The Relationship between Vitamin C and Frailty among Elderly Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Background/Purpose: Nutritional intake including vitamins as vitamin C may affect muscle power and prevent the development of diabetes mellitus in humans by various mechanisms. This why we conduct this case control study to detect relation between vitamin C and DM control and frailty in elderly patients.

Methods: A case control study was conducted among 88 elderly patients aged 60 years and older with type 2 diabetes mellitus were recruited via purposive sampling from the inpatient ward and outpatient clinics of Ain Shams university hospitals from March to December 2019. They were classified according to Hemoglobin A1c levels as controlled and uncontrolled groups. Then, they were further subdivided into frail and non-frail subjects. Comprehensive geriatric assessment, fried criteria and vitamin C levels were measured in all participants.

Results: The research showed that vitamin C level was inversely related to Hemoglobin A1c in all studied participants and in frail patients by using Spearman’s rank correlation coefficient, as the highest vitamin C levels were found in non-frail patients with controlled diabetes mellitus and the lowest levels were found in frail patients with uncontrolled diabetes mellitus. Frail patients had more cognitive impairment, functional dependence and malnourishment than non-frail ones with statistically high significant difference (P-value is 0.001).

Conclusion: Vitamin C levels are affected in elderly patients with type 2 diabetes mellitus by both diabetes mellitus control and frailty. Vitamin C supplementation is recommended for any frail elderly with type 2 diabetes mellitus.

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DM causes deterioration in the musculoskeletal and nervous systems functions, declining cardiopulmonary reserve leading to loss of whole body homeostasis. Thus, it increases the risk of development of various geriatric syndromes such as frailty, cognitive impairment, depression, malnutrition and chronic pain in the elderly population.

Frailty is an important geriatric syndrome. It is defined as a state of increased vulnerability to stressors and a consequence of cumulative decline in multiple physiological systems over a lifespan. It leads to different adverse outcomes as falls, fractures and skeletal muscle loss (sarcopenia) that leads to functional impairment.

There is a strong correlation between nutrients and frailty as nutrients play essential roles in sustaining health and prevention of diseases. Nutrients, including vitamins are vital in multiple health aspects for example, antioxidant vitamins found in diet as vitamins C, E and carotenoids prevent and treat age-related loss of muscle mass and power associated with aging. These vitamins affect skeletal muscle by acting as exogenous antioxidant and anti-inflammatory. Particularly, vitamin C is concerned in collagen and carnitine synthesis, repair of tissues and wound healing.

Therefore, frailty is considered a nutrition-related condition. The age-related physiological changes in the gastrointestinal system as changes in taste and smell, can change dietary preferences, dietary intake and decrease absorption of macro and micronutrients leading to malnutrition and vitamin deficiencies.

Low intake of vitamin C particularly was observed in pre-frail or frail older adults, compared with the healthy ones in a clinical trial included 800 rural Japanese community-dwelling older adults.

Vitamin C plays an important role in skeletal muscle as it contributes in carnitine and collagen synthesis that is a key structural component of skeletal muscle cells and tendons, and carnitine is essential for metabolism of long-chain fatty acids during physical activity. Animal studies illuminated that vitamin C deficiency leads to morphological changes and skeletal muscle atrophy - sarcopenia - the core component of frailty. The most important drivers seem to be upregulation of the ubiquitin ligases atrogin1/muscle atrophy F-box and muscle RING-finger protein1 and a reduction in production of reactive oxygen species.

As oxidative stress causes disturbed glucose metabolism. Thus, vitamin C by acting as antioxidant may help in preventing type 2 diabetes mellitus (T2DM) or getting positive outcomes in T2DM.

There is an inverse correlation between vitamin C levels and T2DM as patients with T2DM have at least 30% lower vitamin C levels than those without diabetes with a similar dietary intake of vitamin C. The lower vitamin C levels in patients with T2DM could be explained by the hypothesis that high blood glucose inhibits the uptake of dehydroascorbic acid (DHA) which is the oxidized transportable form of vitamin C in the cells and may compete with vitamin C for uptake into cells. It is because it’s structural similarity with the active form of vitamin C. Also, increased oxidative stress may diminish antioxidant stores. Thus, uncontrolled T2DM can lead to deficiency of vitamin C and this was established by a study of ascorbic acid turnover that revealed higher vitamin C turnover in patients with uncontrolled T2DM when compared to control ones.

Therefore, the daily use of vitamin C supplements significantly decreases the risk of developing T2DM. High supplementation of 2,000 mg of vitamin C per day for 90 days made an improvement in Hemoglobin bA1c (HbA1c) levels.

Although the important role of vitamin C as antioxidant in frailty prevention and T2DM control, the relationship among vitamin C, frailty and DM is not studied enough in elderly population. Thus we conducted this case control study to detect relation between vitamin C, frailty and DM.

We hypothesized that vitamin C will be low in frail non-controlled diabetic patients in comparison to non-frail controlled diabetic ones.

2. METHODS

2.1. Study Design and Participants

This was a case-control study conducted on 88 elderly subjects, aged 60 years and above with T2DM including males and females that were recruited from the inpatient ward and outpatient clinics of Ain Shams University hospitals from March to December 2019.

The study methods were reviewed and approved by the Research Review Board of the Geriatrics and Gerontology Department–Faculty of Medicine–Ain Shams University and the ethical committee-faculty of medicine, Ain Shams University.

The study sample was divided into controlled and uncontrolled groups depending on HbA1c results. Each group was further subdivided into frail and non-frail sub groups. Comprehensive geriatric assessment and vitamin C serum levels were assessed in all participants. Each group was further subdivided into frail and non-frail sub groups. Comprehensive geriatric assessment and vitamin C serum levels were assessed in all participants. Then the relation between type2 DM, vitamin C level and their relation to frailty also were assessed.

2.2. Inclusion Criteria

Patients aged 60 years and older, males and females, with T2DM who agreed to participate in the current study.

2.3. Exclusion Criteria

1. Those who refused to participate in the study.
2. Heavy smoker older adults.
3. Elderly patients with comorbidities known to influence vitamin C status including malabsorption syndrome, untreated celiac disease,
4. Patients who had undergone a previous bowel resection.
5. Elderly taking medications known to influence vitamin C metabolism or taking supplements of vitamin C.
6. Patients who suffered from end stage renal disease (ESRD) on regular hemodialysis, recent stroke with bulbar symptoms affecting feeding and those with metastatic cancer.
7. Elderly who are on strict exercise regimens to promote weight loss.

2.4. Each Patient Subjected to the Following

I. Informed oral consent was taken.

II. Comprehensive geriatric assessment including:

(1) Detailed history taking: including complete demographic data (e.g. age, gender), special habits of medical importance, past medical history as detailed history of DM, duration, microvascular and macrovascular complications and finally management received by the patient and his or her compliance on it and history of comorbidities as malabsorption and celiac disease, history of previous hospitalization, drug history with special concern to vitamin C supplementation and drugs affect vitamin C metabolism as exclusion criteria, number of comorbidities which the patients had.
(2) Detailed clinical examination: including general and local examination to detect DM complications as peripheral neuropathy, retinopathy and cerebrovascular stroke.
(3) Mini nutritional assessment (MNA) developed by Calvo et al., 2012.18
(4) Cognitive function assessment by Saint-Louis-University-Mental-Status (SLUMS) Arabic version developed by Tarig et al., 2014.19
(5) Mood assessment by Patient Health Questionnaire -2 (PHQ-2).20
(6) Physical function assessment by Activities of Daily Living Index (ADL)21 and Instrumental activities of daily living (IADL).22

III. Fried criteria to diagnose frailty including:

*Weight loss: Subject is asked "In the last year, have you lost more than 10 pounds unintentionally (i.e. not due to dieting or exercise)?" If yes, then frail for weight loss criterion.
*Exhaustion: Subject is asked how many times he feels an effort when doing everything in the last week. If the answer is moderate amount of the time (3–4 days) or most of the time, the subject will be frail.
*Low physical activity: A single response was used to estimate physical activity. Individuals who denies doing daily leisure activities such as walking or guarding and or denied doing some sport activity per week were categorized as physically inactive. Those who reported doing them were considered to be physically active.23
*Walk time: Cutoff for time to walk 15 feet criterion for frailty ≥7 seconds for height ≤173 cm. and ≥6 seconds for height >173 for males and time ≥7 seconds for height ≤159 cm., time ≥6 seconds for height >159 cm. for females.24
*Grip strength using the jamar grip dynamometer: Cutoff for grip strength (Kg) criterion for frailty, is ≤29 for BMI ≤24, ≤30 for BMI 24.1–26, ≤31 for BMI 26.1–28 and ≤32 for BMI < 28 for males. Cutoff for grip strength (Kg) criterion for frailty, is ≤17 for BMI ≤23, ≤17.3 for BMI 23.1–26, ≤18 for BMI 26.1–29 and ≤21 for BMI >29 for females.24 Individuals with at least three of the five criteria of fried were classified as frail.25

IV. Laboratory measures:

(1) HbA1c was measured to determine controlled and uncontrolled diabetic cases. HbA1C was done by a fully automated cation-exchange HPLC system (BioRad, Hercules, and CA). 5 microliter of whole blood sample were collected in capillary tube for analysis. Samples were incubated at 37°C for 30 minutes to remove Shiff base. Participant is considered controlled if he/she had HbA1c <7.26
(2) Non-fasting vitamin C (VC) venous sample was taken from each participant, Serum specimens allowed to be clotted for 10-20 minutes at room temperature which underwent centrifugation at 2000-3000 RPM for 20 minutes. The Samples stored at -20°C and then brought to room temperature before starting the assay. The kit used in the study is an Enzyme-Linked Immunosorbert Assay (ELISA).

2.5. Ethical Considerations

The participants were informed by all data about the study and the aim of it and that there are no physical, social, psychological risks to them. The confidentiality and privacy of participant extracted data was ensured throughout this study.

2.6. Statistical Analysis

Convenient statistical methods were used to analyze the data. Descriptive statistics were done for quantitative data as mean±SD (standard deviation),
while it was done for qualitative data as number and percentage. Independent t-test was used to compare the two groups. The chi-square test was used to compare the two groups.

The data were collected, revised, coded, tabulated and statistically analyzed on a personal computer using IBM Statistical Package for Social Sciences (SPSS) statistics software version 23.0, IBM Corp., USA, 2015.

The level of significance was taken at P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value <0.01: highly significant (HS) otherwise is non-significant.

3. RESULTS

This study included 88 elderly subjects, aged 60 years and above with T2DM including males and females. The study sample was divided into controlled and uncontrolled groups as regards DM according to their HbA1c levels and each of them was further subdivided into frail and non-frail subjects according to Fried criteria.

The four groups of the study were classified as follows:
- Group A (Non Frail controlled)
- Group B (Non frail uncontrolled)
- Group C (Frail controlled)
- Group D (Frail uncontrolled)

About 140 patients have been assessed during the observation period; 10 were excluded due to incomplete data and 42 were excluded as each of them had at least one of the exclusion criteria (9 patients refused to participate, 11 were taking multivitamins including vit C supplementation, 6 patients had ESRD & on regular hemodialysis, 7 had malabsorption syndrome, 4 were heavy smoker, 3 had metastatic liver and breast cancer, 1 patient underwent gastric bypass surgery and 1 had recent stroke and recurrent aspiration).

Main socio-demographic data were summarized in table (1). The age range of all studied groups were 66-80 years old. There were no statistically significant differences among the 4 studied groups regarding age, gender, educational level and smoking habits. Uncontrolled DM groups B &D had higher HbA1c levels in comparison to groups A & C with statistically significant difference; P-value is 0.000 as shown in Table 1.

Regarding vitamin C levels, higher values were found in groups A & B (Non frail) in comparison to groups C & D (Frail) with highly statistical significant difference (P-value is 0.000) as showed in Table 2. Vitamin C levels were higher in controlled DM groups than uncontrolled ones with highly statistical significant

<table>
<thead>
<tr>
<th>Table 1. Sociodemographic data of the study groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A (Non Frail controlled)</strong></td>
</tr>
<tr>
<td>No.=22</td>
</tr>
<tr>
<td><strong>Age</strong>&lt;br&gt;Mean±SD</td>
</tr>
<tr>
<td><strong>Range</strong></td>
</tr>
<tr>
<td><strong>Gender</strong>&lt;br&gt;N %</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Education</strong>&lt;br&gt;N %</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Marital status</strong>&lt;br&gt;N %</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Smoking</strong>&lt;br&gt;N %</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>HbA1C</strong>&lt;br&gt;Mean±SD</td>
</tr>
<tr>
<td><strong>Range</strong></td>
</tr>
<tr>
<td><strong>Comorbidities</strong>&lt;br&gt;N %</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Median (IQR)</strong></td>
</tr>
<tr>
<td><strong>Range</strong></td>
</tr>
</tbody>
</table>

difference (P-value is 0.000) as shown in Table 3.

By using Spearman’s rank correlation coefficient, there was inverse correlation between vitamin C and HbA1c in all studied participants (r value was -0.276, P-value was 0.009) and in frail group (r-value in frail group was -0.757 and P-value was 0.000) which is highly statistically significant difference as shown in Figure 1.

General nutritional status was assessed to all patients in the 4 groups by Mini nutritional Assessment (MNA) which showed that groups C & D (frail patients) had the largest percentage of malnourished patients and at risk of malnutrition with statistically high significant difference (P-value is 0.001) as shown in Table 4.

Risk of malnutrition increased in frail patients compared to non-frail ones according to mini nutritional assessment (MNA) with statistically high significant difference (P-value is 0.001) as shown in Table 5.

Additionally, frail patients had cognitive impairment - according to (SLUMS) Saint Louis University Mental Status Examination - and functional impairment - according to activities of daily living (ADL) and instrumental activities of daily living (IADL) - than non-frail ones with statistically high significant difference (P-value 0.000) as shown in Table 5.

4. DISCUSSION

This study aimed at evaluation of the relation between vitamin C, frailty and T2DM control in elderly patients recruited from the inpatient ward and outpatient clinics of Ain Shams University Hospitals, Cairo, Egypt. Regarding the socio-demographic characteristics, all of the 4 groups of the study were matched for age and sex.

Uncontrolled DM groups have higher HbA1c levels in comparison to controlled groups as HbA1c remains the gold standard test to assess long-term glycemic control in the management of diabetes. It is now also used to diagnose diabetes.26

This study showed a directly proportional correlation between vitamin C and DM control as higher vitamin C levels are present in participants with controlled DM. On the other hand, patients with uncontrolled DM status had lower levels of vitamin C. These are in accordance with the results of a cross sectional study done in New Zealand on 89 individuals with T2DM, pre diabetic and without DM which found that participants with prediabetes and T2DM had inadequate plasma vitamin C concentrations compared with the participants without DM (1).

Also, Park et al found a tenfold decrease in vitamin C level in uncontrolled diabetic patients that developed microvascular complications as proliferative diabetic retinopathy compared to control group.27

Other several studies revealed a decreased vitamin C level in patients with Type 2 diabetes mellitus as a result of vitamin C role as antioxidant through enhancement of prostaglandin (PGE1), prostacyclin (PGI2) and nitric oxide (NO) synthesis that prevent diseases characterized by oxidative stress as T2DM.28,29,30

Another study done in the general medicine department of a tertiary care teaching hospital in India on 208 patients revealed that vitamin C supplementation was beneficial for glycemic control and cardiovascular risk reduction in diabetic patients.31

Moreover, vitamin C supplementation is reported to improve glycemic control.

Figure 1. Correlation between HbA1c and vitamin C in frail group: By using Spearman’s rank correlation coefficient.

Table 2. Comparison between the 4 studied groups as regards vitamin C levels.

<table>
<thead>
<tr>
<th>Group</th>
<th>Vitamin C ng/ml Mean±SD</th>
<th>Range</th>
<th>ANOVA</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>118±52</td>
<td>80–320</td>
<td>56.411</td>
<td>0.000</td>
</tr>
<tr>
<td>B</td>
<td>73±16</td>
<td>50–105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>41±9</td>
<td>30–68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>16±6</td>
<td>5–28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vit. C: Vitamin C.

Table 3. Relation between vitamin C level and DM control (HbA1c levels).

<table>
<thead>
<tr>
<th>Vitamin C ng/ml Mean±SD</th>
<th>Controlled DM</th>
<th>Uncontrolled DM</th>
<th>t test.</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>79.43±53.62</td>
<td>44.66±31.21</td>
<td>3.718</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

DM: Diabetes mellitus, HbA1c: hemoglobin A1c, Vit. C: vitamin C.
In a study performed in Australia on 31 elderly patients with T2DM (26 males and 5 females) with HbA1c 7.6%±0.7% received supplementation with oral ascorbic acid or placebo for 4 months. The study results showed improved postprandial blood glucose compared to placebo. In another study performed on 100 T2DM patients, supplementation of vitamin C to them effectively reduced the blood glucose levels and HbA1c levels, therefore they suggested regular assessment of vitamin C levels in T2DM patients.

Vitamin C levels were significantly decreased in frail individuals in this study. This was confirmed in another prospective study that was done in Spain including 1,643 community-dwelling individuals aged ≥65 in which 10 vitamins (vitamin A, thiamine, riboflavin, niacin, vitamins B6, B12, C, D, E and folates) were assessed using a diet history and frailty assessment was done using fried criteria. It revealed that lower intake of vitamins - less than the dietary reference intake – particularly vitamin C was associated with a higher risk of frailty in the elderly.

Significant age-related loss of skeletal muscle–sarcopenia was associated with both low dietary and circulating vitamin C according to UK EPIC-Norfolk sub cohort study during the second follow-up, health check that was attended by 17,304 participants aged 42–82 y between 1997 and 2000.

Many studies described an inverse association between nutrients such as vitamin C, vitamin D and folate and frailty development. High intake of dietary antioxidant vitamins, particularly vitamin C, was associated with high skeletal muscle mass and power in a cohort study done in United Kingdom on women with a wide age range (18–79 years) and vice versa. These results are significant in prevention of sarcopenia and frailty.

In this study, on assessing cognitive functions of the participants, it was realized that more patients with cognitive impairment (MCI and dementia) were found in the frail patients. This matches with what Montero-Odasso found in a cohort study performed on 252 community older adults free of dementia at baseline to examine the relationship between physical frailty, cognitive status, and gait performance as predictors of cognitive decline and incident dementia. It found that participants with frailty had a higher prevalence of cognitive impairment (77%) compared to those without.

Wallace et al showed that Frailty appears to play a meaningful role in dementia expression in his study that were performed using data from the Rush Memory and Aging Project (MAP) and the Cambridge City over 75s Cohort study (CC75C).

On studying nutritional status among the participants, it was found that largest percentage of patients at risk of malnutrition 50% and malnourished ones 2% were frail compared to 9% at risk of malnutrition.

### Table 4. Comparison of Mini Nutritional Assessment (MNA) results as a screening for the malnutrition among the 4 studied groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
<th>MNA</th>
<th>%</th>
<th>No.</th>
<th>%</th>
<th>No.</th>
<th>%</th>
<th>No.</th>
<th>%</th>
<th>No.</th>
<th>%</th>
<th>Chi-square test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>91%</td>
<td>20</td>
<td>91%</td>
<td>20</td>
<td>55%</td>
<td>12</td>
<td>41%</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21.98</td>
<td>0.001</td>
</tr>
<tr>
<td>At risk</td>
<td>9%</td>
<td>2</td>
<td>9%</td>
<td>2</td>
<td>46%</td>
<td>10</td>
<td>55%</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malnutrition</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>5%</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

MNA: mini nutritional assessment.

### Table 5. Comparison between frail and non-frail patients as regards nutritional, cognitive and functional status.

<table>
<thead>
<tr>
<th></th>
<th>Non frail patients</th>
<th>Frail patients</th>
<th>Chi-square test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>MNA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>40</td>
<td>91%</td>
<td>21</td>
<td>48%</td>
</tr>
<tr>
<td>At risk</td>
<td>4</td>
<td>9%</td>
<td>22</td>
<td>50%</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>0</td>
<td>0%</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>SLUMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>38</td>
<td>86.4%</td>
<td>10</td>
<td>22.7%</td>
</tr>
<tr>
<td>MCI</td>
<td>6</td>
<td>13.6%</td>
<td>16</td>
<td>36.4%</td>
</tr>
<tr>
<td>Dementia</td>
<td>0</td>
<td>0.0%</td>
<td>18</td>
<td>40.9%</td>
</tr>
<tr>
<td>ADL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In dependent</td>
<td>43</td>
<td>97.7%</td>
<td>17</td>
<td>38.6%</td>
</tr>
<tr>
<td>Dependent</td>
<td>1</td>
<td>2.3%</td>
<td>27</td>
<td>61.4%</td>
</tr>
<tr>
<td>IADL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In dependent</td>
<td>29</td>
<td>65.9%</td>
<td>7</td>
<td>15.9%</td>
</tr>
<tr>
<td>Dependent</td>
<td>15</td>
<td>34.1%</td>
<td>37</td>
<td>84.1%</td>
</tr>
</tbody>
</table>

and 0% malnourished in non-frail participants as poor nutritional status problems contribute to the development of frailty syndrome.

Inadequate dietary intake has been associated with many conditions, such as an increased risk of chronic diseases, decreased antioxidant defenses, impaired immune responses and frailty.\(^\text{37}\)

Not only optimal nutrition is essential for the prevention and treatment of different diseases, but also important for the facilitation of independence throughout the life cycle, which improves the quality of life of elderly, and finally promotes healthy aging. In fact, the importance of nutrition as a means for postponing frailty in elderly people is a well-established phenomenon.\(^\text{38}\)

Richard et al mentioned that malnutrition is a leading risk factor for disability, morbidity, and mortality in older adults. It leads to sarcopenia and frailty.\(^\text{39}\)

Also, Cruz-Jentoft et al declared that most malnourished persons are frail, and malnutrition risk is increased in frail people and nutrition has a role in reverting frailty and avoiding its adverse outcomes.\(^\text{40}\)

This study showed higher percentage of functional dependence in frail patients when compared to non-frail ones. This result was confirmed by Park et al, 2019 in a cross-sectional study that was conducted in Pyeong Chang Rural Area in South Korea on 408 older adults. Park showed that social frailty increased risk of ADL disability in elderly.\(^\text{41}\) Another study performed on about 2,804 community-dwelling adults in Singapore revealed higher prevalence of ADL and IADL disability in pre frail and frail patients.\(^\text{42}\)

Moreover, in this study functional dependence was higher among participants with uncontrolled DM (70.5%) compared to those with controlled DM (48%). This was in match with Downeret et al, who declared that, developing ADL disability was associated with baseline diabetes in a study performed among 3,419 Puerto Rican adults aged 60 and older.\(^\text{43}\)

The same result was confirmed in a longitudinal study of 2,270 Mexican Americans aged at least 65 years at baseline who were followed for 19 years. The study revealed that, diabetes was independently associated with higher rates for ADL disability in older Mexican Americans.\(^\text{44}\) Older Americans with chronic diseases as Type 2 DM face an earlier and steeper slope of functional decline as mentioned in study performed on individuals aged 80 years old from the 1998–2014.\(^\text{45}\)

5. CONCLUSION

Vitamin C is an essential micronutrient in older adults, besides its role in oxidative stress reduction, iron absorption, wound healing and common colds prevention, our study declared that vitamin C has an important role in preventing frailty and improving glycemic control in patients with type 2 diabetes mellitus. Therefore, regular assessment of vitamin C levels is necessary in T2DM. Also, vitamin C supplementation is recommended in frail elderly individuals especially if they have type 2 DM.

CONFLICTS OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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REFERENCES


