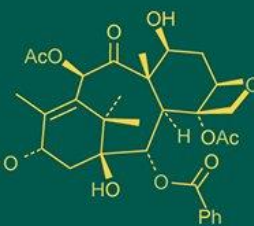
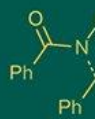


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**Abdelrhman Mohammed El-Arman**

Medical Biochemistry  
Department, Faculty of  
Medicine, Damietta  
University, Damietta, Egypt

**Lamees Mohamed Dawood**

Medical Biochemistry  
Department, Faculty of  
Medicine, Tanta University,  
Tanta, Egypt

**Ayman Abd El-Fattah Wagih**

Medical Biochemistry  
Department, Faculty of  
Medicine, Tanta University,  
Tanta, Egypt

**Nada Hashem Ayad**

Medical Biochemistry  
Department, Faculty of  
Medicine, Tanta University,  
Tanta, Egypt

**Corresponding Author:**  
**Abdelrhman Mohammed El-Arman**

Medical Biochemistry  
Department, Faculty of  
Medicine, Damietta  
University, Damietta, Egypt

## A Study of the effect of vitamin D on ornithine decarboxylase enzyme level and monoacylglycerol lipase enzyme activity in induced obesity in experimental rats

**Abdelrhman Mohammed El-Arman, Lamees Mohamed Dawood, Ayman Abd El-Fattah Wagih and Nada Hashem Ayad**

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### Abstract

**Background:** Obesity is a growing worldwide health problem that is associated with various diseases such as cardiovascular diseases. Ornithine decarboxylase enzyme (ODC) which is related to polyamine metabolism could be considered as a valuable tool for research on lipid metabolism and development of obesity and related diseases. Inhibition of ornithine decarboxylase prevents the differentiation of fibroblasts into adipocytes. Monoacylglycerol lipase (MAGL) complements lipoprotein lipase in completing the hydrolysis of monoacylglycerols. Furthermore, vitamin D plays vital role in remodeling of adipose tissue via apoptosis.

**Materials and methods:** 60 rats were randomly assigned into 4 equal groups: group I were fed on caloric controlled diet for 4 months, group II were fed on high caloric diet rich in fat for 4 months, group III were fed simultaneously on high diet rich in fat and given vitamin D supplementation (500 IU/kg) for 4 months and group IV were fed on high caloric diet rich in fat for 4 months, while vitamin D supplementation (500 IU/kg) was given only in the last month. Colorimetric assays for total cholesterol level, triacylglycerol level and high-density lipoprotein-cholesterol level were used. Immunoassay for ODC levels and colorimetric assay for MAGL activity were used.

**Results:** High-fat diet induced increased total cholesterol, triglycerides and LDL-C with a concomitant reduction in HDL-C and a significant increase in MAGL activity and ODC levels. Long-term supplementation of vitamin D with high-fat diet-fed rats significantly improved the lipid profile and reduced MAGL activity and ODC levels. Meanwhile, rats fed on high fat diet with late supplementation of vitamin D did not show significant correction of dyslipidemia with partial improvement of MAGL activity and ODC levels.

**Conclusion:** Early and long-term vitamin D supplementation improved lipid profile and preserved enzymatic balance.

**Keywords:** Vitamin D, Ornithine Decarboxylase Enzyme, Monoacylglycerol Lipase Enzyme, Obesity, Lipid profile

### Introduction

The aberrant accumulation of excessive fat is the hallmark of obesity, a condition that has the potential to adversely affect health <sup>[1]</sup>. Body mass index (BMI) exceeding 30 kg/m<sup>2</sup> indicates obesity, while overweight is defined as a BMI between 25 and 29.9 kg/m<sup>2</sup> <sup>[2]</sup>. Obesity is a worldwide health concern that is closely linked to a variety of diseases, including type II diabetes mellitus <sup>[3]</sup>.

The conversion of ornithine to putrescine is expedited by ornithine decarboxylase enzyme (ODC) <sup>[4]</sup>, which restricts the rate of polyamine biosynthesis <sup>[5]</sup>. Organic compounds that contain two or more amino groups are known as polyamines <sup>[6]</sup>. Tetra-amine spermine, triamine spermidine, and diamine putrescine are the most frequently encountered polyamines <sup>[7]</sup>.

Polyamines have been considered to be linked to biological phenomena as cell division, proliferation and differentiation <sup>[8]</sup>. Polyamines have the potential to enhance Ca<sup>2+</sup> accumulation in mitochondria, which influences mitochondrial permeability and induces apoptosis. Cytochrome c release, which is a precursor to apoptosis, can also be directly

stimulated by polyamines. Additionally, polyamines can regulate other forms of cell death, such as necrosis [9]. The differentiation of fibroblasts into adipocytes has been shown to be prevented by the irreversible inhibitor alpha-difluoromethylornithine, which inhibits ODC [3]. As such, study of polyamine metabolism could be helpful for the development of pharmaceuticals for obesity [6].

Among the most critical regulators of calcium and phosphorus homeostasis is vitamin D, which is a lipid-soluble vitamin [10]. Its active form is 1, 25-dihydroxycholecalciferol (calcitriol) [11]. It has effects on cellular growth, differentiation, apoptosis [12] and immunity [13]. Furthermore, vitamin D plays vital role in remodeling of adipose tissue via affecting apoptosis [12].

*In vitro*, monoacylglycerol lipase (MAGL) does not exhibit catalytic activity against diacylglycerol or triacylglycerol. However, it can hydrolyze the 1- and 2-ester bonds of monoacylglycerol [14]. Furthermore, MAGL is likely to assist lipoprotein lipase in the finalization of the hydrolysis of monoglycerides that occur as a consequence of the degradation of lipoprotein triglycerides [15].

The objective of the current investigation is to emphasize vitamin D supplementation effect on the ornithine decarboxylase enzyme and the monoacylglycerol lipase enzyme in induced obesity in rats.

## Materials and Methods

**Chemicals:** The vitamin D was acquired from Medical Union Pharmaceuticals in Egypt.

**Experimental design:** The present study was conducted at Medical Biochemistry Department, Faculty of Medicine, Tanta University. This study included 60 albino rats weighing 150-200 g, obtained from an animal housing facility, Tanta University. During the current study, all the rats were housed in wire mesh cages and had unlimited access to water and either regular controlled diet or high fat diet according to their group. Over the course of the experimental period, the rats were maintained at a controlled temperature of  $23 \pm 2^\circ\text{C}$ , a relative humidity of  $55 \pm 5\%$ , and for a 12-hour light/dark cycle. The experimental procedures were conducted in accordance with the Ethical Committee's guidelines at the Faculty of Medicine, at Tanta University, Egypt (Approval code:36264MS667/8/24).

After 7 days of the acclimatization period, rats were randomly allocated into four equal groups:

Group I (Control group) (n=15): This group was fed on caloric controlled diet for 4 months.

- **Group II (Obese control group) (n=15):** This group was fed a high-calorie diet that was rich in fat for a period of four months.

- **Group III (n=15):** This group was provided with a high-calorie diet that was rich in fat and given vitamin D supplementation simultaneously (500 IU/kg) by oral tube for 4 months [16].

- **Group IV (n=15):** This group was fed a high-calorie diet that was rich in fat for 4 months and then given vitamin D supplementation (500 IU/kg) by oral tube in the last month [16].

**Table 1:** Diet composition

| Component                                      | Control diet (gm) | High fat diet (gm) |
|------------------------------------------------|-------------------|--------------------|
| Vegetable oil                                  | 35                | 290                |
| White flour                                    | 618               | 410                |
| Sucrose                                        | 87                | 40                 |
| Barn                                           | 20                | 20                 |
| Casein                                         | 200               | 200                |
| Na acetate                                     | 10                | 10                 |
| K <sub>2</sub> H <sub>2</sub> PO <sub>4</sub>  | 8.4               | 8.4                |
| Na <sub>2</sub> H <sub>2</sub> PO <sub>4</sub> | 8                 | 8                  |
| NaCL                                           | 3.6               | 3.6                |
| Vitamin                                        | 10                | 10                 |
| Total weight                                   | 1000              | 1000               |

- Lee's index was calculated at first and last days of obesity induction, to evaluate whether the rats developed obesity or not. The body weight cube root (g) divided by the size of the body (cm) is known as Lee's index [17]. A score of 0.310 or above indicates that the rats developed obesity [18]. After a 12-hour fast, all rats were sacrificed.
- Blood samples were thawed at room temperature for the measurement of total level of cholesterol (TC), high density lipoprotein cholesterol level (HDL-C) and triacylglycerol level (TAG).
- Subcutaneous fat tissue from the abdomen was extracted for homogenization [19]. 50 mM phosphate buffer saline (pH 7.4) was prepared [20]. The homogenate was centrifuged for 15 min at 4000 rpm. The supernatant was collected and stored in aliquots at  $-80^\circ\text{C}$  for the ODC enzyme immunoassay, and MAGL enzyme activity.

**Colorimetric assay of monoacylglycerol lipase activity using p-nitrophenyl acetate (pNPA) [21]:** Commercial chemicals were purchased from Glenthams Life Sciences Ltd., United Kingdom. Cat. GK374. Volume of 10  $\mu\text{L}$  pNPA 100 mM was added to 890  $\mu\text{L}$  assay buffer. The mixture was incubated in cuvette at  $37^\circ\text{C}$ . Volume of 100  $\mu\text{L}$  diluted tissue homogenate (1:5 with buffer) was added. Immediately the absorbance was recorded at 405 nm and monitored within 5 min. The following equation is used for calculating the concentration of MAGL:

$$c = \frac{A}{\epsilon \cdot l}$$

( $\epsilon$  of pNPA =  $18,000 \text{ M}^{-1} \text{ cm}^{-1}$ )

A = absorbance

$\epsilon$  = molar extinction coefficient ( $\text{L} \cdot \text{mol}^{-1} \cdot \text{cm}^{-1}$ )

c = concentration (mol/L)

l = path length of the cuvette (1 cm)

**Colorimetric assay of cholesterol and triglycerides** <sup>[22]</sup>

By employing a commercial kit that was acquired by Biodiagnostic Co., Egypt, the enzymatic colorimetric method was employed.

**Colorimetric assay of HDL-C** <sup>[23]</sup>: Utilizing a commercial kit acquired from ELI Tech Co., Egypt, the precipitation method was implemented.

**Determination of LDL-C** <sup>[24]</sup>: The concentration of HDL-C, total concentration of cholesterol and concentration of triglyceride were used to determine LDL-C by employing the Friedewald equation.

**Immunoassay of ornithine decarboxylase enzyme** <sup>[25]</sup>: By ELISA technique using commercial kit which was purchased from ELK Biotechnology CO., Ltd, USA. Cat. ELK7159.

**Statistical analysis:** The data that was collected was statistically evaluated using SPSS software version 11. Using a Shapiro-Wilk's test, It was found that all of our parameters were close to normally distributed ( $P > 0.05$ ). Mean  $\pm$  SD was the way the data was presented. Groups were compared using one-way analysis of variance (ANOVA), and post hoc Tukey tests. There was also a linear correlation coefficient calculation.

**Results**

The difference between the studied groups was statistically significant ( $P < 0.001$ ). as regards Lee's index, cholesterol, triglyceride and LDL. Lee's index, cholesterol, triglyceride and LDL were significantly increased in groups II and IV in comparison to groups I and III. HDL levels were significantly decreased in groups II and IV compared to groups I and III Table 2.

**Table 2:** Statistical comparison of Lee's index, cholesterol level (mg/dl), triglycerides level (mg/dl), HDL level (mg/dl), LDL level (mg/dl) among all studied groups

|                       | Group I (Control group) (N=15)   | Group II (High fat diet group) (N=15) | Group III (High fat diet group with vitamin D for 4 months) (N=15) | Group IV (High fat diet group with vitamin D in the last 1 month) (N=15) | P-value  |
|-----------------------|----------------------------------|---------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------|----------|
| Lee's index           | 0.305 $\pm$ 0.002 <sup>b,d</sup> | 0.332 $\pm$ 0.006 <sup>a,c</sup>      | 0.313 $\pm$ 0.003 <sup>b,d</sup>                                   | 0.330 $\pm$ 0.004 <sup>a,c</sup>                                         | <0.001** |
| Cholesterol (mg/dl)   | 61.5 $\pm$ 10.82 <sup>b,d</sup>  | 85.1 $\pm$ 12.84 <sup>a,c</sup>       | 63.8 $\pm$ 4.41 <sup>b,d</sup>                                     | 78.4 $\pm$ 3.67 <sup>a,c</sup>                                           | <0.001** |
| Triglycerides (mg/dl) | 56.2 $\pm$ 13.32 <sup>b,d</sup>  | 79.9 $\pm$ 8.83 <sup>a,c</sup>        | 59.2 $\pm$ 10.10 <sup>b,d</sup>                                    | 73.4 $\pm$ 7.57 <sup>a,c</sup>                                           | <0.001** |
| HDL (mg/dl)           | 20.5 $\pm$ 1.15 <sup>b,d</sup>   | 12.4 $\pm$ 1.38 <sup>a,c</sup>        | 19.1 $\pm$ 1.79 <sup>b,d</sup>                                     | 13.7 $\pm$ 1.92 <sup>a,c</sup>                                           | <0.001** |
| LDL (mg/dl)           | 30.1 $\pm$ 11.8 <sup>b,d</sup>   | 56.8 $\pm$ 14.25 <sup>a,c</sup>       | 32.6 $\pm$ 7.19 <sup>b,d</sup>                                     | 46.7 $\pm$ 7.71 <sup>a,c</sup>                                           | <0.001** |

Data are presented as mean  $\pm$  SD. One-way ANOVA, followed by Tukey's post hoc test, \*\*highly significant ( $P$  value  $< 0.001$ ), a, b, c, d showed significant difference between groups based on Tukey's post hoc test. a denotes significant difference with group I. b denotes significant difference with group II. c denotes significant difference

with group III. d denotes significant difference with group IV.

There were statistically significant differences between all studied groups ( $P < 0.001$ ) as regards ODC level and MAGL activity. ODC levels and MAGL activity were significantly increased in groups II and IV in comparison to groups I and III Table 3.

**Table 3:** Statistical comparison of ornithine decarboxylase level, and monoacylglycerol lipase activity among all studied groups

|                                               | Group I (Control group) (N=15)   | Group II (High fat diet group) (N=15) | Group III (High fat diet group with vitamin D for 4 months) (N=15) | Group IV (High fat diet group with vitamin D in the last 1 month) (N=15) | P-value  |
|-----------------------------------------------|----------------------------------|---------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------|----------|
| Ornithine Decarboxylase level (ng/mg protein) | 2.7 $\pm$ 0.387 <sup>b,d</sup>   | 5.8 $\pm$ 1.576 <sup>a,c</sup>        | 3.3 $\pm$ 0.658 <sup>b,d</sup>                                     | 5.2 $\pm$ 0.893 <sup>a,c</sup>                                           | <0.001** |
| MAGL activity (U/mg protein)                  | 0.052 $\pm$ 0.014 <sup>b,d</sup> | 0.088 $\pm$ 0.020 <sup>a,c</sup>      | 0.061 $\pm$ 0.017 <sup>b,d</sup>                                   | 0.082 $\pm$ 0.015 <sup>a,c</sup>                                         | <0.001** |

Data are presented as mean  $\pm$  SD. One-way ANOVA, followed by Tukey's post hoc test, \*\*highly significant ( $P$  value  $< 0.001$ ), a, b, c, d showed significant difference between groups based on Tukey's post hoc test, <sup>a</sup> denotes significant difference with group I, <sup>b</sup> denotes significant difference with group II, <sup>c</sup> denotes significant difference with group III, <sup>d</sup> denotes significant difference with group IV. Lee's index demonstrates statistically significant positive correlations with total cholesterol, triglycerides, LDL, ODC

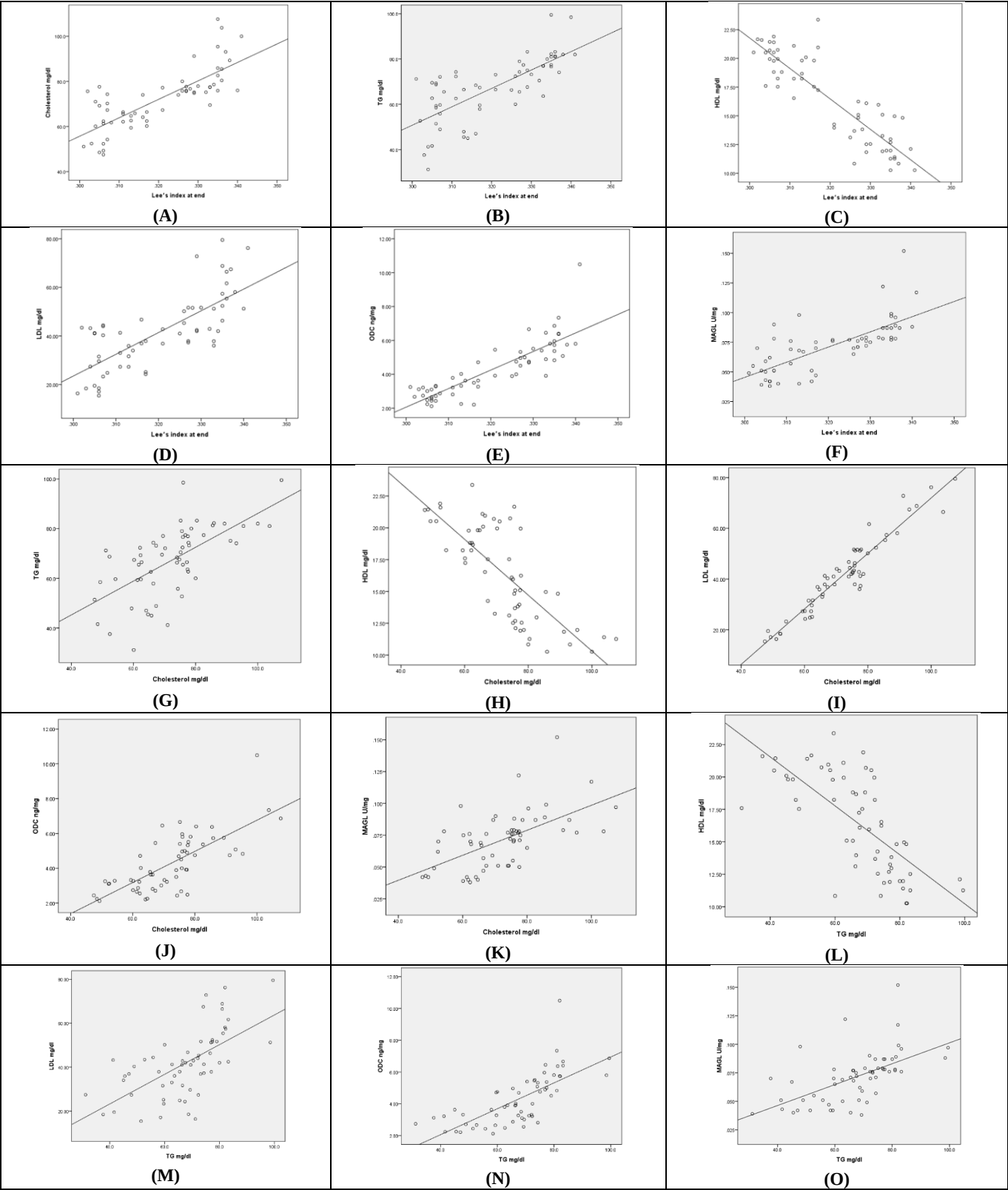
levels, and MAGL activity (all  $P < 0.001$ ). Total cholesterol, triglyceride and LDL levels show statistical positive correlations with ODC levels and MAGL activity. HDL shows a statistically significant negative correlations with LDL, ODC levels and MAGL activity (all  $P < 0.001$ ). ODC levels demonstrates statistically significant positive correlation with MAGL activity ( $P < 0.001$ ) Table 4, Figure 1.

**Table 4:** Statistical correlation between studied parameters among all studied groups

|             |   | Lee's index | Cholesterol | TG       | HDL | LDL | ODC |
|-------------|---|-------------|-------------|----------|-----|-----|-----|
| Cholesterol | r | 0.778**     | --          | --       | --  | --  | --  |
|             | P | <0.001      | --          | --       | --  | --  | --  |
| TG          | r | 0.728**     | 0.640**     | --       | --  | --  | --  |
|             | P | <0.001      | <0.001      | --       | --  | --  | --  |
| HDL         | r | -0.880**    | -0.765**    | -0.699** | --  | --  | --  |

|      |   |         |         |         |          |         |         |
|------|---|---------|---------|---------|----------|---------|---------|
|      | P | <0.001  | <0.001  | <0.001  | --       | --      | --      |
| LDL  | r | 0.744** | 0.956** | 0.627** | -0.763** | --      | --      |
|      | P | <0.001  | <0.001  | <0.001  | <0.001   | --      | --      |
| ODC  | r | 0.852** | 0.733** | 0.708** | -0.772** | 0.695** | --      |
|      | P | <0.001  | <0.001  | <0.001  | <0.001   | <0.001  | --      |
| MAGL | r | 0.728** | 0.587** | 0.582** | -0.606** | 0.537** | 0.699** |
|      | P | <0.001  | <0.001  | <0.001  | <0.001   | <0.001  | <0.001  |

Data are presented as numbers, \*\*highly significant (P value < 0.001).



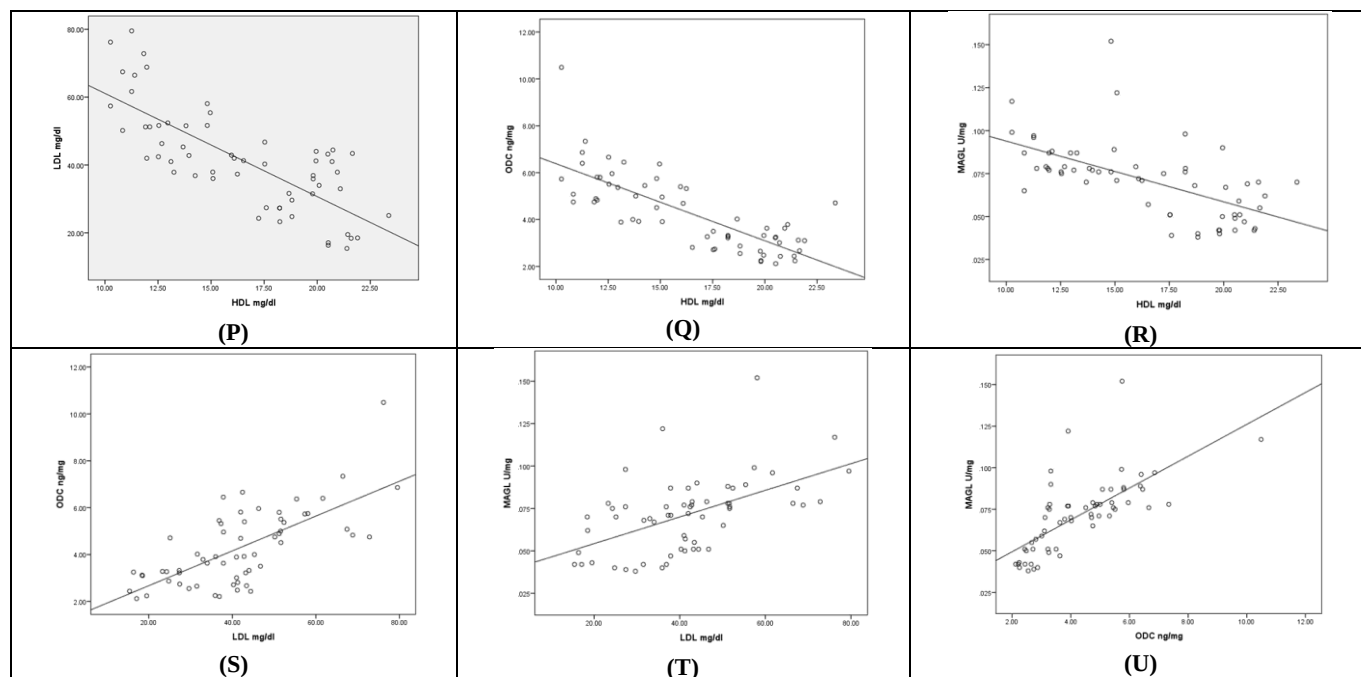


**Fig 1:** (A): Correlation between Lee index and cholesterol level, (B): Correlation between Lee index and TG level, (C): Correlation between Lee index and HDL level, (D): Correlation between Lee index and LDL level, (E): Correlation between Lee index and ODC level, (F): Correlation between Lee index and MAGL activity, (G): Correlation between cholesterol level and TG level, (H): Correlation between cholesterol level and HDL level, (I): Correlation between cholesterol level and LDL level, (J): Correlation between cholesterol level and ODC level, (K): Correlation between cholesterol level and MAGL activity, (L): Correlation between TG level and HDL level, (M): Correlation between TG level and LDL level, (N): Correlation between TG level and ODC level, (O): Correlation between TG level and MAGL activity, (P): Correlation between HDL level and LDL level, (Q): Correlation between HDL level and ODC level, (R): Correlation between HDL level and MAGL activity, (S): Correlation between LDL level and ODC level, (T): Correlation between LDL level and MAGL activity, (U): Correlation between ODC level and MAGL activity

## Discussion

Obesity is characterized by excessive accumulation of fat and a positive energy balance, which is linked to a reduced life expectancy [26, 27]. Obesity is not strictly a cosmetic concern; it is a multifaceted metabolic disorder that elevates the likelihood of a variety of chronic diseases [28]. Its prevalence has been constantly rising over the past decades [29].

In this study, Lee index was calculated for rats in each group at the end of feeding program (after 4 months). A normal basal Lee index was observed in the control group of rats. The successful induction of obesity was confirmed by the marked increase in Lee index observed in group II compared to the control group.

These results are in accordance with those of Gómez-Crisóstomo *et al.* [30], who demonstrated that high-fat diet promotes positive energy balance, adipocyte hypertrophy and increased fat mass relative to body length. Moreover, they reported that insulin resistance, altered leptin signaling and reduced energy expenditure contribute to disproportionate weight gain.

In the current study, group III which was fed simultaneously on high fat diet and vitamin D supplementation (500 IU/kg) for 4 months demonstrated a Lee index close to that of control group values, though slightly higher indicating that early and long-term vitamin D supplementation considerably mitigated obesity induced by a high-fat diet.

These results are in compliance with Szymczak-Pajor *et al.*, [31] who declared that vitamin D, by activating the vitamin D receptor (VDR), modulates adipogenesis and improves insulin sensitivity. Szymczak-Pajor *et al.*, [32] reported that chronic low-grade inflammation is diminished by vitamin D

supplementation, thereby limiting excessive adipose tissue expansion.

Concerning Group IV which was fed a high-calorie, fat-rich diet for 4 months and was given vitamin D supplementation for the last 1 month, In comparison to the control group, the Lee index remained significantly elevated, with only a modest improvement over time following delayed and short-term vitamin D supplementation.

This result is supported by Bennour, I. [33] who stated that the majority of obese rats have not experienced any improvement in their obesity parameters as a result of vitamin D supplementation.

Moreover, Feillet-Coudray, C. *et al.*, [34] stated that the current global epidemic of overweight and obesity is primarily caused by the increased consumption of energy-dense foods that contain high quantities of fat. Cytokines that exhibit proinflammatory properties, such as interleukin-1 and 6 (IL-1 and -6), are released by adipose tissue. Consequently, adiposity is regarded as a condition of low-grade inflammation.

In the current study, The levels of total LDL, cholesterol and triglycerides in group II, which were provided a high in fat diet for four months, were markedly higher than those in group III, which received a high in fat diet and supplementation of vitamin D simultaneously for four months.

This could be supported by the findings of Dibaba, D. *et al.* [35], who cited that supplementation of vitamin D has a positive outcome on the reduction of LDL-C, total cholesterol, and triglyceride levels.

In Group IV which was fed a high-calorie, fat-rich diet for 4 months and was given vitamin D supplementation for the last month, lipid profile remained largely similar to those of

the group II which were fed a high-calorie, fat-rich diet with only minimal improvement which indicates that delayed and short-term vitamin D supplementation has limited corrective capacity once dyslipidemia was established. The incomplete normalization of lipid profile suggests that although vitamin D exerts a protective metabolic effect, short-term and late vitamin D supplementation cannot entirely counterbalance the continuous lipid overload imposed by prolonged high-fat feeding which could be supported by the findings of Bassatine, A. *et al.* [36].

Szymczak-Pajor, I. *et al.* [32], reported that hypertrophied adipocytes, decreased angiogenesis, increased inflammation and hypoxia are the characteristics of dysfunctional adipose tissue in obesity.

In harmony with our results, Corsello, A. [37] revealed that vitamin D supplementation markedly elevates circulating vitamin D levels; however, its clinical significance appears to be restricted. In contrast, Hauger, H. *et al.* [38] stated that the efficacy of routine supplementation of vitamin D in obese individuals to restore normal circulating levels of vitamin D is uncertain.

Furthermore, in adherence to our findings, Douglass *et al.* [39] determined that the weight of MAGL-deficient mice was decreased than that of the control group after four months of high-fat diet administration. Tardelli *et al.* [40] also discovered that mice lacking MAGL exhibited markedly lower weight gain than their control counterparts. In contrast to our discoveries, Jung *et al.* [41], detected that mice that overexpressed MAGL exhibited decreased adiposity, increased lean mass, and reduced weight gain.

In group III in which vitamin D supplementation was administered concomitantly with the high-fat diet, MAGL activity was close to that of the control group. This result was supported by Pramono, A. *et al.* [42], who claimed that vitamin D may reduce lipolysis in human adipocytes by elevating intracellular  $Ca^{2+}$  levels, which in turn results in a decrease in cAMP production.

In contrast, Larrick, B. M. *et al.* [43], demonstrated that the release of glycerol was enhanced in adipocytes under both basal and beta-adrenergically stimulated conditions by vitamin D.

Group IV which was fed on high caloric diet rich in fat for 4 months and was given vitamin D supplementation for the last 1 month in this study demonstrated elevated MAGL activity following late and short-term vitamin D supplementation compared to the control group but less than that of the HFD group.

Ornithine Decarboxylase (ODC) enzyme is the enzyme that restricts the rate of polyamine synthesis which supports essential cellular functions such as cellular differentiation, proliferation and response to oxidative stress [44]. ODC activity has been implicated in adipocyte proliferation and differentiation. Inhibition of ODC significantly impairs triglyceride accumulation and differentiation into mature adipocytes [45].

The control group did not exhibit a significant increase in ODC levels, whereas Group II, which received a high-fat diet, did. This result is supported by Rao, C. V., and Reddy, B. S. [46].

Ramos-Molina *et al.* [47], reported a link between high dietary lipid loads and increased polyamine synthesis since persistent ODC activation can exacerbate inflammatory cascades and impair insulin signaling pathways, which aligns with the dyslipidemia.

In our study, group III, which was simultaneously administered a diet high in fat and supplementation of vitamin D for four months, demonstrated that the combination of high fat diet and concurrent vitamin D supplementation resulted in ODC levels that could be compared to those of the control group.

Karkeni *et al.* [48] found that pro-inflammatory cytokines levels in obese mice were reduced by vitamin D. Early vitamin D supplementation preserves VDR signaling before the development of obesity-associated metabolic stress and inflammation [49], which are known stimulators of polyamines biosynthesis that are essential molecules for cellular growth, proliferation [50].

Cholesterol, triglycerides, and LDL are statistically positively correlated with ODC levels and MAGL activity, while HDL is negatively correlated. ODC levels are statistically positively correlated with MAGL activity.

| BMI        | Body mass index                           |
|------------|-------------------------------------------|
| calcitriol | 1,25-dihydroxycholecalciferol             |
| LDL-C      | Low density lipoprotein cholesterol level |
| LDL        | Low density lipoprotein                   |
| MAGL       | Monoacylglycerol lipase                   |
| ODC        | Ornithine decarboxylase                   |
| VDR        | vitamin D receptor                        |

## Conclusion

This study demonstrates that high-fat diet induces significant metabolic disturbances in rats, as evidenced by increased Lee index, dyslipidemia (elevated TG, reduced HDL-C, cholesterol and LDL-C) and increase of MAGL activity and ODC level. The lipid profile was enhanced and the enzymatic balance was preserved through early and long-term vitamin D supplementation. In contrast, delayed and short-term vitamin D intervention provided only partial improvement emphasizing the critical importance of timing in metabolic modulation. These results demonstrate a rationale for early administration of vitamin D to manage obesity.

Future research is recommended on large scale of obese individuals to confirm the results of this study. Vitamin D monitoring is recommended during obesity management protocols.

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**Conflict of Interest:** Nil.

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