Original Research

THE IMPACT OF EXPOSURE TO CEMENT DUST ON THE PARAMETERS OF OXIDATIVE STRESS AMONG CEMENT PLANT WORKERS

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ABSTRACT

Introduction: Working in cement industry exposes the workers to various hazards that could be in some cases life threatening. One such threat is cement dust which can predispose to oxidative stress. This study is a part of larger project to investigate the negative impacts of cement dust and it specifically aims at determining the parameters of oxidative stress in people working in cement plants in comparison to apparently healthy controls. **Methods:** A cross-sectional comparative study design was adopted in this work. Four cement factories in Nineveh Governorate in Iraq were included in the study for the period from December 2019 to March 2020. Ninety-seven non-smoking healthy workers were compared with 97 apparently healthy controls. Oxidative stress was assessed by measuring malondialdehyde (MDA) and total antioxidant capacity (TAC) in the two groups. **Results:** Significantly higher MDA mean (6.49 ± 1.75 nmol/ml) was found in the workers group as compared to the controls (4.85 ± 1.36 nmol/ml) with a *P*-value of less than 0.001. Conversely, TAC was significantly higher in the control group (16.63 ± 2.99 U/ml) than in the workers (13.12 ± 2.85 U/ml) and the *P*-value was also less than 0.001. **Conclusion:** Cement dust exposure can predispose to oxidative stress by raising MDA and decreasing TAC exposing the workers to the damaging effects of free radicals.

Keywords: cement industry, dust, oxidative stress, occupational health

Introduction

Cement is a fundamental ingredient required for the progress and development of nations (Rampuri, 2017). The global production of cement is around four billion tons each year; and this cement is used in various construction sites as well as for the production of concrete. The demand for cement and concrete is expected to double in the near future to meet the progress and development requirements of the world (Naqi & Jang, 2019). In Iraq, the industry of cement is a major national industry that contributes significantly to the country's infrastructure. Eighteen cement plants are currently present in Iraq, with a production capacity of about 18 million tons per year. Only in Nineveh Governorate, there are 5 cement factories; 3 factories in Badosh and 2 in Hammam Al-Alil (ICSC, 2019).

Many people are employed in cement industry which exposes them to various hazards as a result of long-term contact with the dust. All the workers in cement plants are vulnerable to these hazards because cement dust is emitted at different steps of the manufacturing process. Probably the most important health hazard is the effect of the dust on the respiratory system (Aljeesh et al., 2015).

Another threat to human health is the potential of cement dust to induce oxidative stress from the pro-oxidants present in the dust or due to the increased production of free radicals (Al Salhen, 2014; Aydin et al., 2004; Malekirad et al., 2019; Pournourmohammadi et al., 2008). Chromium and aluminum in the dust are known pro-oxidants that may induce lipid peroxidation of different membranes (Al Salhen, 2014; Malekirad et al., 2019; Marrocco et al., 2017). The free radicals produced from lipid peroxidation are normally neutralized by antioxidants. When there is an imbalance between the two, oxidative stress occurs which can be a risk factor for many serious and chronic medical conditions such as arthritis, diabetes and cancer (Marrocco et al., 2017).

In these disease states, there would be either increase in oxidants and/or decrease in antioxidants (Moylan & Reid, 2007). In osteoarthritis there is a disruption in the hemostasis of cartilage due to increased levels of free radicals which induce oxidative damage and lead to death of chondrocyte (Bolduc et al., 2019). Diabetic patients suffer from different complications which are mediated by oxidative stress, beside its role in insulin resistance which occur due to glucose oxidation and lipid peroxidation (Asmat et al., 2016). Moreover, oxidative stress is involved in many aspects of cancer development (Liou & Storz, 2010).

Beside the negative impacts of cement on respiratory system and oxidative status, many cancer types may be induced like lung, stomach and colorectal (Fatima et al., 2001; Pournourmohammadi et al., 2008). The different constituents present in cement have high alkalinity which would be strong irritants for the skin and can lead to varying skin injuries (Chung et al., 2007; Nunes et al., 2019). Eye problems might also occur due to direct contact of cement with the eyes (Jayakrishnan et al., 2013).

An indirect method to assess the occurrence of oxidative damage is to measure the lipid peroxidation biomarkers because lipid, and especially polyunsaturated fatty acids, are highly prone to oxidation (Cipak Gasparovic et al., 2017; Rajendran et al., 2014). And because oxidative stress occurs due to an imbalance between the free radicals and antioxidant molecules, assessment of antioxidants is also required (Katerji et al., 2019). The peroxidation of polyunsaturated fatty acids leads to the production of malondialdehyde (MDA) which is the commonest aldehyde used to assess oxidative damage (Ito et al., 2019; Rajendran et al., 2014). MDA measurement depends on the production of thiobarbituric acid reactive substance which can be easily detected by spectrophotometer (Ito et al., 2019; Rajendran et al., 2014). Total antioxidant capacity (TAC) is measured by different analytical methods which depend on the production of a colored substance that can also be detected by spectrophotometer at a specific wave length (Pisoschi & Negulescu, 2011).

Jasim et al. (Jasim et al., 2012) conducted a study in Iraq which measured oxidative stress parameters (MDA and an enzymatic antioxidant) among cement workers in Kufa. They reported a significant increase in MDA among workers with no significant variation in antioxidant levels. Al-Hayali (Al-Hayali, 2009) conducted another study in Iraq, which aimed to assess oxidative stress parameters. The author found a statistically significant reduction in the antioxidant glutathione among cement workers in contrast to MDA which was significantly higher. However, the total antioxidant capacity was not measured in those two studies (Al-Hayali, 2009; Jasim et al., 2012).

Although there are no accurate statistics about the numbers of people working in cement factories in Iraq, they are estimated by thousands. Because such workers constitute an important fraction of the society, and due to the numerous health hazards associated with cement dust exposure, a project was initiated to investigate the specific effects of the dust on spirometric and oxidative stress parameters in cement plant workers in Nineveh, Iraq. This particular part of the project focuses on oxidative stress parameters in the workers and how they compare to healthy people. The effects of the dust on the lungs and the correlation between the spirometric parameters and those of oxidative stress in the workers have already been published (Shanshal & Al-Qazaz, 2020a, 2020b; Shanshal & Al-Qazaz, 2021).

Methods:

Details of the methods employed in this project are available in our previously published papers (Shanshal & Al-Qazaz, 2020b; Shanshal & Al-Qazaz, 2021). Briefly, a cross-sectional comparative study design was applied on workers from four cement factories in Nineveh from December 2019 to March 2020. Appropriate approvals were obtained from the Central Ethical Committee at Nineveh Health Directorate (reference number 34777 in 16/12/2019) and from Directorate of the Northern Cement Cooperation (reference number 6936 in 17/11/2019). Consents from participants were also obtained. All workers from the four factories who are in direct contact with cement dust were asked to participate in the study. Ninety-seven non-smoking males constituted the final workers group and were matched with 97 apparently healthy non-smoking male volunteers. Subjects of the control group were employees in the Directorate of Agriculture, College of Dentistry and College of Pharmacy in Mosul.

Being older than eighteen years, having service duration of more than one year and working in the milling or packaging sections of the factories were the inclusion criteria for the workers group. Chronic conditions such as hypertension, diabetes or gout and using antioxidant supplements were considered exclusion factors.

Five millilitres of blood were taken from each participant using disposable syringes. A gel tube was used to allow clotting of the blood for half an hour at room temperature. After centrifugation at 3,000 rpm for 10 minutes, serum was collected to be used for the assessment of oxidative stress parameters (MDA and TAC) and kits from Elabscience® (Texas, USA) were used. The MDA in the serum reacts with thiobarbituric acid in the kit to produce a red compound which can be detected by spectrophotometer at 532 nm. On the other hand, TAC is detected by the formation of stable-colored complexes resulting from the reduction of Fe^{3+} to Fe^{2+} in the kit by the antioxidants in the serum. These colored complexes can be measured spectrophotometrically at 520 nm.

Statistical analysis: Statistical Package for Social Science from IBM (SPSS, version 25) (IBM Corp., Armonk, NY, USA) was used for processing and analyzing the data. A *P*-value smaller than 0.05 was taken to be significant. Differences in continuous variables between workers and controls were assessed by independent samples t-test. The relationships between oxidative stress parameters were determined by calculating the Pearson's correlation coefficient.

Results:

At the start, 105 workers attended an interview to participate in the study. Of these, 8 workers were eliminated due to their refusal of blood donation leaving 97 workers to constitute the final group for the workers. The control group consisted of 97 apparently healthy subjects who agreed to take part in the study. As a result, the workers' response rate was 92 percent, whereas the controls' response rate was 100 percent.

Socio-demographic characteristics of the participants are detailed in our previous paper. In short, the differences in the socio-demographics between the two study groups were non-significant as shown by independent sample t-test (*P*-value > 0.05) indicating that the two groups were matched (Shanshal & Al-Qazaz, 2020b; Shanshal & Al-Qazaz, 2021). Table1 summarize these socio-demographic characteristics.

Table 1: Socio-demographic characteristics of the workers and controls, adapted from (Shanshal & Al-Qazaz, 2021).

Variable	Workers (n=97)	Controls (n=97)	t-test*	*P*-value
Age Mean ± SD	39.46 ± 9.51	38.24 ± 8.54	0.945	0.346
Height Mean ± SD	172.11 ± 8.05	174.14 ± 6.07	- 1.983	0.06
Weight Mean ± SD	83.21 ± 15.4	85.22 ± 12.95	-0.984	0.326
BMI Mean ± SD	28.07 ± 4.85	28.14 ± 4.31	-0.105	0.916

*****Independent samples t-test

With regard to the measured oxidative stress parameters in the two study groups, significant difference was found between the means of MDA with a higher value in the workers group (6.49 ± 1.75 nmol/ml in the group of workers versus 4.85 ± 1.36 nmol/ml in the healthy controls). Conversely, the level of TAC was significantly higher in the controls than in the workers (16.63 ± 2.99 U/ml in the controls versus 13.12 ± 2.85 U/ml in the workers). These statistical differences are presented in table 2. Significant positive statistical correlation was found between MDA and the age of the workers. No other significant correlation was obtained (Table 3).

Table 2: Differences in oxidative stress parameters between the study groups

Variable	Workers (n=97)	Controls (n=97)	t-test*	*P*-value
MDA (nmol/ml)			7.273	**<0.001§**
Mean ± SD	6.49 ± 1.75	4.85 ± 1.36		
Median (IQR: 25-75)	6.20 (4.96-7.89)	4.58 (4.05-5.3)		
TAC (U/ml)			-8.336	**<0.001§**
Mean ± SD	13.12 ± 2.85	16.63 ± 2.99		
Median (IQR: 25-75)	12.95 (11.16-14.98)	16.28 (14.43-18.38)		

*Independent samples t-test

Table 3: Correlations between age and oxidative stress parameters in the study groups

Variable	Age (workers)		Age (controls)	
	r*	*P*-value	r*	*P*-value
MDA	0.263	**0.009§**	-0.044	0.668
TAC	0.154	0.132	-0.089	0.385

*Pearson correlation

Discussion:

An increase in the generation of reactive oxygen species brought about by exposure to cement dust can result in oxidative stress (Malekirad et al., 2019) and this was confirmed in this study. An appropriate matching between the workers and the controls was achieved in this study in terms of numbers included and the socio-demographics. This was evident from the lack of significant differences between the two groups in the matching criteria. This matching was lacking from other similar studies carried out in Iraq (Al-Hayali, 2009; Jasim et al., 2012) and Libya (Al Salhen, 2014) where groups which were not matched or had different numbers of participants were employed. Working in the milling or packaging departments and being directly subjected to the dust were important inclusion criteria in our study for the workers group, while working away from cement plants and being healthy constituted the criteria for the control group. Similar criteria were applied in Egypt (Hakim et al., 2018) and Palestine (Aljeesh et al., 2015). However, studies carried out in Iran (Malekirad et al., 2019; Omidianidost et al., 2019; Rafeemanesh et al., 2015) used office employees from the same factory as the control group whereas those directly exposed to the dust comprised the worker group.

The average of the workers' age in this study (39.46 ± 9.51) was lower than that in studies conducted in Congo (46.5 ± 9.6) and Greece (47 ± 19) (Mbelambela et al., 2018; Rachiotis et al., 2018), but higher than the mean age in an Iranian study (35.73 ± 7.3) (Omidianidost et al., 2019). The average of the duration of employment was 15.4 years for the workers in the current study compared to 24.34 years recorded in a study by Hakim et al. (2018) in Egypt. Primary education was prevalent among the workers in the present study (55.7%) while secondary and university education had lower percentages (28.9% and 15.4% respectively). In contrast, the workers in a Nigerian study were mainly tertiary educated (Musa et al., 2012).

Significant differences between the workers and the controls in the measured oxidative stress parameters were observed in the current study, with higher MDA in the workers and higher TAC in the controls. Similarly, higher MDA levels in the workers was reported in Iran (Afaghi et al., 2015), Iraq (Al-Hayali, 2009; Jasim et al., 2012), in Libya (Al Salhen, 2014), in Egypt (Elhosary et al., 2014) and in Turkey (Orman et al., 2005). For TAC, Pournourmohammadi et al. (2008) reported comparable result with higher mean in the control group. Some studies, (Al Salhen, 2014; Elhosary et al., 2014; Jasim et al., 2012), assessed individual antioxidant components of the serum rather than measuring the total antioxidant capacity, and they still reported results which are comparable to ours. There were, however, some studies that failed to report any difference in antioxidant activity such as those conducted by Malekirad et al. (2019) and Afaghi et al. (2015). Since the workers and the controls in the current study

were matched for socio-demographic characteristics, these significant differences in MDA and TAC that favors oxidative stress can only be attributed to cement dust exposure.

The positive correlation between the age and MDA in the workers was in agreement with a study conducted in Egypt (Elhosary et al., 2014). The lack of significant correlation between age and MDA in the controls probably indicates that the positive correlation seen in the workers was due to longer contact with cement dust rather than just the older age.

Oxidative status can be affected by a variety of factors such as lifestyle and living conditions. Taking these factors into account should be considered in future works.

Limitation of the study

Diet can have an important effect on oxidative status, and this was not evaluated in the study. Nonetheless, this study aimed at assessing the parameters of oxidative stress and test how they compare between cement workers and healthy subjects.

Conclusion

Exposure to cement dust exposure can negatively affect health, one mechanism could be increasing MDA and decreasing TAC in the exposed workers.

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Conflicts of Interest

The author declares no conflicts of interest.

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