior of postural stability. While there were significant decrease between pre and post-fatigue in the overall and M/L of postural stability.

Considering the Limits of stability there were no significant differences between pre and post fatigue in forward, backward, forward left, right and backward left. While there were significant decrease between pre and post-fatigue in the overall, left, right and backward right.

As well as, there was no significant difference in middle and lower chest expansion and max. voluntary ventilation, but there was significant decrease between pre and post-fatigue in the upper chest expansion and there was decrease in maximum voluntary ventilation pre-fatigue and post fatigue but not statistical difference.

**Table (4): Correlation between the overall of postural stability, chest expansion and Maximum voluntary ventilation in pre and post fatigue.**

| Variables | Correlation (r) | | P- value | |
|---|---|---|---|---|
| | Pre-fatigue | Post-fatigue | Pre-fatigue | Post-fatigue |
| Overall of postural stability+ upper of chest expansion | 0.211 | 0.140 | 0.204 | 0.401 |
| Overall of postural stability+ middle of chest expansion | 0.413 | 0.570 | 0.010* | 0.001* |
| Overall of postural stability+ lower of chest expansion | 0.051 | 0.703 | 0.760 | 0.001 * |
| Overall of postural stability+ Max. voluntary ventilation | -0.190 | 0.749 | 0.252 | 0.001 * |

P-value < 0.05, then r is significantly different from 0 and the variables show some degree of correlation, *= significant.

Statistical analysis in Table (4) showed results of Spearman correlation co-efficient test. Data revealed that there was no significant correlation between the overall of postural stability and upper and middle chest expansion in the pre and post-fatigue. Also, there was no significant correlation between the overall of postural stability and lower chest expansion and maximum voluntary ventilation in the pre fatigue.

While, there was significant strong direct correlation between the overall of postural stability and lower chest expansion, also between the overall of postural stability and maximum voluntary ventilation in the post-fatigue. There was significant medium direct correlation between the overall of postural stability and middle chest expansion pre and post fatigue.

## III. Discussion

The purpose of this study was to investigate the effect of fatigue on balance and chest expansion in normal adults. The finding of this study revealed that there was significant decrease in overall and mediolateral postural stability post fatigue while there was no significant difference in anterioposterior postural stability pre-post fatigue.

There was significant decrease in maximum voluntary ventilation and upper chest expansion pre-post fatigue while there was no significant difference in lower and middle chest expansion pre-post fatigue.

There are primary reasons that have been proposed to explain why fatigue decreased the dynamic postural balance, the balance is controlled by C.N.S through integration of sensory information from the vestibular somatosensory and visual system and when the muscles that control balance are fatigued, these systems would be affected thus inhibiting proper balance control . [25]. Second the muscular fatigue increase the muscle spindle discharged which disrupts the afferent feedback input to C.N.S that causes alternation in proprioceptive and kinesthetic properties of joint which has a negative effect on postural control [26].

The application of fatigue protocol on a part of the body and the muscles acting on a joint causes the sensory receptors to send messages to the C.N.S that result reduction of neural transmission therefore dynamic balance control is decreased. [27]

**Simoneau et al (2006)** examined how moderate fatigue by fast walking affected the control of balance of ten healthy young adults and they reported a negative effect on the control of balance. [28]. In addition **Miura et al (2004) and Lee et al(2003)** found that the muscular fatigue induces an adverse change in the proprioception as well as postural control [29,30].

The results of the study were supported by **Gribble et al (2004,2007 and 2009)** who found a significant decrease postural control after lower extremity muscle fatigue in healthy participants which indicated that the balance was affected by fatigue. [31]

**Yaggie and Armstrong (2004)** also examined the impact of lower extremity fatigue on balance indexes using the sport-KAT2000 system before and immediately after fatigue protocol. They reported that lower extremity fatigue adversely affected balance index scores which is agreement with the results of our current study. [32]

The fatigue affected on the diaphragm muscle which plays an important role in respiratory functions and lung capacity so the maximum voluntary ventilation and upper chest expansion decreased after fatigue when comparing with pre fatigue. [33]

On the other hand diaphragmatic fatigue is accompanied by a sympathetically mediated redistribution of blood flow away from active locomotor muscles [34] known as the respiratory muscle metaboreflex [35]. This "steal" phenomenon compromises leg blood flow, hastens the development of peripheral locomotor muscle fatigue in which that the diaphragmatic work contributes in part to the whole body endurance exercise capacity. [36]

**Romer et al (2006)** also stated that fatiguing respiratory muscle work compromises active limb locomotor blood flow and catalyzes locomotor muscle fatigue, In turn, exacerbation of effort perception would be expected to precipitate a reduction in central motor control (balance), thereby facilitating the premature termination of exercise [37] A disturbance of the normal relationship between information on muscle length and tension in the control system can be envisaged in all conditions associated with breathlessness [38] and this findings were in agree with our findings.

**Limitation**

limitation of the current study was the inclusion of a blind investigator, and thus we recommend for further research and also the bias of selection of the sample due to lacking of randomization.

## IV. Conclusion

According to the findings of this study it was concluded that fatigue decreased the dynamic postural balance in normal adults and this implies that muscles of fatigued individuals are at increased risk for musculoskeletal injuries and also the fatigue decreased the maximum voluntary ventilation and upper chest expansion as the fatigue affected on diaphragm muscle so effect on lung capacity.

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