EFFECTS OF A 12-WEEK STRENGTH TRAINING ON HAND FUNCTION OF TYPE II DIABETES MELLITUS PATIENTS

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Abstract

Study aim: The purpose of this study was to establish the effects of a 12-week strength training (ST) programme on hand function in type 2 diabetes mellitus (T2DM) patients in a tertiary health institution in Benin-City. The findings of this study would help clinicians/clinical staff to take ST into consideration in the management of patients with T2DM thereby enhancing clinical outcome. Material and methods: This study was a pre-test, post-test control group design. A total of 36 T2DM patients participated in the study. Handgrip and pinch strength were measured using electronic hand dynamometer (in kg) and mechanical pinch gauge (in kg) respectively prior to and following a 12-week ST programme. The amount of handgrip and pinch strength of both hands generated by each participant was used as a quantitative measurement of the development of hand function. Data generated were analyzed using inferential statistics of one way analysis of variance (ANOVA) and the statistical significance was accepted for p value of <0.05. Results: The findings of the study showed that ST programme had significant effects on hand function of T2DM patients. Conclusion: It was concluded that ST programme can substantially enhance hand function of patients with T2DM. Therefore, ST programme should be considered a key element in the management of T2DM patients.

Keywords: Strength training, hand function and type 2 diabetes mellitus

Introduction

Strength training (ST), also known as weight training or resistance training has gained popularity in recent years, largely due to its appeal and positive impact on many diverse populations, such as athletic, recreational and clinical communities. ST programmes are

used to achieve many different goals, such as enhancement of athletic performance, reduction of the risk or rehabilitation of injury and improvement of muscular tone, size, strength and endurance. Thus, ST increases the concentration of various hormones and growth-promoting agents in the body that may contribute to these improved muscular strength and size (American College of Sport Medicine position stand, 2009).

A popular cliché says "it takes a village to raise a child, but it takes 19 bones and 19 joints in the hand for it to function smoothly". The hand of human is the effector organ of the upper limb as it is capable of performing countless actions including prehension, precision, adaptation, exploration, perception, and manipulation. The hand is not only a motor organ but also a very sensitive and accurate sensory receptor, which feeds back information essential for its own performance. The hand is greatly affected by diabetic musculoskeletal and neuropathy complications. Adequate muscle power is required for optimum productivity while decreased muscle strength is a predictor of physical limitations (Magee, 2002). Patients with T2DM have been reported to be more disabled in self-care tasks and other daily living activities than non-diabetic subjects because of many hand complications (Bardan & Lather, 2012). Savas, Koroglu, Koyuncuoglu, Uzar, Celik, and Tamer (2007) demonstrated that reduced grip and pinch strength was related to disability of the hands and suggested that negative influence of diabetes on muscle quality could contribute to poor muscle function and hand weakness. This is because grip and pinch strength testing are commonly used to evaluate hand function for disability ratings and to assess responses to various forms of therapy. It was stated by Jacquemin, Burns, and Little (2004) that weakness of hand muscles is a symptom of large number of pathologies which could result in loss of hand function.

Moreover, muscular weakness as a result of diabetic neuropathy, obesity or chronicity of diabetes have been identify as the causes of limited hand function (Redmond, Bain, Laslet, & Mcneil, 2009). Conjointly with the brain, the hand is the most important organ for accomplishing tasks of adaptation, exploration, prehension, precision, perception, and manipulation, unique to humans (Chao, An, Conney, & Linscheid, 1989). According to Ruprai, Tajpuriya, and Mishra (2015), grip strength and pinch powers are good predictors of total muscular strength and endurance and are important parameters of hand function. The grip and pinch strength measurements are commonly used to evaluate the integrated performances of hand muscles by determining maximal grip and pinch forces that could be produced in one muscular contraction. Grip and pinch strength measurements are therefore reflections of precision-handling and are frequently used for quantitative assessment of hand function. Hand strength can be used to determine a treatment, assess nutrition, assess risk of mortality in people with acute or chronic illnesses, as a prognostic factor, and as a marker for general muscle strength (Smith, Martin, Henry, Weeks, & Bryant, 2006). Substantial evidence has pointed to the obvious effects of ST on handgrip strength in T2DM patients with little evidence of such on hand function. To this end, this study was initiated to establish the effects of ST programme on hand function in T2DM patients.

Research hypothesis

There is no significant difference in the hand function of T2DM patients prior to and following a12-week ST programme.

Material and methods

Research design

This study was a pre-test, post-test control group experimental design of the effects of a 12-week ST programme on hand function in T2DM patients.

Population

The population of this study included fifty four (54) T2DM patients between the biological ages of 51 to 73 years who were receiving treatment at the Endocrinology Unit of Internal Medicine Department, University of Benin Teaching Hospital, Benin-City, Nigeria.

Sample size and sampling technique

A total of thirty six (36) patients with T2DM in the above mentioned hospital participated in this study. They were recruited using the simple random sampling technique. Balloting without replacement was used to select two-third (2/3) of the population for the study. The names of the patients were written on pieces of paper each and these pieces of paper were put in a bag from where one piece of paper was picked at a time and the name on the piece of paper picked was recorded. This process was repeated until the desired sample size was obtained. Thereafter, the recorded names were also assigned randomly into two (2) groups (experimental and control groups). Eighteen (18) participants were assigned to experimental group and the other eighteen (18) to control group using the same process. The first name picked was assigned to experimental group and the second name to control group, the procedure was continued till the last name in the bag was picked.

Data collection instruments

The research instrument for this study was an adaptation of Sharkely (1990) experimental protocols. The protocol is illustrated as follow:

Table 1: Strength training programme

Exercises	Set, Repetition, Rest between sets
Bench press	2*, 8 (70% 1RM), 3 minutes
Military press	2*, 8 (70% 1RM), 3 minutes
Arm curl	2*, 8 (70% 1RM), 3 minutes
Latissimus pull	2*, 8 (70% 1RM), 3 minutes

The following are the test equipment that was used to measure the hand function.

Electronic hand dynamometer

Hand grip strength of both hands was measured using a Camry Electronic Hand Dynamometer (Model: EH101). It comes with dual scale readout of forces in kilograms and pounds and however, all readings were recorded in kilograms in the present study.

Mechanical pinch gauge

Mechanical pinch gauge was used to measure the three basic pinch tests of both hands including key pinch (lateral pinch) - thumb pad to lateral aspect of middle phalanx of index finger, palmer pinch (chuck pinch) - thumb pad to pads of the index and middle fingers, and tip pinch (thumb-index pulp pinch) - thumb tip to index fingertip. It is calibrated in pounds and kilograms of force and all readings were equally recorded in kilograms in the present study.

Validity of the instrument

The test instrument was an adaptation of Sharkely (1990) experimentation. However, the test instrument was certified by experts in exercise physiology and physiotherapy as appropriate for the study. The validation was effected at the Outpatients Unit of Physiotherapy Department, University of Benin Teaching Hospital, Benin-City. The following variables were measured: the handgrip and pinch strength as well as hand function of T2DM patients. It was observed that the use of the facility and procedure were feasible for the conduct of the study. This department was equally served as the project site.

Reliability of the instrument

A pilot study was conducted to establish the suitability of using the instrument for T2DM to which eight (8) T2DM patients, four (4) per group were used. The split-half method of reliability was used in obtaining the data that were subjected to Pearson Product Coefficient of Correlation. A Coefficient of 0.79 was obtained and it was considered high reliability and therefore justified the suitability and relevance of using the instrument and protocol for the study.

Method of Data Collection

The study received ethical approval from the Research Ethics Committee of the hospital to conduct this study. All the participants were recruited consecutively through their hospital files at the Endocrinology Unit of Internal Medicine Department, University of Benin Teaching Hospital, Benin-City.

ST programme protocol

Prior to ST programme, a detailed explanation of the test, training programme and the objectives of the study was provided for the participants and then the participants signed a participant's informed consent form before participating in this study and thereafter, the participants were randomly assigned to experimental and control groups. The hand function of both groups were measured before the training and then the participants were subjected to a 12-week ST programme of a frequency of 3 times per week (Monday, Wednesday, and Friday) with each session lasted for 50 minutes at 70% one-repetition maximum (70% 1RM) consisted of two sets of 8 repetitions for each muscle group with 3 minutes rest between sets. Periodization of the training was based on the recommendation of progressive ST for adults and T2DM (American College of Sports Medicine position stand, 2009). In this way, the protocol consisted of a weekly alteration of the intensity divided into a week of moderate overload (70% of 1RM, 8 repetitions). The ST programme was purely on upper limbs muscle strengthening that was aimed at improving hand function of the participants. The training programme included bench press, military press, arm curl and latissimus pull, which were performed on a multi weight-lifting machine. Thereafter, hand function of the participants was equally measured after the training.

Grip strength measurement

To standardize the measurement, the following guidelines were established; the arm positioning followed the American Society of Hand Therapists guidelines (Fess, 1992), with the subject comfortably seated with the shoulder slightly forward and the elbow flexed at a 90° angle, with the forearm and wrist in a neutral position. A demonstration of how to use the device was first given to each participant by the researcher, to familiarize the participant with the use of the apparatus and to eliminate the element of fear. Alternately, three maximum power gripping efforts were made by each hand of the participant, with three-second contractions and ten-second rest periods between the attempts and only the best of the three attempts was recorded. Motivation, such as verbal encouragement and competition between group members was used maximally. No assistance of the hand under test was allowed, but facial grimaces and associated movements of the other hand were not discouraged. The device was adjusted for different hand sizes and preferences by adjusting the centre knob and its calibration was also assessed periodically throughout the study.

Pinch strength measurements

The following guidelines were followed in the measurements of pinch strength; the gauge was "zeroed" before each pinch test by rotating the small curled knob on top of the dial indicator in a counterclockwise direction until it rests against the black pointer at the zero marking. As in grip strength measurement, test instructions and motivation were equally provided.

- *Key pinch (lateral pinch)*

The participant comfortably seated or upright, test arm at the side with elbow flexed 90°, palm facing inward, pinch gauge between flexed PIP joint of index finger and thumb, the researcher stood in front of the participant to the side stabilizing the pinch gauge and then had the participant to squeeze, hold, and release the pinch gauge (i.e. participant applied pinch force at the pinch groove while holding the pinch gauge between his/her thumb and index fingers). Here, as muscle fatigue begins with the first concentrated effort, a single maximum effort only was recorded.

- *Palmer pinch (chuck pinch)*

The participant comfortably seated or upright, test arm at the side with elbow flexed 90°, palm facing downward, pinch gauge between thumb and the index and middle fingers, the researcher's position and duty were the same as in key pinch measurement and also a single maximum effort was recorded.

- *Tip pinch (thumb-index pulp pinch)*

Here, the measurement protocol is the same as in palmer pinch (chuck pinch) except that the pinch gauge was between thumb and test finger without interference of other fingers.

Measurement of hand function

The present study made use of handgrip strength, key pinch strength, palmer pinch strength and tip pinch strength as a general quantitative measurement of hand function extrapolating the works of Weiss and Flatt (1971) and Dickson and Calnan (1972). Therefore, the amount of grip and pinch strength generated by each participant was added and was used as a quantitative measurement of the development of hand function. Similarly, grip and pinch strength testing are commonly used together to evaluate hand function for disability ratings and to assess responses to various forms of therapy. This is because they assess both intrinsic and extrinsic hand muscles (Savas et al., 2007).

Method of Data Analysis

An inferential statistics of one-way analysis of variance (ANOVA) was used to test the hypothesis. Then, Turkey's honesty significant difference post-hoc test was used to identify the source of the difference between the groups. Statistical significance was accepted for p value of <0.05.

Results

The results are presented in Table 2 and 3.

Table 2: Analysis of Variance (ANOVA) Showing Difference in the Hand Function of the Participants.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	580.593	3	193.531	7.114	.000
Within Groups	1849.900	68	27.204		
Total	2430.493	71			

Df-degree of freedom, F-test is a ratio of sample variance, Sig.-the two-tailed p-value associated with the null that the groups have the same variance.

The one-way analysis of variance (ANOVA) conducted to determine the significance of the difference in the hand function prior to and following a 12-week ST programme is presented in the Table 2 above. The F-value of 7.114 with 3 and 71 degree of freedom was observed to be statistically significant at 0.05 (p<0.05). Thus, the hypothesis which states that there is no significant difference in the hand function of T2DM patients prior to and following a12-week ST programme was rejected. This implies that the ST programme had substantial effect on the hand function of the participants. However, this difference necessitated the conduct of post-hoc test to identify where the difference lies.

Table 3: Turkey's Honesty Significant Difference Post Hoc Test Showing Difference in the Hand Function of the Participants

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Pre-exp	Post-exp	-7.20000*	1.73859	.001
	Pre-control	-1.05556	1.73859	.929
	Post-control	-1.11111	1.73859	.919
Post-exp	Pre-exp	7.20000*	1.73859	.001
	Pre-control	6.14444*	1.73859	.004
	Post-control	6.08889*	1.73859	.004
Pre-control	Pre-exp	1.05556	1.73859	.929
	Post-exp	-6.14444*	1.73859	.004
	Post-control	-.05556	1.73859	1.000
Post-control	Pre-exp	1.11111	1.73859	.919
	Post-exp	-6.08889*	1.73859	.004
	Pre-control	.05556	1.73859	1.000

From the Table 3, Turkey's honesty significant difference test was conducted to determine the difference in variation in the hand function of the participants. Statistically significant differences were found in all the pair wise of mean difference except pre-exp versus pre-control (-1.05556), pre-exp versus post control (-1.11111), pre-control versus pre-exp (1.05556), pre-control versus post-control (-.05556), post-control versus pre-exp (1.11111) and post-control versus pre-control (.05556). This indicates that the entire pair wise mean had variable and thus, the training influenced the variation in the hand function of the participants.

Discussion of findings

This study showed that the ST programme administered had substantial effect on the participants' hand function. Previous studies have reported similar findings that ST programme had marked effects on hand function in individuals with T2DM (Sheri, Ronald, Bo, Judith, Bryan, Richard, & Barry, 2010; Komal & Suvarna, 2015). This is in contrast to the studies of Ozdirenc, Biberoglu, and Ozcan (2003) and, Cetinus, Buyukbese, Uzel, Ekerbicer and Karaoguz (2005) who reported insignificant improvement in hand function of T2DM patients following few weeks of ST programme. This contrasting finding might be as a result of variation in study methodology including subject characteristics or differences in measuring instruments of hand function. It could also be as a result of differences in the gradients or clinical characteristics of T2DM morbidity.

However, the significant improvement in hand function observed in this study can be viewed in two different perspectives. Firstly, the increase in handgrip strength as the root of initial episode of better hand function because the grip strength reflects the strength generated by the contraction of the various arm and hand muscles involved in the proper functioning of the hand. This is because there is a consensus that handgrip strength is a determinant of hand function and is commonly used to evaluate functional limitation of the hand (Ruprai et al., 2015; Smith et al., 2006). Secondly, the positive impact of ST programme on both the intrinsic and extrinsic muscles of the hand and forearm which enhance both grip and pinch strength and thus, enable the hand to function smoothly could also explain the better hand function observed in this study. This claim is in line with the study of Santos, Montrezol, Pauli, Sartori-Cintra, Colantonio, Gomes … and Pauli (2014).

Conclusion

Based on the effects of a 12-week ST programme on hand function of T2DM Patients in a Tertiary Health Institution in Benin-City, it was concluded that ST programme can substantially improve hand function of patients with T2DM. Therefore, ST programme is a good training modality for improving hand function of patients with T2DM.

Based on the findings, the following recommendations were made:

1. ST programme should be considered a key element in the management of T2DM.
2. Hand function measures should be introduced into clinical practice.
3. Clinicians/clinical staff should be trained in using and interpreting the hand function measures.

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