Assessment of respiratory muscles endurance in diabetic patients

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ABSTRACT

Objectives: Respiratory muscle endurance is of interest in pulmonary, critical care and many other areas of medicine. The maximal voluntary ventilation (MVV) test is an objective dynamic method for measuring the working capacity of respiratory muscles. Therefore, we designed the present study to determine the effect imposed by diabetes mellitus on respiratory muscle endurance in Saudi diabetic patients.

Methods: We conducted this study in the Department of Physiology, College of Medicine, King Khalid University Hospital and Diabetic Centre, King Abdul-Aziz University Hospital, Riyadh, Saudi Arabia during the year 2002-2004. In this study, we recruited 39 male diabetic patients and equal number of control subjects and all participants were non-smokers with age range of 23-71 years. The subjects were matched for age, height and weight. We determined the respiratory muscles endurance by a direct MVV test during inspiratory and expiratory phases of respiration by using a MP-100 student Bio Pac system and compared the results using a paired t-test.

Results: In inspiratory and expiratory phases of respiration, diabetic patients showed a significant reduction in the mean values of direct MVV test ($p<0.001$) relative to their matched controls.

Conclusion: We conclude that in diabetic patients the respiratory muscles endurance is impaired by a decreased in MVV values. This decline in MVV further showed that the diabetic patients have a reduced inhaled and exhaled volumes during consecutive breaths.

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Diabetes mellitus (DM) is increasing worldwide at an alarming rate with a predicted global prevalence of 4% in 1995[1] and an expected rise to 9% by the year 2025.[2] Although DM has a worldwide distribution, it is observed more commonly in the developed European countries, United States and Middle-East countries.[3] Diabetes mellitus is associated with long term damage, dysfunction and failure of various organs[2] and its complications are mainly a consequence of macro-vascular and micro-vascular damage. A great attention has been centered towards the complications of DM include cardiovascular disease, diabetic retinopathy, nephropathy and neuropathy, however; the pulmonary complications of DM have been poorly characterized. Moreover, physicians should know the size of the problem of pulmonary complications as a consequence on the novel techniques used in the treatment of DM through the respiratory system such as inhaled insulin. Early recognition of respiratory muscle involvement in diabetic patients is important as it can lead to serious complications which may cause respiratory

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failure. Laboratory assessment of respiratory muscle function in clinical practice involves different types of endurance tests.[4] Maximal voluntary ventilation (MVV) evaluates respiratory function through a dynamic exercise, and for that reason it is more closely related to the pathophysiology of the disease. Maximal voluntary ventilation is the largest volume that can be breathed into and out of the lungs with voluntary effort during 12-15 seconds interval[5] and as one of the marker for respiratory muscles performance. A number of biochemical, enzymatic, genetic and functional changes of skeletal muscles in association with DM have been reported.[6,7] But curiously, less attention has been paid to investigate the respiratory muscle function in humans by using direct MVV test. Some studies reflect the data in diabetic patients by calculating the in-direct MVV by multiplying the forced expiratory volume in one second (FEV_1) with 35 or 40.[8] Keeping in view, the sensitivity of this major public health problem and realizing the significance of direct MVV test, we took one step forward and recorded the direct MVV to determine the respiratory muscle endurance in diabetic patients.

Methods. This study was conducted at the Department of Physiology, College of Medicine, King Khalid University Hospital, and Diabetic Center, King Abdul-Aziz University Hospital (KAUH), King Saud University, Riyadh, Kingdom of Saudi Arabia during the period between 2002-2004.

Subjects. One hundred and sixty-five medical files of diabetic patients were reviewed and referred to the Diabetic Center, KAUH. A detailed clinical history was taken to determine whether they would be included in the study or not on the basis of the exclusion criteria. After the initial interviews 39 apparently healthy male diabetic patients with a mean age of 49.96 ± 2.51 years (mean ± SEM), range 23-71 years with mean duration of disease 15.92 ± 1.59 years (mean ± SEM), range 2-30 years, were selected and 126 were excluded. These diabetic patients were 17 type 1 DM and 22 type 2 DM. Controls were selected in a similar manner to the diabetics, from approximately 106 interviewed, 39 apparently healthy male control subjects were selected with a mean age of 47.23 ± 1.49 years (mean ± SEM), range 22-65 years. Keeping in view, the significance of anthropometric variables on respiratory muscles, we individually matched all the diabetic patients for age, height, and weight with controls. Controls were from the same community with a similar living status relative to diabetics. All subjects completed a questionnaire, which included anthropometric data and consent form. The Ethics Committee, College of Medicine, King Khalid University Hospital, approved the study.

Exclusion criteria. Subjects with clinical abnormalities of the vertebral column, thoracic cage, neuromuscular diseases, known cases of gross anemia, pulmonary tuberculosis, bronchial asthma, chronic bronchitis, bronchiectasis, emphysema, ischemic heart disease, malignancy, drug addicts, cigarette smokers, those who had undergone vigorous exercise, abdominal, or chest surgery, also patients with known complications of DM such as diabetic neuropathy, myopathy, nephropathy and retinopathy were also excluded from the study.

Direct MVV test was performed during inspiratory and expiratory phases of respiration on MP 100 Student Bio Pac System. All the tests were carried out at a fixed time of the day (10.00-14.00 hours) to minimize diurnal variation. The apparatus was operated within the ambient temperature range of 20-25°C. After taking a detailed history and anthropometric data. The subjects were informed about the whole maneuver. The subjects were encouraged to practice this maneuver before performing the test and was attempted to reduce a number of variables that could interfere with the pattern of breathing either before or during the experiment and efforts were also made to limit any stress and to relax the subject and train them to breathe adequately. The test was performed with the subject in standing position and the subject inspired and expired forcefully for the period of 15 seconds into the mouth pieces which was connected with MP-100 Student Bio Pac System. The test was repeated 3 times after adequate rest, and results were appeared in computer and direct MVV test results were obtained.

Statistical analysis. Statistical analysis was conducted using a student paired t-test for independent group (2-tailed). The level of significance was taken as $p<0.05$.

Results. Anthropometric data for age, height and weight for diabetic patients and their matched controls are shown in **Table 1**. Means for age, height or weight were not significantly different between the groups.

Direct maximal voluntary ventilation. Direct MVV test data in inspiratory and expiratory phases of respiration for diabetic patients and their matched controls are shown in **Table 2**. Diabetic patients had statistically significant reductions in the mean values of MVV both in inspiratory and expiratory phases of respiration. In the control group, the mean values were 272.44 ± 22.23 L/min (mean ± SEM; range 82.1-689.46 L/min) during the inspiratory phase and 272.59 ± 22.0 L/min (mean ± SEM; range 83.59-

Table 1 - Anthropometric parameters between diabetic patients and their matched controls.

Parameter	Diabetic patients (mean±SEM) (n=39)	Control (mean±SEM) (n=39)	%	*p* value
Age (years)	49.96 ± 2.51	47.23 ± 1.49	- 5.78	NS
Height (cm)	168.75 ± 1.15	168.92 ± 1.69	+ 0.10	NS
Weight (kg)	80.16 ± 1.93	82.86 ± 3.13	+ 3.25	NS
NS=non-significant				

Table 2 - Direct maximal voluntary ventilation (MVV) data between diabetic patients and their matched controls in inspiratory and expiratory phases of respiration.

Parameter	Diabetic patients (mean±SEM) (n=39)	Control (mean±SEM) (n=39)	%	*p* value
MVV in inspiratory phase (L/min)	105.53 ± 8.72	272.44 ± 22.23	+158.16	0.001
MVV in expiratory phase (L/min)	100.88 ± 8.73	272.59 ± 22.00	+170.21	0.001

660.63 L/min) during expiratory phase. However, in diabetic patients, the MVV values were 105.53 ± 8.72 L/min (mean ± SEM; range 30.57-126.79 L/min) during the inspiratory phase and 100.88 ± 8.73 L/min (mean ± SEM; range 29.72-234.40 L/min) during expiratory phase. The overall MVV values in 3 (7.7%) cases were less in control group and 24 (61.5%) were less in diabetic patients compared to the normal values for MVV.

Discussion. Respiratory muscle endurance is of interest in pulmonary, critical care and many other areas of medicine. The capacity of the respiratory muscle pump to respond to the load imposed by disease is the basis of an understanding of ventilatory failure. Severe weakness of these muscles and decreased endurance may result in respiratory disaster. The best way to prevent such a crisis is to detect early evidence of factors affecting the respiratory muscles endurance. Measurement of the mechanical work of breathing during MVV is useful for assessing the working capacity of respiratory muscles.[7] In the present study, we observed a reduction in inhaled and exhaled volumes in consecutive breaths during the direct MVV test (**Table 2**). The overall MVV values in 3 (7.7%) cases were less in control group and 24 (61.53%) were less in diabetic patients compared to the normal values for MVV. Rochester[9] and Barnhart and Balmes[10] demonstrated that MVV test is the only simple index of respiratory muscle endurance which reflects the function of the entire ventilatory apparatus and is a main pulmonary test used in categorizing dyspnea. Ioannis et al,[11] reported that the assessment of respiratory muscles weakness is important and MVV is an objective dynamic method for measuring the capacity of respiratory muscles. Similarly, Enright et al,[12] reported that reduction in MVV may be caused by upper or lower airways obstruction, restriction or muscle weakness. In addition, Ruppel[13] demonstrated that the decreased in MVV values may be due to muscle weakness, airway obstruction, or poor effort. Keeping in view the observations on MVV and poor performing efforts demonstrated by Ruppel,[13] in the present study, we tried to reduce a number of variables that could interfere with the pattern of breathing either before or during the experiment. Thus, efforts were made to limit any stress and to relax the subject and train them to breathe adequately. Neder et al,[14] reported that the MVV is a test of the overall function of the respiratory system and is influenced not only by respiratory muscles strength, but also by the compliance of the lung-thorax system, the condition of the ventilatory control systems and the resistance of both airways and tissues. Additionally, they also reported that inspiratory and expiratory muscles are utilized during maximal voluntary effort and weakness or decreased endurance of either system may result in low MVV. Conrand[15] demonstrated that normal individuals can sustain inspiratory and expiratory volumes during the testing interval whereas subjects with muscular weakness markedly decreased the MVV. In the present study, we observed decreased mean values in both inspiratory and expiratory phases of respiration. This impairment in MVV in diabetic patients showed decline in respiratory endurance which may leads to respiratory exertion and breathlessness. Additionally, our results showed that the diabetic patients failed to sustained inspiratory and expiratory volumes during the testing interval due to the muscular weakness. Varthakavi et al,[16] Lord et al,[17] Andersen et al,[18] and Van Schie et al,[19] conducted a study on muscle weakness and other body deformities in diabetic patients and found that the diabetic patients had a reduced muscle strength. Furthermore, Mancini et al,[20] and Scano et

al,[21] reported that breathlessness is also associated with DM. Heimer et al,[8] studied the respiratory muscle strength and endurance in 31 diabetic patients. The MVV was significantly decreased in the diabetic group and correlated with the duration of diabetes. This decline shows decreased respiratory muscle endurance in diabetic patients compared to the control group.

The present study confirms the finding of others, and concludes that the MVV in diabetic patients is significantly decreased as compared to their matched controls. This decline in MVV values showed that the diabetic patients have a reduction in the inhaled and exhaled volumes during consecutive breaths. This impairment in MVV is most probably due to the decreased respiratory muscles endurance or weakness hence the MVV is markedly decreased in diabetic patients. It is also advisable, therefore, that physicians should contemplate on respiratory system in a same way as that of other complications of DM.

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