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EFFECT OF AUDIOVISUAL FOOT- ANKLE EXERCISE ON FOOT SENSATION AND LOWER EXTREMITIES CIRCULATION AMONG PATIENTS WITH DIABETES MELLITUS

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Abstract

Background: Diabetes related complications typically developed gradually, particularly when diabetes mellitus (DM) is poorly managed. Among these, diabetic foot problems represent a significant public health problem, that contribute to the global burden of disability and substantially reduce quality of foot health. Audiovisual foot and ankle exercise is a non-pharmacological therapy for patients with DM, had positive effects on foot health and overall mobility. Aim: To evaluate the effect of audiovisual foot- ankle exercise on foot sensation and lower extremities circulation among patients with diabetes mellitus. Design: A pretest-posttest, nonequivalent, control group quasi-experimental design. Sample: A purposive sample of 60 adult male and female patients with type 2 DM, were selected from 8/2023 to 2/2024 and divided into study and control groups. Setting: The study was conducted at medical outpatient clinics in National Institute of Diabetes and Endocrinology in Cairo, Egypt. Tools: Personal and Medical Background Information Form (PMBIF), 10-g Monofilament of Semmes-Weinstein (SWM) Test and Ankle Brachial Index Scale (ABI). Results: The mean age of the study and control groups were 47.13±10.29 and 51.77±8.07 years respectively. Females represented approximately three fourth in both groups. A statistically significant differences in foot sensation between the study and control groups in the post test (2) was found. Concerning ABI; there were statistically significant differences between the study and control groups in the post-test (1) and post-test (2). Conclusion: Performing audiovisual foot ankle exercise as a nonpharmacological therapy for patients with DM is effective to improve foot sensation and lower extremities circulation. Recommendation: Incorporating audiovisual foot ankle exercise into the routine care of patients with DM is recommended to support foot health and prevent complications.

Keywords: Diabetes Mellitus, Audiovisual Foot Ankle Exercise, Foot Sensation, ABI, Lower Extremities Circulation.

1. INTRODUCTION

Diabetes Mellitus is a chronic metabolic disorder, that affects carbohydrate, fat and protein metabolism, characterized by inappropriately elevated blood glucose levels, that results from insufficient insulin supply, or ineffective due to insulin resistance [1], [2]. Diabetes mellitus is a cause of morbidity mainly due to its complications that usually develop gradually and occur when diabetes is not properly managed [3]. Complications of diabetes are categorized into two main categories; macrovascular and microvascular complications. Macrovascular complications including coronary heart disease,

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cerebrovascular disease, and peripheral arterial disease, while microvascular complications mainly involve diabetic retinopathy, diabetic nephropathy, diabetic neuropathy and sexual dysfunction [4]. According to the International Working Group on the Diabetic Foot (IWGDF), neuropathy and/or peripheral arterial disease in the lower extremity are the main pathologies of serious foot problems in patient with diabetes mellitus [4],[5]. The main risk factors for foot problems in patients with DM include diabetic peripheral neuropathy (DPN), peripheral arterial disease (PAD) and foot deformities [6]. Pharmacological and nonpharmacological therapy are used concurrently in the management of patients with diabetes mellitus. Foot exercise is one of nonpharmacological therapies used to improve blood circulation in the legs, strengthen leg muscles, increase the neurological status of the legs and prevent further injuries to the feet [7]. In addition, foot exercise decreases blood sugar levels, specifically in actively moving muscles, can increase contraction so that, enhances the permeability of cell membranes so, decreases insulin resistance, and increases insulin sensitivity [8]. Audio visual foot ankle exercise is one of the educational media that can be used to increase patients' knowledge and self-care practice and also prevent foot complications [9]. Therefore, the aim of this study was to evaluate the effect of audiovisual foot- ankle exercise on foot sensation and lower extremities circulation among patients with diabetes mellitus.

2. SIGNIFICANCE OF THE STUDY

International Diabetes Federation (IDF), (2025) reported that about 588.7 million adults were living with diabetes in 2024. This number is expected to increase to 852.5 million by 2050. Additionally, International Diabetes Federation, (2021) mentioned that neuropathy as a complication of DM represent 19.9%, also peripheral artery disease constitutes 1.2% of complications of DM in Egypt. Egypt is ranked nineth among the countries most affected by diabetes worldwide. The total number of people living with diabetes in Egypt was 13.2 million in 2024. This number is projected to rise to 24.7 million by 2050. The rising prevalence of diabetes highlight the growing global health challenge as a stark reminder of the urgent need for comprehensive prevention and treatment efforts [10], [11].

Diabetes Mellitus related complications lead to developing of serious adverse health conditions that shorten the life expectancy, lower the quality of life and increase medical care costs. Arguably, the most disabling of these complications are the lower-extremity complications of peripheral neuropathy, peripheral arterial disease, impaired foot sensation and musculoskeletal function changes [12]. Audiovisual foot ankle exercise is a therapeutic practice performed for individuals with diabetes mellitus with the aim of reducing the risk of injury, improving blood circulation and foot sensitivity [8]. This study intends to provide new evidence-based on the clinical findings to support and add data for practice guidelines that might enhance nursing care outcomes of patients with diabetes mellitus. In addition, the researcher aspires that the expected findings of the current study will help in building up and provision of knowledge of nursing for the benefit of all concerned parties of patients, practicing nurses and nursing students as well. The findings of the study will generate motivation for further researches in this topic.

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3. METHODS

3.1 Aim

The current study was conducted to evaluate the effect of audiovisual foot- ankle exercise on foot sensation and lower extremities circulation among patients with diabetes mellitus; to achieve the aim of this study, the following research hypotheses were postulated to be tested:

H_1: The total posttest mean score of 10-g monofilament of Semmes-Weinstein of patients with type 2 diabetes mellitus who perform audiovisual foot ankle exercise will be statistically significant different from the total posttest mean score of 10-g monofilament of a control group who receive only routine hospital care.

H_2: The total posttest mean score of Ankle Brachial Index Scale (ABIs) of patients with type 2 diabetes mellitus who perform audiovisual foot ankle exercise will be statistically significant different from the total posttest mean score of ABIs of a control group who receive only routine hospital care.

3.2 Design

A pretest-posttest, nonequivalent, control group quasi-experimental design was utilized to achieve the aim of the current study.

3.3 Sample

A purposive sample of 60 male and female adult patients with type 2 DM who fulfill the eligibility criteria, were selected for a period of six consecutive months from 8/2023to 2/2024, it was divided into two equal groups (study and control groups, 30 patients/ each group).

The inclusion criteria include: patients with DM on regular treatment, had smart phone or someone around living with, have Ankle Brachial Index ABI score of 0.91 up to1.00, have independent walking ability, able to communicate, not experience diabetes foot complications and not receiving any exercise program. Patients who had renal failure, liver disease, cardio and peripheral vascular, neurological diseases, stroke, presence of an active foot ulcer, gangrene and history of amputation, vision problems without glasses, hearing loss, uncontrolled DM (Hypoglycemia below 80 mg/dl or hyperglycemia above 300 mg/dl), uncontrolled hypertension, extreme obesity (BMI ≥37.5 kg/m2) and severe lower limb edema were excluded from the study.

3.4 Setting

The study was conducted at National Institution of Diabetes and Endocrinology outpatient clinic, in one of the Hospitals in Cairo, Egypt.

3.5 Data Collection Tools

Three tools were utilized to collect data pertinent to this study namely: Personal and Medical Background Information Form (PMBIF), 10-g Monofilament of Semmes-Weinstein (SWM) Test and Ankle Brachial Index Scale (ABI).

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Tool I: Personal and Medical Background Information Form (PMBIF)

This tool was developed by the researcher; it consisted of two parts; the first part is personal background; it includes age, gender, educational level, employment status, marital status, and telephone number…. etc. while the second part is related to medical information including duration of diabetes, type of medication, smoking history, weight, height, body mass index (BMI), present, past and family history and previous exposure to any exercise program.

Tool II: 10-g Monofilament of Semmes-Weinstein (SWM)

Test used to examine the Merkel and Meissner receptor function and the relationship with the diameter of large nerve fibers and the associated guidelines for measuring sensation and pressure for each foot. It consists of a nylon filament mounted on a holder, calibrated to bend at 10 grams of force, which is generally perceptible in a foot with protective sensation.

The patients were blinded to the application, the10-gram monofilament wire will be applied to each foot at up to 10 sites, including the pulp of the first, third, and fifth digit, the planter aspect of the first, third and fifth metatarsophalangeal joints; the planter medial arch and the planter lateral midfoot; the plantar central heel and the dorsal first web space, the 10 g monofilament was gently pushed until it bends, then hold for 1-3 seconds for each site then was lifted from the skin. The sequence was applied randomly once at each of the testing sites on each foot it took about 30 seconds for each foot. Scoring; yes-no' method, meaning that the patient responds by yes, each time he/she feels the application of a monofilament. Each foot had a score of 0-10 corresponding to the number of sites at which patients perceived application of the SWM test .

Patients' responses were recorded on the screening form. The patient was recorded to have normal foot sensation, if detecting eight or more application of monofilaments and will be recorded to have abnormal foot sensation, if detecting seven or fewer application of the SWM test. Reliability score of 10-g monofilament was established at The Kappa coefficients range: 0.78-0.93 [13]. Cronbach's alpha reliability for the current tool in the study was established and indicated (0.89).

Tool III: Ankle Brachial Index Scale (ABI)

used to assess lower extremities circulation. The researcher using Ankle Brachial Index Scale, which was done by standard manual sphygmomanometer and standard hand-held Doppler, it took about 15-20 minutes [14].

The calculation of ABI was done using the following formula:

$$\text{Ankle brachial Index} = \frac{\text{Highest ankle pressure}}{\text{Highest brachial arm pressure}}$$

Scoring**;** Upon completing calculations, each reading was compared with the interpretations of ABI; value of reading was classified as follows: if ABI value ranged from 1.00 -1.40 it indicated normal extremity circulation, if ABI value ranged from 0.91- 0.99 it

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indicated borderline peripheral artery disease, while ABI value ≤ 0.90 it indicates abnormal extremity circulation (diagnosis of peripheral artery disease) according to the American Heart Association (AHA) guidelines issued at 2021[15]. Reliability score of ABI was established; a sensitivity of 88.89%, specificity of 99.32%, an accuracy of 99.01% [16], [17]. Cronbach's alpha reliability for the current tool in the study was established and indicated (0.85).

3.6 Procedure

Upon receiving the formal approval from Research Ethics Committee at Faculty of Nursing, Cairo University (June 2023), and the official permission from the hospital administrators, the study was conducted through four phases: preparatory, assessment, implementation, and evaluation.

Preparatory phase; it was concerned with the preparation of the audiovisual foot ankle exercise by the researcher; it was published originally in English then, translated into a simple Arabic language to be easily understandable by the patients, it was uploaded to the mobile of patients in the study group. Content validity of the study tools was established by a panel of experts in Medical Surgical Nursing field. The Ankle Brachial Index Scale was used to identify the eligible patients; potential patients who met the eligibility criteria and choose to participate in the study were individually interviewed to explain the aim, study nature and all ethical considerations, then written informed consent was obtained from each participant.

Assessment Phase; data collection started with control group who were receiving the routine hospital care that consists of routine follow up, monitoring blood sugar and foot assessment if there were any foot problems. Then, the data was collected from the study group; this sequence was carried out to prevent any potential cross-contamination between the two groups. Baseline data was established from the patients in both groups using Personal and Medical Data Form, 10-g Monofilament of Semmes-Weinstein Test and Ankle Brachial Index Scale which took approximately between thirty to thirty-five minutes per participant.

Implementation Phase; each patient in the study group received individualized instruction by the researcher regarding the Audiovisual Foot-Ankle Exercise until mastering of the exercise that was installed in the patients' smart phone or smart phone of the person living with. The researcher conducted a session for each patient including instruction that integrated simultaneously with practice as well as redemonstration by the patient. The session took approximately ten to fifteen minutes. The patient in the study group was instructed to repeat the proposed intervention at home at least three times/week for four weeks [18], [19], [20]. The researcher followed up the patients through the phone during the intervention period to provide clarification and ensure the participants' adherence.

Evaluation Phase; the researcher monitored the selected outcomes (foot sensation and lower extremities circulation) among both groups during the intervention period. The first post intervention assessment was conducted after four weeks to determine the value of

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the ABIS, 10g SWM test, based on a study conducted by [21], [22] where the scores of nerve conduction velocity improved after 4 weeks. The second post intervention assessment was carried out after eight weeks in the outpatient clinic to determine the final value of the dependent variables based on a study conducted by [23] regarding the nerve conduction; where the sensory nerve at eight weeks showed a significant difference for conduction velocity. To apply the principles of fairness and justice after finishing data collection from both groups, the participants of the control group received a copy of the audiovisual exercise steps.

3.7 Statistical Analysis

The collected data were processed and analyzed using statistical package for the social science (SPSS) program version 20 [24]

4. RESULTS

Study findings will be presented in four sections; **the first section** is directed to description of participants personal data, while **the second section** represented medical related data. **The third section** is devoted to presenting the research hypotheses testing results. **The fourth section** is devoted to correlations between selected variables among the studied patients.

4.1 Section I: Description of Participants

Table 1: Comparison of Personal Data among the Study and Control Groups (n=60).

Variable	Study group (n=30)		Control group (n=30)		X^2	P-(Value)
	No.	%	No.	%		
Age/ year						
20-	3	10	3	10	5.03	0.28
31-	9	30	8	26.7		
41-	8	26.7	9	30		
51-60	10	33.3	10	33.3		
Mean± SD	47.13±10.29		51.77±8.07			
Educational level						
Can't read and write	3	10	10	33.3	9.14	0.10
Can read and write	9	30	4	13.3		
Primary school	3	10	0	0		
Preparatory school	2	6.7	3	10		
Secondary school	11	36.7	10	33.3		
University graduated	2	6.7	3	10		
Marital status						
Single	2	6.7	1	3.3	6.0	0.31
Married	24	80	24	80		
Divorced	1	3.3	0	0		
Widow	2	6.6	5	16.7		
Separated	1	3.3	0	0		

** Significant at p≤ 0.05 at 2-tailed.*

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Table (1) revealed no statistically significant differences between the study and control groups regarding all personal characteristics (P ≥ 0.05).

80% of study and control groups were married with mean age of the study group was 47.13±10.29 years, while the mean age of the control group was 51.77±8.07 years. 36.7% of the study group and 33.3% of the control group had secondary education.

Figure (1) illustrates that 76.7% of the study group and 70% of the control group were females.

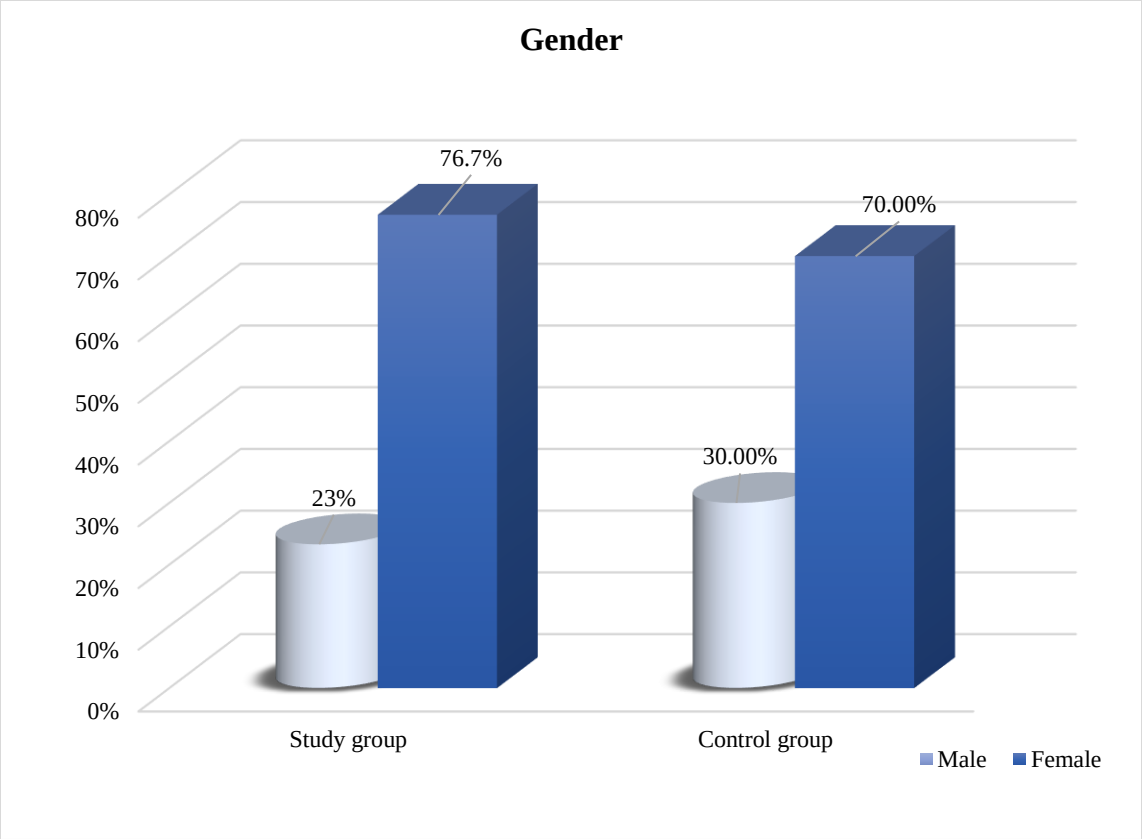

Figure 1: Percentage distribution of gender among study and control groups (n= 60)

4.2 Section II: Medical related data.

Table 2 shows no statistically significant differences between the two groups regarding all medical characteristics (P ≥ 0.05). 36.7% of study group and 40% of the control group experienced diabetes mellitus for more than or equal five years ago; as well 80% of the study group and 70% of control group had a family history of diabetes.

Among those with a family history, 83.3% of the study group and 71.4% of the control group reported that diabetes had been present in their family for five years or more.

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Table 2: Comparison of medical Data among the Study and Control Groups (n=60)

Variable	Study group (n=30)		Control group (n=30)		X^2	P-(Value)
	No.	%	No.	%		
Duration of DM:						
<1 year	9	30	8	26.7	2.50	0.48
1-<3 year	9	30	6	20		
3-<5 year	1	3.3	4	13.3		
≥5 year	11	36.7	12	40		
Family history of DM						
Yes	24	80	21	70	1.69	0.43
No	6	20	9	30		
Since when:						
<1year	0	0	0	0	7.35	0.03
1-<3 year	4	16.7	1	4.8		
3-<5 years	0	0	5	23.8		
≥5 years	20	83.3	15	71.4		
Last value of HbA1c	**Mean± SD 7.88±0.86**		**Mean± SD 8.04±1.36**		**T 9.14**	**0.10**
Last value of FBS	110.22±36.81		128.54±23.37			
Weight	82.97±10.11		82.27±19.13		0.18	0.31
Height	166.0±5.76		151.40±36.29		2.18	0.11

** Significant at p≤ 0.05 ** Highly Significant at p≤0.01 at 2 tailed.*

4.3 Section III: Test of Hypotheses

Table 3: Comparison of Mean Scores of foot sensation between Study and Control Groups (n = 60).

	Right foot sensation	Left foot sensation
	Mean± SD	**Mean± SD**
Pretest		
Study Group n=30	7.97±0.56	8.07±0.58
Control Group n=30	7.80±0.81	7.90±0.71
	t = 0.93 P =0.11	t = 0.99 P =0.15
Posttest (1) 4th week		
Study Group n=30	8.27±0.69	8.33±0.61
Control Group n=30	7.50±0.68	7.60±0.62
	t = 4.32 P= 0.88	t = 4.63 P =0.69
Posttest (2) 8th week		
Study Group n=30	8.63±0.56	8.67±0.61
Control Group n=30	7.37±0.72	7.47±0.63
	t = 7.64 P= 0.03*	t = 7.52 P =0.02*
F Repeated measures ANOVA	9.15 0.00**	7.56 0.00**

*Significant at the p≤ 0.05 probability level at 2 tailed.

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Table (3) highlights no statistically significant differences ($p > 0.05$) in foot sensation between the study and control groups in the pretest and posttest (1) while, there were statistically significant differences ($p \leq 0.05$) in foot sensation between the study and control groups in the post test (2). The ANOVA revealed significant overall effect ($p \leq 0.05$).

Table 4: Comparison of Mean Scores for the Ankle Brachial Index (ABI) Between Study and Control Groups (n = 60).

Assessment	Study Group n=30	Control Group n=30	t	P	F	Repeated measures ANOVA
	Mean ± SD	Mean ± SD				
Pre test	0.95±0.04	0.95±0.03	1.31	0.66	18.65	0.00**
Posttest (1) 4th week	0.97±0.04	0.93±0.03	3.71	0.02*		
Posttest (2) 8th week	1.02±0.06	0.93±0.03	7.51	0.00**		

*Significant at the p≤ 0.05 at 2 tailed. **Significant at the p≤ 0.00 at 2 tailed.

Table (4) shows that, there were no statistically significant differences ($p > 0.05$) in ABI between the study and control groups before intervention.

However, there were statistically significant differences ($p \leq 0.05$) between the study and control groups in the post-test (1) and post-test (2).

The ANOVA revealed significant overall effect ($p \leq 0.05$).

4.4 Section IV: Correlations between selected variables among the studied patients

Table 5: Correlation between total mean scores of foot sensation and Ankle-Brachial Index among Study and control groups (n=60)

Variable	Study group (n=30)											
	Pretest				Posttest (1) 4th week				Posttest (2) 8th week			
	Rt. foot		Lt. foot		Rt. foot		Lt. foot		Rt. foot		Lt. foot	
	r	P	r	p	r	p	r	P	r	p	r	p
Lt. foot sensation	0.64	0.00*			0.93	0.00*			0.75	0.00*		
ABI	0.31	0.09	0.41	0.03*	0.32	0.09	0.28	0.13	0.10	0.60	0.22	0.24
	control group (n=30)											
Lt. foot sensation	0.93	0.00*			0.89	0.00*			0.91	0.00*		
ABI	0.55	0.00*	0.45	0.01*	0.40	0.03*	0.25	0.19	0.36	0.05*	0.21	0.27

*Significant at the p≤ 0.05 at 2 tailed.

Table (5) concludes that there were significant statistical positive correlations between right and left foot sensation in pretest, posttest (1) and posttest (2) among both study and control groups. There was positive correlation between left foot sensation and ABI in pretest among study group and also between right foot sensation and ABI in pretest, posttest (1) and (2) among control group.

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5. DISCUSSION

The results of the current study illustrated that about two thirds of the study and control group ages ranged from 41-60 years, with the mean age of the study group was 47.13±10.29, while the mean age of the control group was 51.77±8.07 years. This pattern is consistent with previous literature indicating that T2DM is the most prevalent form of diabetes among adults, accounting for more than 90% of all cases [25], who indicated that the risk of developing T2DM increases significantly with age, particularly after the age of 35, largely due to factors such as increased insulin resistance and un controlled blood glucose level. Several large-scale studies have shown similar age trends; for instance, [26] reported that an average age of diagnosis with T2DM is 45 years in a sample of nearly 24,000 individuals.

The findings of this study are supported by previous research study by Graciella and Prabawati (2020) who used quasi-experimental with pre and post-test non-control group design, which has found that more than two thirds of the study sample age ranged from 46-55 years [27]. Another study conducted by Suza, Hijriana, Ariani and Hariati (2020) in their study about the effect of lower extremity exercises on ankle brachial index values among type 2 diabetes mellitus patients, mentioned that more than one third of the study sample age ranged between 46-65 years old [22]. In addition, a study carried out by Ramadhan, Hadisaputro and Rumahorbo (2020) titled "Combination of diabetic foot exercise and foot massage on ankle brachial index on patients with type 2 diabetes mellitus" found that the mean age of study sample was 57.86± 4.859 years old for the study group and 57.93± 4.365 years old for the control group [28]. Similarily, a study titled " the influence of diabetic foot exercises on the risk of diabetic ulcers in patients with diabetes mellitus" conducted by Purwaningsih, Wiratmoko and Suwanto (2024) reported that more about two thirds of the study subjects aged 50-60 years [6].

Concerning gender, the current study revealed that more than two thirds of the study and control groups were females. This result aligns with existing literature indicating that, although the prevalence of type 2 diabetes mellitus (T2DM) is rising in both sexes, sex-specific differences in risk profiles and disease presentation are evident; men tend to be diagnosed earlier and often with lower body fat mass, while women, on the other hand, usually carry more risk factors of T2DM as a result of obesity.

There's also growing evidence that psychosocial stress may increase the risk of developing T2DM in women. Over their lifetime, women go through more hormonal changes and physical shifts due to pregnancy and menopause. Pregnancy, in particular, can sometimes reveal underlying metabolic issues, and developing gestational diabetes is one of the strongest indicators that a woman may develop T2DM later in life [29].

The finding was consistent with the results reported by Graciella and Prabawati (2020) who concluded that more than half of the study sample were females [27]. In addition, Faizah, Efendi and Suprajitno (2021) in their study titled "The effects of foot exercise with audiovisual and group support foot exercises to diabetes mellitus patients" where the majority of the study sample were females [7]; moreover, Asih and Widiastuti (2024) in

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their study "The effect of active range of motion exercise on foot sensitivity in type II diabetes mellitus patients" found that more than half of the study subjects were females. This similarity further supports the observation that women are more frequently represented in diabetes-related research populations [30].

Regarding the educational level, the current study showed that more than one third of the study and control groups had secondary education, this could be related to their residency in rural areas as broader national patterns in Egypt, where rural areas have lower literacy and educational completion rates compared to urban areas. As reflected in an Egyptian study conducted by Salama, Fouad and Ibrahim (2021) titled "Self-management education program and metabolic indicators in type 2 diabetes at Zagazig University hospital, Egypt" which revealed that approximately half of study sample reaching secondary school [31]. Another Egyptian study by Azzam, Ibrahim and Abd El-Ghany (2021) titled " Factors affecting glycemic control among Egyptian people with diabetes attending primary health care facilities in Mansoura District" mentioned that more than one third of the study subjects had completed secondary education [32].

These findings were relatively congruent with Silva et al. (2023) who conducted a study about effects of a home-based foot–ankle exercise program with educational booklet for foot dysfunctions in people with diabetic neuropathy; the authors reported that the largest proportion of the study subjects had secondary school [33].

However, these findings didn’t agree with Asih and Widiastuti (2024) who reported that the majority of the study subjects had elementary (primary) education [30] and Purwaningsih et al. (2024) who reported that the major percentage of the study subjects had primary school [6].

As regards to marital status, the majority of the study and control groups were married and their age was more than 50 years in which they are expected to be married. This finding is congruent with previous studies conducted in Egypt by Salama et al. (2021) who reported that the majority of the study subjects were married [31]. In addition, Azzam et al. (2021) mentioned that more than two thirds of the study were married [32].

Regarding the medical data, more than one third of the study and control groups were living with diabetes mellitus for five years or more.

It could be due to the duration of diabetes is a key factor influencing the development of complications, particularly foot problems where prolonged exposure to hyper glycemia leads to microvascular and macrovascular damage, neuropathy and impaired wound healing [34], [10].

This finding aligns with the study conducted by Sukartini, Panji Asmoro and Nandani Alifah (2019) in a study about the influence of diabetic foot exercise in sensory peripheral neuropathy with monofilament test on diabetes mellitus, clients were documented that about one third of the treatment group had been living with diabetes mellitus for five to ten years and about near to half of the control group had been living with diabetes mellitus for more than ten years [19]. Also, Ramadhan et al. (2020) revealed that the majority of

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the study subjects had been living with diabetes mellitus for five to ten years [28]. Another study by Budi (2023) titled " Effect of foot exercises on index brachial ankle values in patients with diabetes mellitus" reported that near half of the study subjects had been living with diabetes mellitus for five to ten years [35].

The findings of the present study also revealed that the majority of study and control groups had family history of diabetes and also, experienced diabetes mellitus for more than or equal five years ago. This might be explained by the fact that family history is a strong risk factor for type 2 diabetes, it could reflect the shared genetic predispositions as well as the common environmental and behavioral factors, such as physical inactivity, unhealthy diet, alcohol and tobacco use, and socioeconomic status including education level, employment, and household income [36]. On the other hand, some researchers had reported 40–80 percent reduced risk of type 2 diabetes associated with family history, probably due to increased perceived risk and motivation to change lifestyles for mitigating risk [37]. This finding is congruent with Suza et al. (2020) study that reported more than two thirds of the study subjects had family history of diabetes [22].

In the current study, it was observed that there were no statistically significant differences among the study and control groups regarding lab investigations, weight, height and body mass index. These finding are consistent with Embuai et al. (2019) in a study titled "Effect of foot exercise and care on peripheral vascular status in patients with diabetes mellitus" mentioned that there was no statistically significant difference among the study and control groups regarding HbA1C [18].

The results were similar to a study conducted by Heidari, Zolaktaf, Ghasemi and Nejadian (2021) titled " Integrated exercise and glycemic and peripheral sensation control in diabetic neuropathy: A single-blind, randomized controlled trial" who found that there were no statistically significant differences among the study and control groups regarding weight, height and body mass index [38]. Furthermore, Nayak, Ray, Anand, Baruah and Goyal (2024) in their study about protocolized foot exercises help in improvement of diabetic foot ulcers and quality of life when added to standard therapy, they reported that there were no statistically significant differences among the study and control groups regarding HbA1C, fasting blood sugar and body mass index [39].

The first hypothesis of the current study stated that the total posttest mean score of 10-g monofilament of Semmes-Weinstein of patients with type 2 diabetes mellitus who perform audiovisual foot ankle exercise will be statistically significant different from the total posttest mean score of 10-g monofilament of a control group who receive routine hospital care. The findings of the current study revealed that there were no statistically significant differences in foot sensation between the study and control groups in pretest, posttest (1) while, there were statistically significant differences in foot sensation between the study and control groups in the post test (2), this could be interpreted in the light of neurological recovery particularly in chronic conditions.

Although, diabetic neuropathy is gradual, sensory interventions and neural rehabilitation often require time to induce changes in neural pathways and sensory processing, so

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immediate effects may not be apparent, but with consistent target intervention, the nervous system demonstrate an ability to adapt, leading to gradual but measurable enhancement in sensory function and improvements in foot sensation over time [9]. This adaptive capacity is supported by evidence suggesting that sustained practice carried out over a sufficient period, typically eight weeks or more allows for accumulated neural adaptation, potentially contribute to structural and functional improvements in peripheral nerve pathways. This is supported by findings from a systematic review and meta-analysis, which indicated that foot-ankle exercise programs of 8–12 weeks duration may result in improvements in neuropathy signs and symptoms [40].

This result is congruent with the findings of Asih and Widiastuti (2024) who observed significant improvement in foot sensation among study group in posttest [30]. Furthermore, Faizah et al. (2021) reported statistically significant differences in foot sensation between posttest (1) and posttest (2) [7]. Similarly, Sukartini et al. (2019) found that there were statistically significant differences in foot sensation in posttest among the study group [19]. Moreover, the result is in the same line with Embuai et al. (2019) who found statistically significant differences in foot sensation in the posttest among study group [17]. By contrast, this finding didn't agree with Heidari et al. (2021) who mentioned that about one third only of the study group have improvement in foot sensation [38].

The second hypothesis of the study mentioned that the total posttest mean score of Ankle Brachial Index Scale (ABIs) of patients with type 2 diabetes mellitus who perform audiovisual foot ankle exercise will be statistically significant different from the total posttest mean score of ABIs of a control group. The results of the current study, showed no statistically significant differences ($p < 0.05$) in ABI between the study and control groups in the pretest. However, there were statistically significant differences ($p \leq 0.05$) between the study and control groups in the post-test (1) and post-test (2). This might be due to the regular foot-ankle exercises that enhance blood circulation in the lower extremities leading to increasing blood flow, reduced peripheral vascular resistance and improve endothelial function, all of which contribute to better vascular health, which is crucial for tissue health and the prevention of complications as evidenced by improvement in ABI score, which is a critical indicator of peripheral arterial health [12].

This finding is consistent with Suza et al. (2020) who reported that there were statistically significant differences between the two intervention groups in post-test (1) [22]. Similarly, Ramadhan et al. (2020) reported statistically significant differences between the study and control groups in post-test (1) and post-test (2) [28]. In the same line, Faizah et al. (2021) found statistically significant differences between the three intervention groups in posttest (1) and post-test (2) [7]. In addition, Jatmiko (2024) in research about the application of foot exercise increases ankle brachial values index (ABI) in Type 2 diabetes mellitus patients noticed that there was improvement in ABI results after performing foot ankle exercise in both feet [41]. Moreover, Setyowati, Pratiwi, Amalia and Hedianto (2024) in a study titled "The effect of diabetic foot exercises on Ankle Brachial Index (ABI) values in patients with diabetes mellitus Type II" mentioned that there were statistically significant differences in posttest suggesting improved peripheral circulation [42].

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Correlations Between Selected Variables Among the Studied Patients

According to study findings there were significant statistical positive correlations in both study and control groups between right and left foot sensation in pretest, posttest (1) and posttest (2), this result reflected that peripheral neuropathy in patients with diabetes typically presents symmetrically, affecting both feet leading to bilateral loss of protective sensation. After bilateral foot ankle exercise; sensory improvements happened, so comparable sensory effects in both feet, assuming symmetry of such effect occurred [43].

In respect to the relationship between foot sensation and ABI, there was positive correlation between ABI and left foot sensation among study group at pretest and between right foot sensation and ABI in pretest, posttest (1) and (2) among control group. The researcher viewed that the positive correlation between ABI and left foot sensation in the study group at pretest suggests that adequate peripheral perfusion is associated with better sensory nerve function prior to intervention. In contrast, the lack of continued correlation in the study group after the exercise intervention may suggest that therapeutic foot–ankle exercises contributed to sensory improvements independent of vascular status, potentially through enhanced neuromuscular activation, proprioceptive training, or neuroplasticity.

This could explain the diminished correlation post-intervention, as sensory gains may have been driven by mechanisms beyond perfusion alone [44]. In the control group, a consistent positive correlation across pretest, posttest 1, and posttest 2 may indicate a stable vascular-sensory relationship over time in the absence of intervention. These results of pretest are congruent with Kristianto et al. (2023) in a study investigating the correlation of leg pain responses with ankle-brachial index and peripheral sensory responses in foot of type 2 diabetes mellitus who found that there was significant relationship between ABI and foot sensation [45].

6. CONCLUSION

Patients with type 2 diabetes mellitus who performed the audiovisual foot ankle exercise had different posttest total mean score of 10-g monofilament of Semmes-Weinstein and different posttest total mean score of Ankle Brachial Index Scale (ABIs).

The study findings documented that using the audiovisual foot ankle exercise among patients with type 2 DM improve foot sensation and lower extremities circulation. Integrating audiovisual foot ankle exercise as a nonpharmacological therapy for patients with type 2 DM is effective for those patients to improve their foot health status.

6.1 Recommendation and Implications

Based on the study findings, the researcher recommends the following:

Replication of the study on larger probability sample selected from different geographical areas in Egypt to obtain more generalizable data. Incorporating audiovisual foot ankle exercise into the routine care of patients with DM to support foot health and prevent lower extremity complications.

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7. DECLARATIONS

7.1 Ethical Considerations

This study was part of Doctoral thesis, formal approval was granted from the Ethical Committee of Scientific Research at Faculty of Nursing, Cairo- University. Also, an official permission to conduct the study was obtained from the hospital administrators. Participation in the study is entirely voluntary and based on the participants' agreement and they have the right to withdraw at any point without penalty.

7.2 Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

7.3 Competing Interests

The authors declare that they have no competing interests.

7.4 Funding

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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