

*Original Research Article*

**Effect of Monomer Inhalation on The Lung Function Volume of Dentistry Female Students By Using The Spirometer**

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**Abstract**

The aim of this study was focused on the adverse effects of the poly methyl methacrylate monomers on the physiological lung functions.

The total number of female students were 42 with range of age from 20-22 years. The lung function was measured by using a standard protocol and spirometry to measure (FVC), (FVC1), (FVC1/FVC), AND (PEF). The participants was exposed to monomer in prosthetic laboratory and immediately the test was repeated after exposure to the monomer, then the lung function test was repeated to measure the delayed post-work effect of monomer.

The largest differences in the mean and standard deviation of the FVC and PEF between the pre-work and the measurement after the inhalation of the monomer immediately. FVC was significantly lower ( $p < 0.05$ ) in student after work with mean  $(2.3891 \pm 0.60623)$  than pre-work mean  $(5.7577 \pm 1.88277)$ . FEV1 show significant decrease ( $P < 0.05$ ) in student after work with mean  $(2.4782 \pm 0.70515)$  than pre-work mean  $(4.5291 \pm 1.39558)$ . Ratio of FEV1/FVC was significantly lower ( $P < 0.05$ ) in student after work with mean  $(65.7818 \pm 8.26448)$  than pre-work mean  $(87.6864 \pm 6.92760)$ , but it will return after 4 days with mean  $(84.3759 \pm 9.85705)$  and the result was non-significant between pre- work and after 4 days .

The effect of monomer in airway passage for the subject which exposed for one time causes obstruction and restriction but temporary effect and started to decrease or loss after 4days but if continuous exposure to monomer that given obstruction or restriction to airway passage and may lead to any respiratory problem.

**Key Words:** Monomer, inhalation, lung, function, volume, dentistry, students, spirometer.

**تأثير المونمر المستنشق على حجم و وظائف الرئة لطالبات كلية طب الاسنان بأستخدام جهاز السبايروميتر**

**الخلاصة**

ركزت هذه الدراسة على التأثيرات الجانبية لمونومرات الميثيل ميثاكريلات المتعددة على وظائف الرئة الفسيولوجية. كان العدد الإجمالي للطالبات (٤٢) مع معدل العمر من (٢٢-٢٠) سنة، تم قياس وظيفة الرئة بأستخدام البروتوكول القياسي وجهاز قياس التنفس لقياس (PEF), (FVC1/FVC), (FVC1), (FVC). تم إجراء قياس ما قبل العمل، ثم تعرض المشاركون للمونومر في مختبر صناعة الاسنان، وعلى الفور تم تكرار الاختبار بعد التعرض للمونومر، وأخيرا تم توجيه المشاركين إلى العيش عادي لمدة (٤) أيام، ثم قياس وظيفة الرئة تم تكرار الاختبار لقياس التأثير المتأخر لما بعد العمل للمونومر.

كانت أكبر فروق في المتوسط والانحراف المعياري ل FVC و PEF بين ما قبل العمل والقياس بعد استنشاق المونومر على الفور FVC. كان أقل بكثير ( $p < 0.05$ ) للطالب بعد العمل بمتوسط  $(2,3891 \pm 0,60623)$  ( $5,7577 \pm 1,88277$ ) ( $1,88277 \pm 0,70515$ ) ( $4,5291 \pm 1,39558$ ). FEV1 أظهرت انخفاضا معنويا ( $P < 0.05$ ) لدى الطالب بعد العمل بمتوسط  $(2,4782 \pm 0,70515)$  مقارنة بمتوسط ما قبل العمل  $(4,5291 \pm 1,39558)$ . كانت نسبة FEV1/FVC أقل بكثير ( $P < 0.05$ ) في الطالب بعد العمل بمتوسط حسابي  $(65,7818 \pm 8,26448)$  مقارنة بمتوسط ما قبل العمل  $(87,6864 \pm 6,92760)$ ، ( $84,3759 \pm 9,85705$ )،

لكنه سيعود بعد ٤ أيام بمتوسط حسابي ( $9,857.05 \pm 84,375.9$ ) وكانت النتيجة غير معنوية بين قبل العمل و بعد ٤ أيام. كما يظهر PEF انخفاض معنوي ( $P < 0.05$ ) في الطالب بعد العمل بمتوسط ( $0,602.2 \pm 2,148.2$ ) عن متوسط ما قبل العمل ( $1,488.88 \pm 5,412.3$ ). نستنتج من هذه الدراسة تأثير المونومر في ممر مجرى الهواء للشخص الذي يتعرض لمرة واحدة بسبب تضيق وتقييد ولكن تأثيره مؤقت ويبدأ في الانخفاض أو الخسارة بعد ٤ أيام ولكن إذا تعرض بشكل مستمر لمونومر يؤدي ال تضيق أو تقييد ممر مجرى الهواء و قد يؤدي إلى أي مشكلة في الجهاز التنفسي.

## **Introduction**

**M**onomer was highly used wide-fields “as in the industries, dentistry and reconstructive surgeries ;in the dentistry more than (98%) of the restorations are done by the monomers and polymers” [1-2]. Methacrylate serve as bases for acrylic resins, these resin based dental materials are used extensively today in dentistry [3]. There are many applications of such material in dentistry like cavity restorative materials such as (composites self and light cured), general dental applications dentures (bases, tissue conditioners, liners, artificial teeth, etc.), cavity, pulpal and margin sealants, oral and maxillofacial appliances [4]. Though, significant concerning still remains about their biocompatibility, in spite of its good physical and mechanical properties and excellent esthetic characteristics, in turn, may cause some side effects [4]. Experimental and clinical studies have been documented that the methacrylic monomers might cause a wide ranging of adverse effects on health for example irritation to skin, mucous membrane and eyes, stomatitis, allergic dermatitis, neuropathy, asthma, liver toxicity, central nervous system disturbances, and fertility disturbances, but the most important adverse effects on the health include irritation of the respiratory tract and sensitization [5-8].

The dental staff was at higher risk of adverse reactions to the monomers than patients[1-2]. In dental resin based materials, the monomers that used are volatile and usually, it is possible to smell them in the dental clinics and laboratories. Methyl methacrylate (MMA) is highly volatile (with a vapor pressure of 36-47 hPa at 20°C)[7-8]. Repeated inhalation might be harmful and may cause serious disorders in the central nervous system and lung physiological functions [9]. In the study on animals, Sokmen and Oktemer was indicated that

when rats were exposed to MMA monomer vapor at a low concentration (0.45 ppm), histopathological manifestations of trachea and lungs were observed; the statistically significant pathologic changes were hyperplasia of peri-bronchial lymphoid follicles, loss of the cilia of trachea and bronchial respiratory epithelium, and respiratory capillary hyperemia. At sub-lethal concentrations, pulmonary lesions were seen including edema, emphysema and collapsed lungs [10].

A case of immediately asthmatic reaction that occurred following provocation of MMA was reported by Lozewicz et al.. After numerous years of this work, dyspnea have been developed, chest tightness, and cough which continue for several hours after exposure to even small amounts of methyl methacrylate [11].

The study of Jaakkola et al. [12] found that the daily use of MMA was significantly related to increase the risk of adult onset asthma, work-related cough or phlegm, and nasal symptoms. The nasal symptoms showed a dose-response relation with increasing years of exposure to MMA, and those (with >10 years of exposure) had also increased risk of dyspnoea, hoarseness, and wheezing with dyspnea[12]. On the basis of reduction in final mean body weight and squamous metaplasia at the site of entry (the respiratory system of mice), the lowest stated ‘no-observed-effect-levels’(NOELs) and ‘lowest-observed-effect-levels’ (LOELs) in a sub-chronic inhalation bioassay in which several dose levels were administered were 250 and 500 ppm (1025 and 2050 mg/m<sup>3</sup>), respectively [13-14].

These results from previous studies were demonstrated the ventilation importance in working places for people who used MMA. And many techniques would be employed to reduce doctors, nurses, patients & other medical staff contact with monomer exposure during dental procedures in order

to reduce the risks of possible complications.

The aim of this study was focused on the adverse effect of the poly methyl methacrylate monomers on the physiological lung functions.

### **Materials and Methods**

That study was conducted in general wards in Prosthodontics Department in Dentistry Collage in University of Babylon in Hilla city, Iraq, lasted from (17-February-2017 to 20-April-2017). The total number of female students were 42 with range of age from 20-22 years. All the participant students were healthy controlled and good general and respiratory conditions with exclusion of anyone with smoker, bronchitis, allergy and any other respiratory disease, they were prevented from exposure to any perfume or aromatic overlaps for a period of 24 hours before starting of tests.

### **Pulmonary Function Test**

The lung function test can be measured by using a standard protocol and spirometry to measure the forced vital capacity (FVC), forced expiratory volume in the first second (FVC1), ratio of forced expiratory volume in the first second/forced vital capacity (FVC1/FVC), and peak expiratory flow (PEF) [15]. The height, weight were measured by using a stadiometer, without shoes, using standard techniques (patient standing erect with the head in the Frankfort horizontal plane) [15]. The age, race/ethnicity and other participants data were entered in software program of spirometer [16] (SpirobankII,

Italy). The principle of action of spirometer device by measuring the air that can be breathed into the lungs during inspiration and excited out the lung during expiration.

**Pre-work measurement:** The participants were instructed how to perform the test by putting the nose clip to plug the nasal pathway, then ask him to breath with deep inspiration started put the mouthpiece in the mouth. the mouthpiece Immediately was put inside the mouth between the teeth with complete sealing by the lips to prevent the air passage during maximal forced expiration that must be lasted for 6 seconds at least. The test measurements were repeated for three times and the greater of three measurements was employ, and was represent of the percentage of the value predicted for height,, age weight and gender depended on standardized table.

**Immediately-work measurement:** With protection by latex gloves, face mask, eye glasses and laboratory coat; all the students were used cold cured acrylic (Vertex, Netherlands) (powder 30 ml and monomer 10 ml) for preparation of special tray or record base in well ventilated laboratory (8×5 meters),the duration of exposure to monomer was 30 minutes, immediately the test was repeated after exposure to the monomer in the laboratory by the same manner.

**Post-work measurement:** After that the participants were instructed to subsist as normal daily life for (4) days, then the lung function test was repeated.



**Figure 1:**Method of lung function test by spirometer.

To analyse the data of this study one-way ANOVA of Statistical Package for Social Sciences computer program (SPSS) was employed and Tukey as post Hoc test to analyse the statistical difference among the groups.

### **Results**

Tables (1) included mean and standard deviation of the FVC, FVC1, FVC1/FVC and PEF. It's obvious that the largest differences in mean and standard deviation of the FVC and PEF between the pre-work and the measurement after the inhalation of the monomer immediately (Table 1).

FVC was significantly lower ( $p < 0.05$ ) in student after work with mean ( $2.3891 \pm 0.60623$ ) than pre-work mean ( $5.7577 \pm 1.88277$ ) (Table 1 & 2).

FEV1 showed significant decrease ( $P < 0.05$ ) in student after work with mean ( $2.4782 \pm 0.70515$ ) than pre-work mean ( $4.5291 \pm 1.39558$ ) (Table 1&3).

Ratio of FEV1/FVC was significantly lower ( $P < 0.05$ ) in student after work with mean ( $65.7818 \pm 8.26448$ ) than pre-work mean ( $87.6864 \pm 6.92760$ ), but it will return after 4 days with mean ( $84.3759 \pm 9.85705$ ) and the

result was non-significant between pre-work and after 4 days (Table 1&4).

Also PEF showed significant decrease ( $P < 0.05$ ) in student after work with mean ( $2.1482 \pm 0.60202$ ) than pre-work mean ( $5.4123 \pm 1.48888$ ), but it will return after 4 days with mean ( $5.3350 \pm 1.27517$ ) and the result was non-significant between pre-work and after 4 days (Table 1&5).

FEF 25% showed significant decrease ( $p < 0.05$ ) in student after work with mean ( $2.0841 \pm 0.99259$ ) than pre-work mean ( $3.5377 \pm 2.12409$ ), but it will return after 4 days with mean ( $3.6355 \pm 1.67172$ ) and the result was non-significant between pre-work and after 4 days (Table 1&6).

FEF 50% showed significant decrease ( $p < 0.05$ ) in student after work with mean ( $1.7414 \pm 0.87947$ ) than pre-work mean ( $2.9864 \pm 1.44179$ ), but it will return after 4 days with mean ( $2.0982 \pm 1.29773$ ) (Table 1&7).

FEF 75% was significantly lower ( $p < 0.05$ ) in student after work with mean ( $1.6777 \pm 0.76180$ ) than pre-work mean ( $2.8818 \pm 1.24529$ ), but it will return after 4 days with mean ( $2.1927 \pm 0.80528$ ) (Table 1&8).

**Table 1:** Mean and standard deviations for all variables.

Variables	Group	mean± S.D
<b>FVC (liter)</b>	Pre-work mon.	5.7577±1.88277
	Immediately-work	2.3891±0.60623
	Post-work4days	4.0732± 1.15765
<b>FEV1 (liter)</b>	Pre-work mon.	4.5291± 1.39558
	Immediately-work	2.4782± 0.70515
	Post-work4days	3.4059±0.93675
<b>FEV1/FVC %</b>	Pre-work mon.	87.6864±6.92760
	Immediately-work	65.7818±8.26448
	Post-work4days	84.3759±9.85705
<b>PEF L/s</b>	Pre-work mon.	5.4123±1.48888
	Immediately-work	2.1482±0.60202
	Post-work4days	5.3350±1.27517
<b>FEF 25% L/s</b>	Pre-work mon.	3.5377±2.12409
	Immediately-work	2.0841±.99259
	Post-work4days	3.6355±1.67172
<b>FEF50% L/s</b>	Pre-work mon.	2.9864±1.44179
	Immediately-work	1.7414 ±.87947
	Post-work4days	2.0982±1.29773
<b>FEF 75% L/s</b>	Pre-work mon.	2.8818±1.24529
	Immediately-work	1.6777±.76180
	Post-work4days	2.1927±.80528

**Table 2:** The FVC

RELATION	P
Pre-work MMA and immediate work	p<0.05
Pre-work MMAand Post-work4days	p<0.05
immediate work and Post-work4days	p<0.05

**Table 3:** the FEV1

RELATION	P
Pre-work MMA and immediate work	p<0.05
Pre-work MMAand Post-work4days	p<0.05
immediate work and Post-work4days	p<0.05

**Table 4:** the FEV1/FVC %

RELATION	P
Pre-work MMA and immediate work	p<0.05
Pre-work MMA and Post-work4days	p> 0.05
immediate work and Post-work4days	p<0.05

**Table 5:** the PEF

RELATION	P
Pre-work MMA and immediate work	p<0.05
Pre-work MMA and Post-work4days	p> 0.05
immediate work and Post-work4days	p<0.05

**Table 6:** the FEF 25%

RELATION	P
Pre-work MMA and immediate work	p<0.05
Pre-work MMA and Post-work4days	p> 0.05
immediate work and Post-work4days	P <0.05

**Table 7:** the FEF 50%

RELATION	P
Pre-work MMA and immediate work	P<0.05
Pre-work MMA and Post-work4days	P<0.05
immediate work and Post-work4days	P<0.05

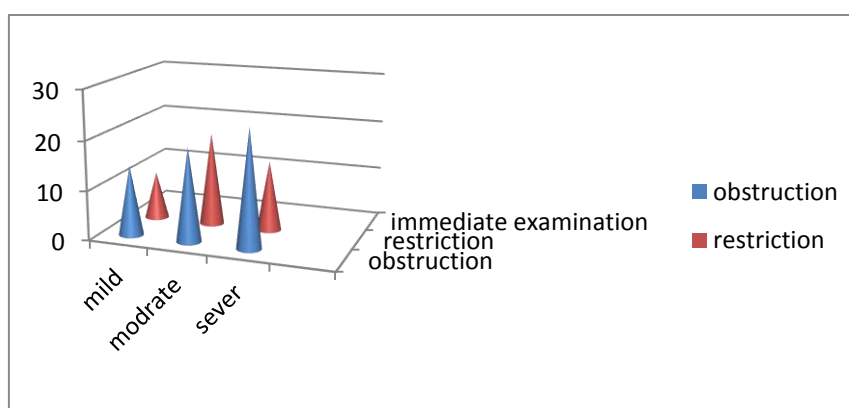
The difference of mean is significant at the 0.05 level.

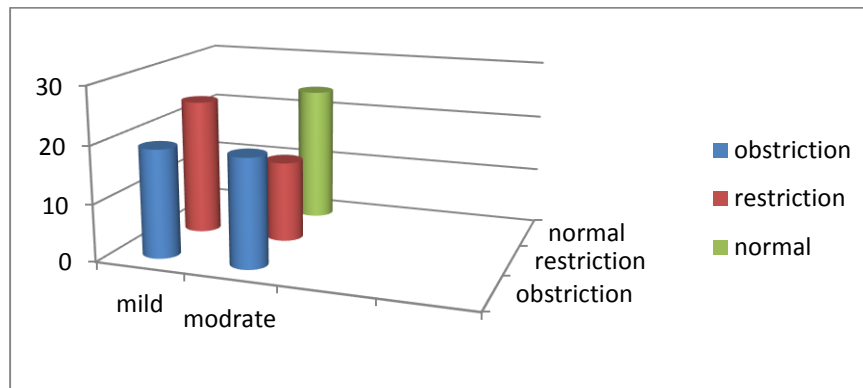
**Table 8:** The FEF 75%

RELATION	P
Pre-work MMA and immediate work	P<0.05
Pre-work MMA and Post-work4days	P<0.05
immediate work and Post-work4days	p> 0.05

**Table 9:** Results of diagnosis of the spirometer

Diagnosis	Immediate subject work %	After 4 days to subject work %
Mild obstruction	14.2	19
Moderate obstruction	19	19
Sever obstruction	23.9	0
Mild restriction	9.7	23.9
Moderate restriction	19	14.2
Sever restriction	14.2	0
Normal	0	23.9

**Figure 2:** refer to obstruction and restriction result immediate examination percentage.



**Figure 3:** Obstruction and restriction result examination after (4 days) percentage.

### Discussion

The result of pre-work and immediate work give significant change for (FVC, FEV<sub>1</sub>, FEV<sub>1</sub>/FVC, PEF & FEF (25%,50%,75%) in the table (9), the reason related to inhalation of the monomer which replaced to air lead to decrease volume and capacity of the lung.

The figure (2) given the obstruction refer to FEV<sub>1</sub> when less than 70% lead to obstructive mean narrowing of the airways [18,19] which occur as mild (14.2%) that mean the FEV<sub>1</sub> less than 50-80%, moderate (19%) when the FEV<sub>1</sub> less than 30-49% and sever(23.9%) FEV<sub>1</sub>less than 30% [17]. The result was agreed with Pellegrino et al. found the degree of restriction is also graded related to FEV<sub>1</sub>.

Also the results of study found significant change in FVC less than 70% lead to restriction mean decrease lung capacity than normal pattern [19, 20], and it occur as mild (9.7%), moderate (19%) and sever (14.2%) that mean depend on degree of decrease of FVC, that was agreed with Glady and co-workers [21], which said that the difference between the FVC and the slow VC in prediction of the restriction, the study agree with Miyashita et al. [22] suggested that the impairment pattern lead to restrictive ventilator due to reduced FVC observed.

The test repeated after 4 days to the same subjects when compared between result test Pre-work monomer and Post-work 4 days the result given significant change for (FVC, FEV<sub>1</sub>, and FEF (50%,75%) and there is non-significant change in (FEV<sub>1</sub>/FVC %, PEF and FEF 25% ), that's depended to ability of the monomer to absorb and distribute rapidly when

exposure by inhalation and also metabolized rapidly to form a methacrylic acid and converted to a carbon dioxide through the tricarboxylic acid cycle, which excited by expiration the air through the lung, and small fraction eliminated by urine, and little amounts by the face [23-25].

In the table (2-9) and also when make the comparism between result test immediate work and Post-work4days the result given significant change for (FVC, FEV<sub>1</sub>, FEV<sub>1</sub>/FVC, PEF & FEF (50%, 25%) and there is non-significant change in (FEF75% ), in the table (2-9) and also the result gets from the figure (2) is obstructive occurs as mild (19%), moderate (19%), and restriction result change it occurs as mild (23.9%), moderate (14.2%) and normal (23.9%), which that give conclusion the effect of monomer less degree than immediate but the restriction and obstruction in still air-way tract but less degree and may return normal if not used monomer more than 4 days. The effect of monomer for small air-way related to FEF (25% 50%,75%) [26] but FEF (50%,75%) still gives significant change but (FEF25%) return to normal value may be improved amount of monomer left the small air-way through 4 days, this study agree with Marez *et al.* [27]) found that the exposure to monomer will effect on the functions of pulmonary and an obstruction in the airway will reported, and also Mizunuma *et al.* [28] who found that monomer irritated the respiratory system that caused cough at a higher prevalence in exposed group.

## **Conclusion**

We conclude from this study the effect of monomer in airway passage for the subject which exposed for one time causes obstruction and restriction but temporary effect and started to decrease or loss after 4 days but if continuous exposure to monomer that given mild obstruction or restriction to airway passage and may lead to any respiratory problem.

## **Abbreviations**

FEV1: Forced expiratory volume in 1 second.

FEV1/FVC ratio : Ratio of FEV1 to FVC

FVC : Forced vital capacity.

PEF : Peak expiratory flow.

FEF (25%,50%,75%) :force expiratory flow.

MMA : monomer

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