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# EFFECT OF HYPERBARIC OXYGEN THERAPY ON FROZEN SHOULDER IN DIABETIC ELDERLY

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**Abstract**

**Purpose:** The aim of this work was to assess the effect of (HBOT) on frozen shoulder in diabetic elderly. **Patients and Methods:** Sixty patients of both sexes represent the sample of this study. The patients' ages ranged from 66-75 years with a mean value of 67.90± 1.71 years. The patients were selected from Out-patients' Clinic at Air Force Hospital. They were assigned randomly into two groups equal in number; the study group (GA) and the control group (GB). (GA): treated by traditional medical treatment prescribed by treating physician and traditional physical therapy in the form of ROM exercise and Mobilization exercises 3 times per week for 6 weeks in addition to HBOT therapy. The Control group (GB): treated by traditional medical treatment prescribed by treating physician and traditional physical therapy in the form of ROM exercises and Mobilization exercises 3 times per week for 6 weeks. The duration of treatment was 6 weeks, HBOT therapy session was between 2-2.5 bar for 1 hour 5 times per week for 6 weeks (30 session) for group (A) only. Digital Inclinometer was used to measure shoulder joint degree, MRI for examine the shoulder joint to detect thickening of the Coracohumeral Ligament. Shoulder pain and disability index (SPADI) is a self-administered questionnaire that consists of two dimensions, one for pain and the other for functional activities assess before and after treatment in both groups. **Results:** Comparison of each variable pre and post treatment in each group revealed a significant improvement in all different parameters in study groups (GA) $P \leq 0.05$; except for thickening of the Coracohumeral Ligament was not significant at both groups. Comparison of post treatment results of both groups showed that hyperbaric oxygen therapy used in study group (A) showed significant increase in ROM than group (B) and significant decrease in SPADI. **Conclusion:** Hyperbaric oxygen therapy have significant positive effect on frozen shoulder in diabetic elderly patients.

**Keywords:** Hyper Baric Oxygen Therapy (HBOT), Frozen Shoulder, Diabetic, Elderly.

## INTRODUCTION

Diabetes is a fast-growing health problem in Egypt with a significant impact on morbidity, mortality, and health care resources. The International Diabetes Federation (IDF) has identified Egypt as the ninth leading country in the world for the number of patients with

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diabetes. The prevalence of diabetes in Egypt was almost tripled over the last 2 decades **(Hegazi et al., 2015).**

Frozen shoulder, also called adhesive capsulitis, is a painful condition in which the movement of the shoulder becomes limited. Frozen shoulder occurs when the strong connective tissue surrounding the shoulder joint (called the shoulder joint capsule) become thick, stiff, and inflamed. (The joint capsule contains the ligaments that attach the top of the upper arm bone [umeral head] to the shoulder socket [glenoid], firmly holding the joint in place **(Wheeler, 2021).**

Research has shown that people with diabetes are up to twice as likely to suffer from frozen shoulder due to effects on collagen in the shoulder, which holds the bones together in a joint. Collagen can become sticky if glucose molecules become attached, resulting in movement being restricted and the shoulder begins to stiffen. This process is known as glycosylation. Poorly controlled diabetes has long been linked to muscular and skeletal problems, with consistently high blood sugars likely to increase the risk of complications such as frozen shoulder **(Balci et al ,1999).**

The pathophysiology of frozen shoulder in diabetes is linked to chronic inflammation, accumulation of advanced glycation end-products (AGEs), and fibrosis of the joint capsule, which contribute to persistent stiffness and poor recovery (Whelton & Peach, 2018). Systematic reviews confirm that diabetic patients with frozen shoulder experience worse pain, greater restriction in range of motion, and less favorable outcomes compared to non-diabetic populations **(Zreik et al., 2016; Uppal, Evans, & Smith, 2015).**

Hyperbaric oxygen therapy (HBOT) involves breathing pure oxygen in a pressurized environment. Hyperbaric oxygen therapy is a well-established treatment for decompression sickness, a potential risk of scuba diving. Other conditions treated with hyperbaric oxygen therapy include serious infections, bubbles of air in blood vessels, and wounds that may not heal as a result of diabetes or radiation injury. In a hyperbaric oxygen therapy chamber, the air pressure is increased two to three times higher than normal air pressure. Under these conditions, lungs can gather much more oxygen than would be possible breathing pure oxygen at normal air pressure. The blood carries this extra oxygen throughout the body, this helps fight bacteria and stimulate the release of substances called growth factors and stem cells, which promote healing. Studies show HBOT offers marked improvements in patients suffering from serious inflammation and swelling, particularly in the extremities **(Novak et al, 2016).**

**Significance of the study:**

Diabetic frozen shoulder is a painful debilitating condition which can be diagnosed clinically with higher incidence in diabetic patients, up to 30%. It is a condition of chronic inflammation and proliferative fibrosis resulting in painful limitation of shoulder movements with classical clinical signs. Diabetic patients are more likely to develop the disease and more likely to require operative management. Diabetic frozen shoulder is a difficult condition to manage, and the clinician must strike a balance between improving range of movement and treating pain.

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Treatment options principally include physiotherapy and intra-articular injections, and progression to hyperbaric oxygen therapy **(Whelton and Peach, 2017).**

Inflammation is an integral finding in numerous medical conditions and coincides with nearly all types of injuries and insults to the body. Numerous studies have reported chronic inflammation in Diabetes, and diabetic frozen shoulder.

Hyperbaric Oxygen Therapy has been demonstrated to substantially attenuate inflammation throughout the body. HBOT drives increased levels of oxygen into the body, which travels through the plasma, subsequently reducing inflammation and pain.

Studies have shown that HBOT increases anti-inflammatory levels and provides increased cellular aid to heal target regions. As oxygen serves as one of the primary mechanisms to ameliorating inflammation, HBOT creates the environment where this process is stimulated and enhanced **(Wahl et al., 2019).**

Diabetic frozen shoulder patients need a new line of treatment for improving their health and for supporting their life so the investigator hopes that HBOT play this role in addition to traditional line of treatment in the present protocol.

Thus, it becomes evident that Hyper baric Oxygen Therapy (HBOT) may represent a new therapeutic option in the management of frozen shoulder, particularly since its effect has not been sufficiently investigated in previous literature. Therefore, the importance of this study arises from its attempt to examine the effect of Hyper baric Oxygen Therapy (HBOT) on frozen shoulder in diabetic elderly, which may contribute to improving the available treatment strategies.

**Aims of the study:**

This study aimed to assess the effect of (HBOT) on frozen shoulder in diabetic elderly.

**Research question:**

Does (HBOT) have an effect on frozen shoulder in diabetic elderly?

**Research design and setting:**

This case-control study was conducted at Air Force Hospital; during January 2023 till October 2024.

**Sample:**

Sixty patients of both genders were recruited from outpatient clinic of air force hospital, their age between over 66 years old and 75 years old suffering from frozen shoulder among elderly diabetic.

**Inclusion criteria:**

1) Sixty elderly diabetic frozen shoulder patients were from both genders.
2) The patients were previously diagnosed with diabetic frozen shoulder from not less than 6 months ago.

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3) Patients were both sexes aged between 65 years old to 75 years old.
4) BMI was than 30 kg / $m^2$.
5) Fasting blood glucose was less than 200 mg/dl.

**Exclusive criteria:**

Patients who met one of the following criteria were excluded from the study:

A) Chronic sinusitis.
B) Chronic obstructive pulmonary disease with air trapping.
C) Cardiac disease.
D) Emphysema with co2 retention.
E) Thoracic surgery.
F) Middle ear barotrauma.
G) Mentally retarded patients.

**1- Instrumentation:**

1) Blood glucose test using (ACCU-CHEK Performa) to check the blood glucose. It was less than 200 mg/dl.
2) Weight and height scale: was used to calculate body mass index (Figure 3).
3) Digital Inclinometer (ROM): was used to assess shoulder joint for each patient flexion, extension, abduction, and adduction, internal and external rotation.
4) MRI for examine the shoulder joint: using MRI model: GE health care 1.5 Tesla. The MRI examination of the shoulder is an effective, quick and painless diagnostic method. It is used to detect thickening of the Coracohumeral Ligament. It should be greater than 4 mm (Figure 5) (Mengiardi et al,2004).
5) Shoulder pain and disability index (SPADI): It is a patient completed questionnaire with 13 items assessing pain level and extent of difficulty with ADLs requiring the use of the upper extremities. The pain subscale has 5-items and the disability subscale have 8-items. The patient was instructed to choose the number that best describes their level of pain and extent of difficulty using the involved shoulder.

**Ethical Consideration**

Before starting the study, an official permission was obtained from the institutional ethical committee and prior an informed consent of all the subjects were obtained before conducting the study.

Sixty patients of both genders were recruited from outpatient clinic of air force hospital, their age between over 66 years old and 75 years old suffering from frozen shoulder among elderly diabetic.

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In this study patients were randomly divided into two equal groups, and each group composed of 30 patients.

1) Group (A):

Represented the study group that accomplish the designed program of medical treatment from physician and traditional physical therapy in form of ROM ex & mobilization of glenohumeral joint plus Hyper baric Oxygen Therapy (HBOT) between 2-2.5 bar for 1 hour 5 times per week for 6 weeks (30 session).

2) Group (B):

Represent the control group that accomplishes medical treatment and ROM exercises & mobilization of glenohumeral joint 3 times per week for 6 weeks (18 sessions).

**2- Instrumentation:**

A- For evaluation:

1) Blood glucose test using (ACCU-CHEK Performa) to check the blood glucose. It was less than 200 mg/dl.
2) Weight and height scale: was used to calculate body mass index (Figure 3).
3) Digital Inclinometer (ROM): was used to assess shoulder joint for each patient flexion, extension, abduction, and adduction, internal and external rotation.
4) MRI for examine the shoulder joint: using MRI model: GE health care 1.5 Tesla. The MRI examination of the shoulder is an effective, quick and painless diagnostic method. It is used to detect thickening of the Coracohumeral Ligament. It should be greater than 4 mm (Mengiardi et al,2004).
5) Shoulder pain and disability index (SPADI) (Appendix III).

It is a patient completed questionnaire with 13 items assessing pain level and extent of difficulty with ADLs requiring the use of the upper extremities.

The pain subscale has 5-items and the disability subscale have 8-items.

The patient was instructed to choose the number that best describes their level of pain and extent of difficulty using the involved shoulder.

B- For Treatment:

1) ROM exercises.
2) Mobilization exercises.
3) Hyper baric oxygen therapy (HBOT):

- Model: HAUX-STARMED2300/3/ICU.
- Manfacture: HAUX-LIFE-SUPPORT.

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### 3- Procedure:

A consent form was signed from each patient as an agreement to be a member in the present study.

### A) Evaluation procedures:

1) **Blood glucose test:** a blood glucose test using (ACCU-CHEK Performa) to check the blood glucose that screens for diabetes by measuring the level of glucose (sugar) in a patient's blood and was less than 200 mg/dl. It carried out only before starting the program of treatment (Medline Plus et al., 2021).
2) **Weight and height scale was used** to calculate the body mass index: it is a simple calculation using a person's height and weight. The formula is BMI = kg/m2 where kg is a person's weight in kilograms and m2 is their height in meters squared. It was carried out only before starting the program of treatment (Hong & Haung, 2022).
3) ROM **test using digital inclinometer was used** to assess of shoulder joint for each patient (flexion, extension, abduction, and adduction, internal and external). Digital Inclinometer is a device is used to measure range of motion in the joints of the body. Accepted values for a normal ROM for shoulder joint (flexion=180, extension=50, abduction=180 and adduction=50). It was carried out before and after the program of treatment (Hippensteel etal, 2019).
4) MRI **for shoulder joint:** The MRI examination of the shoulder is an effective, quick and painless diagnostic method. It was used to detect thickening of the Coracohumeral Ligament. It should be greater than 4 mm. It was carried out before and after the program of treatment (Mengiardi et al,2004).
5) **Shoulder pain and disability index (SPADI):** is a patient completed questionnaire with 13 items assessing pain level and extent of difficulty with ADLs requiring the use of the upper extremities. The pain subscale has 5-items and the disability subscale have 8-items. The patient was instructed to choose the number that best describes their level of pain and extent of difficulty using the involved shoulder. The pain scale is summed up to a total of 50 while the disability scale sums up to 80. The total SPADI score is expressed as a percentage. A score of 0 indicates best 100 indicates worst. A higher score shows more disability. It was carried out before and after the program of treatment (Roach et al, 1991).

### B-Treatment Procedure:

Preparation for Treatment:

1- Verbal explanation about the importance of this research and about the treatment programs were explained to the patients.
2- All patients of both groups were instructed not to make any serious changes in their life style and activities of daily living.

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3- Each patient of the two groups continued taking their usual medication as prescribed by the physician and ROM exercises and mobilization all over the research time.

4- Each patient of the two groups signed a consent form which included that he/she voluntarily accepted to participate in the research program and a detailed description of the procedure were explained and he/she could discontinue participation in this research at any time without prejudice to him/her.

5- Each patient from study group took the HBOT therapy five times per week for 6 weeks in addition to ROM exercises and mobilization exercises for glenohumeral joint.

6- Each patient from group B treated by ROM exercises and mobilization exercises for glenohumeral joint three times per week for 6 weeks.

1) ROM exercises: Range of motion exercise refers to activity aimed at improving movement of a specific joint. This motion was influenced by several structures: configuration of bone surfaces within the joint, joint capsule, ligaments, tendons, and muscles acting on the joint. Patient moved the shoulder joint throughout the available range. Joint receives partial assisting from the physiotherapist at the end of active free range. Range of motion exercises for shoulder joint were done 20 times for each range of motion (flexion, extension, abduction, and adduction, internal and external rotation) 3 times per week for 6 weeks (18 sessions) for group A&B.

2) Mobilization exercises: anterior and posterior: the patient was relaxed in sitting position, a belt was placed around the head of the humorous to glide the humorous head appropriately, as the therapist's hand was used over the appropriate aspect of the head of the humorous. A counter pressure also was applied to the scapula with the therapist's other hand. The glide was sustained during slow active shoulder movements to the end of the pain-free range and released after return to the starting position. Three sets of 10 repetitions were applied, with 1 minute between sets (Mulligan,1999).

3) Hyperbaric oxygen therapy pressure was done between 2-2.5 bar for 1 hour 5 times per week for 6 weeks (30 session) for group (A) only (Camporesi and Bosco,2014)

**Statistical data analysis:**

Descriptive statistics (mean and standard deviation) were used to assess the baseline characteristics of the study patients/subjects (McLaughlin 2002). Data were included in a database and analyzed by means of statistical software package namely SPSS Windows (version 25 windows).

Analytical tests included unpaired student t test (two sided) for comparing each group. Paired t test was used for comparing values before and after treatment. Level of Significance was $P< 0.05$ (Bluman, 2014).

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## RESULTS

**Table 1: The descriptive data for both study and control groups.**

| Group / Item | Study group | | control group | | Independent samples t test | | S |
|---|---|---|---|---|---|---|---|
| | Mean | ±SD | Mean | ±SD | t-value | p | |
| **Age (years)** | 67.90 | 1.71 | 66.27 | 12.45 | 0.71 | .479 | NS |
| **Height (m)** | 1.71 | 0.06 | 1.74 | 0.05 | 1.69 | .096 | NS |
| **Weight (kilograms)** | 80.83 | 8.22 | 83.93 | 7.53 | 1.52 | .133 | NS |
| **BMI** | 27.53 | 1.85 | 27.89 | 1.31 | 0.86 | .392 | NS |
| **FBS** | 178.67 | 13.97 | 180.83 | 14.70 | 0.583 | .562 | NS |

*Non-significant at P- value at > 0.05.

In table (1) the mean values of age of both study and control groups were [67.90 ±1.71] and [66.27 ± 12.45] respectively. Their height was [1.71 ±0.06] and [1.74 ± 0.05] respectively. Their weight was [80.83 ±8.22] and [83.93 ± 7.53] kilograms respectively. Their BMI was [27.53±1.85] and [ 27.89 ± 1.31] respectively. Their FBS was [ 178.67± 20.97] and [180.83± 14.70] mg/dl respectively. Comparison of pretests indicated that there is no significant difference related to age, height and weight, BMI and FBS

**Table 2: Comparison of the mean values of (ROM) flexion, extension, abduction, and adduction, internal and external rotation posttest between both groups**

| Group / Item | Posttest | | | | | | S |
|---|---|---|---|---|---|---|---|
| | study group | | Control group | | Independent samples t test | | |
| | Mean | ±SD | Mean | ±SD | t-value | p | |
| (ROM): flexion | 110.07 | 8.74 | 102.83 | 8.97 | 3.166 | 0.000* | **S** |
| (ROM): extension | 29.13 | 3.26 | 24.57 | 4.36 | 4.588 | 0.000* | **S** |
| (ROM): abduction | 88.30 | 7.32 | 82.70 | 5.69 | 3.308 | 0.000* | **S** |
| (ROM adduction, | 20.07 | 3.00 | 18.33 | 2.95 | 2.265 | 0.027* | **S** |
| (ROM): internal rotation | 19.97 | 3.19 | 16.10 | 3.20 | 4.691 | 0.000* | **S** |
| (ROM): external rotation. | 38.27 | 4.40 | 31.10 | 4.54 | 6.212 | 0.000* | **S** |

*Significant at P value at ≤ 0.05.

In table (2) comparison of the mean values of (ROM): flexion degree posttest between both groups revealed that in the study group posttest (ROM): flexion degree mean value ±SD was [110.07 ±8.74], in the control group posttest, (ROM): flexion degree mean value ±SD was [102.83 ±8.97]. Comparison of posttests indicated that there is a highly significant difference in (ROM): flexion degree means value ± SD between both groups' posttest.

Comparison of the mean values of (ROM): extension degree posttest between both groups revealed that in the study group posttest (ROM): extension degree mean value ±SD was [29.13 ±3.26], in the control group posttest, (ROM): extension degree mean value ±SD was [24.57 ±4.36].

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Comparison of posttests indicated that there is a highly significant difference in (ROM): extension degree means value ± SD between both groups' posttest.

Comparison of the mean values of (ROM): abduction degree posttest between both groups revealed that in the study group posttest (ROM): abduction degree mean value ±SD was [88.30 ±7.32], in the control group posttest, (ROM): abduction degree mean value ±SD was [82.70 ±5.69]. Comparison of posttests indicated that there is a highly significant difference in (ROM): abduction degree means value ± SD between both groups posttest.Comparison of the mean values of (ROM): adduction degree posttest between both groups revealed that in the study group posttest (ROM): adduction degree mean value ±SD was [20.07 ±3.00], in the control group posttest, (ROM): flexion degree mean value ±SD was [18.33 ±2.95]. Comparison of posttests indicated that there is a significant difference in (ROM): adduction degree means value ± SD between both groups' posttest.

Comparison of the mean values of Digital Inclinometer (ROM): internal rotation degree posttest between both groups revealed that in the study group posttest (ROM): internal rotation degree mean value ±SD was [19.97 ±3.19], in the control group posttest, (ROM): internal rotation degree mean value ±SD was [16.10 ±3.20]. Comparison of posttests indicated that there is a highly significant difference in (ROM): internal rotation degree means value ± SD between both groups' posttest.

Comparison of the mean values of (ROM): external rotation. degree posttest between both groups revealed that in the study group posttest (ROM): external rotation. degree mean value ±SD was [38.27±4.40], in the control group posttest, (ROM): external rotation. degree mean value ±SD was [31.10 ±4.54]. Comparison of posttests indicated that there is a highly significant difference in (ROM): external rotation. degree means value ± SD between both groups' posttest.

**Table 3: Comparison of the mean values of thickening of the Coracohumeral Ligament posttest between both groups**

| Group / Item | Posttest | | | | | | |
|---|---|---|---|---|---|---|---|
| | study group | | Control group | Independent samples t test | | | S |
| | Mean | ±SD | Mean | ±SD | t-value | p | |
| thickening of the Coracohumeral Ligament by MRI | 3.96 | 0.29 | 3.92 | 0.25 | 0.591 | 0.57 | NS |

*Non-Significant at P value at ≤ 0.05.

In table (3) comparison of the mean values of thickening of the Coracohumeral Ligament by MRI posttest between both groups revealed that in the study group posttest thickening of the Coracohumeral Ligament by MRI mean value ±SD was [3.96 ±0.29], in the control group posttest, thickening of the Coracohumeral Ligament by MRI mean value ±SD was [3.92 ±0.25]. Comparison of posttests indicated that there is no significant difference in thickening of the Coracohumeral Ligament by MRI means value ± SD between both groups' posttest.

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**Table 4: Comparison of the mean values of Shoulder pain and disability index (SPADI): posttest between both groups**

| Group / Item | Posttest | | | | | | |
|---|---|---|---|---|---|---|---|
| | study group | | Control group | | Independent samples t test | | S |
| | Mean | ±SD | Mean | ±SD | t-value | p | |
| Shoulder pain index | 32.13 | 2.62 | 35.30 | 3.52 | 3.94 | 0.00* | S |
| Shoulder disability index | 52.57 | 3.39 | 59.33 | 5.87 | 5.46 | 0.00* | S |
| Total Shoulder pain and disability index | 84.63 | 4.84 | 94.77 | 7.20 | 6.40 | 0.00* | S |

*Significant at P value at ≤ 0.05.

In table (4) comparison of the mean values of Shoulder pain index posttest between both groups revealed that in the study group posttest Shoulder pain index mean value ±SD was [32.13 ±2.62], in the control group posttest, Shoulder pain index mean value ±SD was [35.30 ±3.52]. Comparison of posttests indicated that there is a significant difference in Shoulder pain index means value ± SD between both groups' posttest.

Comparison of the mean values of Shoulder disability index posttest between both groups revealed that in the study group posttest Shoulder disability index mean value ±SD was [52.57 ±3.39], in the control group posttest, Shoulder disability index mean value ±SD was [59.33 ±5.87]. Comparison of posttests indicated that there is a significant difference in Shoulder disability index means value ± SD between both groups' posttest.

Comparison of the mean values of Total Shoulder pain and disability index posttest between both groups revealed that in the study group posttest Total Shoulder pain and disability index mean value ±SD was [84.63 ±4.84], in the control group posttest, Shoulder pain index mean value ±SD was [94.77 ±7.20]. Comparison of posttests indicated that there is a significant difference in Total Shoulder pain and disability index (SPADI) between both groups' posttest.

## DISCUSSION

The main findings of the current study confirmed that Hyperbaric Oxygen Therapy (HBOT) had a significant positive effect on frozen shoulder in diabetic elderly. The study group, which was treated by Oxygen Therapy (HBOT) in addition to the designed ROM exercises program and Mobilization exercises program showed significant improvement of (ROM) flexion, extension, abduction, adduction, internal, external rotation and Shoulder pain and disability index (SPADI). Except no improvement of thickening of the Coracohumeral Ligament. In control group the designed ROM exercises program and Mobilization exercises program for 6 weeks showed slightly improvement in (ROM) flexion, extension, abduction, and adduction, internal and external rotation and Shoulder pain and disability index (SPADI). Except no improvement of thickening of the Coracohumeral Ligament.

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However, the slightly improvement of (ROM) flexion, extension, abduction, and adduction, internal and external rotation may be explained as the use the Hyperbaric Oxygen therapy (HBOT) as a new treatment line for short period of sessions (6 weeks).

This work was in line with the work of Li et al., 2025 (rabbit rotator cuff tear model) used HBOT 2 ATA × 2h/day × 5 days and showed improved tendon-bone healing and vascularization (supports biological plausibility around shoulder tissues, but does not measure human frozen-shoulder ROM).

In the light of presence of inflammatory pathways Fibroblasts transform into contractile myofibroblasts producing excess collagen of Frozen shoulder patients; the results of the current study can be explained on the basis of the proven effects of Hyperbaric Oxygen therapy (HBOT) on the inflammation processes and cellular structures and functions (Javadi et al., 2022).

The results of this study as no improvement of Coracohumeral Ligament measurements could be explained by Capsular inflammation and fibrosis, initial synovitis triggers fibroblast and myofibroblast proliferation, with collagen deposition and thickening of the Coracohumeral joint capsule (Dudkiewic, et al, 2022). Also, the short period of program sessions (6 weeks) could reduce the effect of (HBOT).

Moreover, the study results reported that there was highly significant difference between pretest and posttest among study group related Shoulder pain and disability index (SPADI) but there was a significant different between study group and control group. These results could be explained as the improvement of ROM degrees among frozen shoulder patients after HBOT in order to improve disability and pain scores.

The results of the current study confirmed the hypothesis that application of HBOT has a positive effect on the frozen shoulder in diabetic elderly.

## CONCLUSIONS

Hyperbaric oxygen therapy had a positive significant effect on frozen shoulder in diabetic elderly related to range of motion and SPADI.

### Recommendations

**The following Suggested Recommendations are for further researchers:**

- Future studies should include larger sample sizes to improve statistical power and generalizability.
- Apply (HBOT). Longer treatment duration and follow-up periods are needed to evaluate the sustained effects of HBOT.
- Further randomized controlled trials should focus on biomechanical and histological outcomes (collagen remodeling (
- Comparative studies between HBOT and other non-invasive modalities (extracorporeal shockwave therapy, laser therapy) may provide insights into optimal management strategies for diabetic frozen shoulder.

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