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EFFECTS OF PLYOMETRIC EXERCISE ON CONCOMITANTS OF FITNESS AND METABOLIC PROFILE IN TYPE 2 DIABETES PATIENTS

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ABSTRACT

Background: The prevalence of type 2 diabetes mellitus has been on the increase both in high and medium/low income countries. This increase is associated with health and economic consequences, especially in low sub-Saharan Africa that is resource stricken. Availability of affordable and easy to implement treatment intervention will surely reduce these health and economic sequealae of type 2 diabetes mellitus. This study was carried out to investigate the effects of plyometric exercise on concomitants of fitness and metabolic profile in type 2 diabetes patients.

Methods: Simple random sampling technique was employed to recruit participants (n=27) for this study after meeting the inclusion criteria. Physical and physiological measurements were taken from the participants before and after six weeks of plyometric exercise for the experimental group and the control who did not participate in plyometric exercise.

Results: A total number of twenty seven (control= 13) participated in the study and there are not significant differences in the physical and physiological parameters of the two groups. There are significant differences in the physiological parameter after six (6) weeks of plyometric exercise among the experimental groups while there are no significant differences among the control group. The eta squared statistics of few parameters show that the effect sizes range between medium and large association.

Conclusion: It is concluded that among the concomitants of fitness, plyometric exercise is effective only in improving muscle fitness and body composition.

Keywords: Plyometric, exercise, diabetes mellitus, strength

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INTRODUCTION

Type 2 diabetes is one of the fastest growing public health problems in both developed and developing countries [1]. It accounts for approximately 90% of diabetes cases worldwide and is associated with a large economic burden and premature mortality [2]. It is estimated that the number of people with diabetes in the world will double in coming years, from 171 million in 2000 to 366 million in 2030 [1]. According to the International Diabetes Federation (IDF) over 5 million people suffer from diabetes mellitus in Africa and the number is expected to increase to 15 million by 2025 [3]. The estimated prevalence of diabetes mellitus in Africa is 1% in rural areas, up to 7% in urban sub-Sahara Africa, and between 8-13% in more developed areas such as South Africa and in population of Indian origin [4]. The prevalence in Nigeria has been reported to vary from 0.65% in rural Mangu (North) to 11% in urban Lagos (West) and data from the World Health Organization (WHO) suggests that Nigeria has the greatest number of people living with diabetes mellitus in Africa [5,6].

Type 2 diabetes is considered a late-onset chronic disease as a result of tissue resistance to insulin. However, it was observed that individuals with lower levels of physical fitness have high levels of insulin resistance as well as fewer glucose transporters [7,8]. Insulin resistance syndrome continues to gain support as an important risk factor for premature coronary artery disease, hyperinsulinemia, central obesity and overlap of metabolic abnormalities such as hypertriglyceridemia and low level of high density lipoprotein, altered low density lipoprotein, and elevated free fatty acids [8]. Therefore, regular physical activity should be integrated to promote good metabolic fitness, a state associated with reduced risk for many chronic diseases [9].

Several measures have been directed towards the management of type 2 diabetes mellitus. These include dietary adjustment, drug therapy as well as exercise therapy [10]. Exercise has been found to improve insulin sensitivity, glucose concentration and also improve concomitants of physical fitness among individuals with type 2 diabetes mellitus [11,12]. Circuit training, aerobic exercises and progressive resistance training have been shown to improve physical fitness among normal individuals and diabetes patients [13,14,15].

Plyometric exercises are designed to be more similar in form of sport specific skills and involve light resistance to allow for explosive speed, thus can do much for improving sport specific speed and power [16]. These exercises promote muscle recruitment, improve muscle strength, and increase muscle endurance, enhances posture and balance, weight loss and decrease the risk of injuries [16]. Previous studies have used plyometric training in improving physical fitness among in apparently healthy individuals and athletes but its effect is yet to be determined among Type 2 diabetes patients [17,18,19]. This study was carried out to investigate on the effects of plyometric exercise on concomitants of fitness and metabolic profile in type 2 diabetes patients.

MATERIALS AND METHODS

The study population was Nigerian adults with Type II diabetes mellitus who were attending Aminu Kano teaching Hospital for their management. The participants were randomly assigned into experimental and control groups after meeting the inclusion criteria. Simple random sampling technique was used to recruit 27 subjects for this study into experimental and control groups by balloting.

Inclusion criteria were Type 2 DM for a minimum duration of six months, age between 30 - 60 years, stable cardiovascular status/fitness as carefully selected by the Consultant Physician/Endocrinologist and informed consent to participate while exclusion criteria were other classes of DM (except type 2 DM), changes during the previous 2 months in oral hypoglycemic, antihypertensive, or body weight (5%), established renal disease as identified by the Consultant Physician/Endocrinologist, limitation in physical activity/activity of daily living because of disease, presence of co-morbidities that make participation inadvisable such as cardiovascular disease, significant peripheral neuropathy and diabetes mellitus foot syndrome, amputation, musculoskeletal disorders and arthritis and decline of consent.

Measurements

Blood pressure, body composition, muscle power, muscle endurance, muscle strength, muscle flexibility of the participants were measured using standardized methods and techniques [20,21]. Also, fasting blood sugar (FBS) and random blood sugar (RBS) of all participants were measured with a glucometer. The blood lipids (triglyceride [TG], total cholesterol [TC], high density lipoprotein [HDL], and low density lipoprotein [LDL] of all participants were determined in the laboratory of the Aminu Kano Teaching Hospital (AKTH), Kano, Nigeria.

Training Procedure

Participants in the exercise group trained for 30 minutes, 2 times per week on non-consecutive days for six weeks. Prior to the commencement of the training, there was one session of demonstration of the various exercises and each subject was made to practice the exercises.

Warm-up: This was done prior to the main exercise so as to prepare the cardiovascular system and the body for plyometric training and to reduce the risk of injury during the exercise. Subjects performed 5minutes of cycling on a bicycle ergo meter. Then 2 minutes of stretching (dynamic) e.g. striding was performed by each participant after the cycling as it is easier to stretch a muscle when it is warm. Subjects held each stretch for 15seconds.

Plyometric training: Subjects performed 2 sets of 10 repetitions of each plyometric exercises which include squat jumps, plyometric push-ups, and ring drills 2 times per week for 20mins with 1-2 minutes of rest periods in between sets. Progression was made from low intensity plyometric exercises (squat jumps and plyometric push-ups) to moderate intensity exercise (ring drills).

Cool down: Subjects performed 3 minutes of cycling on the bicycle ergometer. This was performed after the plyometric exercise sessions were completed. This slowly decreases the cardiovascular work and overall metabolism that were elevated during plyometric training because a sudden stop of exercise could be dangerous.

DATA ANALYSIS PROCEDURE

Descriptive statistic of the mean and standard deviation was used to describe characteristics of the participants. Inferential statistics of paired-samples t-test was computed to determine differences in pre and post intervention within the experimental group after 6 weeks of intervention and control group in fitness parameters following 6 weeks of initial measurement. The effect sizes of the variables were determined using Paired Squares eta. Statistical significance was set at an alpha level of 0.05. Data was analyzed using Statistical Package for Social Sciences (SPSS) version 23.0.

RESULTS

As shown in the table 1 below, the mean BMI indicates that participants in both experimental and control groups are overweight and within the middle age category, having blood pressure within the normal range and the participants have a body fat percentage within the normal range (20-30%). There are no significant differences between physical and physiologic parameters of both experimental and control groups at baseline as shown in table 1 below.

Table 1: Physical and Physiologic Characteristics of the Participants (N=27)

Variables	Combined group N = 27 (m±sd)	Experimental group n = 14 (m±sd)	Control group n = 13 (m±sd)	t-value
Age (years)	47.81 ± 5.492	47.86 ± 5.447	47.77 ± 5.761	0.87
Height (m)	1.65 ± 0.0439	1.65 ± 0.053	1.64 ± 0.032	0.37
WT (Kg)	73.81 ± 6.889	73.21 ± 7.319	74.46 ± 6.628	0.65
BMI (Kg/m²) WC	27.04 ± 2.835 97.67 ±7.03	26.64 ± 3.104 97.36 ±8.69	27.46 ± 2.570 98.00 ±5.00	0.46 0.82
SBP (mmHg)	130.93 ± 14.874	132.86 ± 16.257	128.85 ± 13.564	0.50
DBP (mmHg)	78.15 ± 10.014	77.14 ± 10.691	79.23 ± 9.541	0.73
BF (%)	30.48±7.015	30.76±7.430	30.17 ± 6.827	0.63
MS (Kg)	19.04±9.975	18.57±10.338	19.54 ± 9.963	0.62
MF (cm)	9.65±7.228	9.13±8.389	10.21 ± 6.025	0.71
ME	6.93±4.922	4.50±3.391	3.92±2.532	0.62
MP (W)	1941.70 ± 542.97	1982.20 ± 576.37	1898.10±524.32	0.32

m = mean, sd = standard deviation. WT=Weight (Kg), BMI= Body mass index (kg/m^2), WC= waist circumference, SBP=Systolic blood pressure (mmHg), DBP=Diastolic blood pressure (mmHg), BF (%) = Body fat percentage, MS=muscle strength, MF = muscle flexibility, ME = Muscle endurance, MP = muscle power.

Table 2 below shows there are significant differences in all variables between pre and post plyometric exercise intervention in the experimental group after 6 weeks. Also, from the table 2 are the values that show the magnitude of associations (Eta squared). The eta squared statistics results show that the effect sizes range between medium and large association. However, there are no significant differences in all the variables of the control group after 6 weeks as shown in table 3 below.

Table 2: Comparison of Physical and Physiological Variables in Experimental Group after 6 weeks of Intervention (n=14).

Variable	Pre m±sd	Post m±sd	Df	p-value	Eta Squared
WT	73.21±7.32	70.14±6.69	13	0.001	0.72
BMI	26.64±3.10	25.64±2.98	13	0.001	0.46
WC	97.36±8.69	96.21±8.45	13	0.001	
SBP	132.86±16.26	124.87±13.43	13	0.001	0.56
DBP	77.86±10.51	74.64±5.71	13	0.001	
MS	18.57±10.34	28.43±13.97	13	0.001	0.77
ME	4.50±3.39	10.00±4.58	13	0.001	0.56
MF	9.13±8.39	9.74±8.95	13	0.001	
BF	30.76±7.43	32.54±7.51	13	0.001	
MP	1982.07±576.24	1989.57±580.09	13	0.001	
FBS	8.31±1.81	7.43±2.28	13	0.001	
RBS	11.31±2.12	10.64±2.82	13	0.001	
HDL	1.24±0.04	1.84+0.13	13	0.001	0.63
LDL	4.10±0.92	3.63±0.97	13	0.001	
TG	1.28±0.31	1.27±0.42	13	0.001	
TC	6.03±0.86	6.46±0.78	13	0.001	

m=mean, sd=standard deviation, WT=weight, BMI = body mass index, WC=Waist Circumference, SBP = systolic blood pressure, DBP = diastolic blood pressure, FBS = fasting blood sugar concentration, RBS = random blood sugar concentration, HDL = high density lipoprotein, LDL = low density lipoprotein, TG = triglycerides, TC = total cholesterol, BF = body fat percentage, MS=muscle strength, MF = muscle flexibility, ME = Muscle endurance, MP = muscle power.

Table 3: Comparison of Physical and Physiological Variables in Control Group after 6 weeks of Intervention (n=13).

Variable	Pre m±sd	Post m±sd	t-value	p-value
WT	74.46±6.63	74.62±6.57	-0.56	0.58
BMI	27.46±2.57	27.39±2.76	0.16	0.87
WC	98.00±5.00	98.01±4.96	-1.00	0.33
SBP	128.85±13.56	133.85±8.70	-1.73	0.11
DBP	79.23±9.54	79.23±7.60	0.00	1.00
MS	20.62±10.52	19.92±10.26	0.85	0.42
ME	3.92±2.53	3.62±2.63	1.08	0.30
MF	10.21±6.06	9.93±5.95	1.56	0.14
BF	29.40±7.24	30.00±6.23	-0.76	0.46
MP	1757.76±558.82	1771.31±550.04	-0.74	0.48
FBS	8.39±1.69	8.46±1.61	-1.20	0.26
RBS	11.06±1.27	11.40±1.16	-1.81	0.10
HDL	1.31±0.40	1.25±0.49	0.69	0.50
LDL	4.31±1.09	4.11±0.60	0.69	0.51
TG	1.97±0.64	1.66±0.64	1.39	0.19
TC	6.36±0.68	6.64±0.66	-2.17	0.051

m=mean, sd=standard deviation, WT=weight, BMI = body mass index, WC=Waist Circumference, SBP = systolic blood pressure, DBP = diastolic blood pressure, FBS = fasting blood sugar concentration, RBS = random blood sugar concentration, HDL = high density lipoprotein, LDL = low density lipoprotein, TG = triglycerides, TC = total cholesterol, BF = body fat percentage, MS=muscle strength, MF = muscle flexibility, ME = Muscle endurance, MP = muscle power.

DISCUSSION AND CONCLUSION

This study was carried out to evaluate the effects of plyometric training on concomitant of fitness and metabolic profile among Nigerians adults with type 2 diabetes mellitus. The outcome reveals significant improvement in concomitant of fitness and metabolic profiles of the experimental group, but without any significant improvement in that of the control group.

The significant increase in muscle strength identified by this study is in line with previous studies conducted wheretype 2 diabetics patients were subjected to aerobic and progressive resistance exercises [22,23,24]. The results of this study is also similar to that of Masamoto, Larson,Gates and Faigenbaum (2003) who reported plyometric training to be effective in improving muscular strength, but this was carried out on athletes making it difficult to compare it with the present study [25]. This could, however, be due to the impact of the exercise on muscle fibers leading to their hypertrophy as well as increase utilization of stored fat for energy during the exercise. The findings of this study also indicate that subjects in the experimental group did improved significantly in muscle power and flexibility over those in the control group after the training. This is in line with the study by Faigenbaum et al (2007) [17]. This difference could be due to the fact that subjects in this study were diabetic, older and unfit unlike subjects in previous study whom were apparently healthy adolescent or young adults and athletes.

Comparison of the pre and post blood pressure reduction in blood pressure of the resistance exercise group shows a reduction in the blood pressure but no reduction in the blood pressure of the control group. There are conclusive evidences on the positive effects of resistance exercises on blood pressure. Kelley and Kelley (2000) in a meta-analysis reported that progressive resistance exercise has positive effects on reducing resting systolic and diastolic blood pressure in adults [26]. Also, Cornelissen and Fagard (2005) posited that moderate resistance exercise could be part of the non-pharmacological intervention strategy in the prevention and management of high blood pressure [27]. It is also pertinent to point out that the American Heart Association and American College of Sports Medicine endorsed the use of resistance exercise as an integral part of exercise to enhance health and cardiovascular disease prevention [28,29].

Glycemic control is, however, an important and challenging aspect in people with type 2 diabetes and exercise along with other management helps to address this problem. An increasing interest has been seen over the last decade on the role of resistance exercise in the management of type 2 diabetes mellitus regarding improvement in insulin sensitivity [30]. The outcome of this study shows significant decrease in blood glucose concentration which is consistent with the findings of Gordon et al (2008), Baum, Votteler and Schiab (2007) and Brooks, Layne, and Gordon (2007) who found significant improvement in blood glucose concentration after subjecting T2DM patients to aerobic and progressive resistance exercises[31,32, 33]. Though this present study was unable to control well for dietary intake and medications taken by the participants, there was significant reduction in the blood glucose as a result of resistance exercise. In a recent study, it is reported that resistance exercise provides type 2 diabetes mellitus subjects similar effects to aerobic exercises and it is a useful alternative for people who are unable to participate in aerobic exercise [34].

Resistance exercises have been suggested to be more accessible for of training for less mobile groups of subjects [35] and also acting as an alternative to aerobic exercises for more mobile individuals [33]. This study further revealed that plyometric training has significant effect in decreasing blood lipid after six weeks of exercise. Though our study recruited both male and female as subjects, Bemben and Bemben (2000) reported earlier that resistance exercises had significant positive effects on high-density lipoprotein cholesterol (HDL-C) among postmenopausal women of Oklahoma [36]. Also, our findings are supported by the studies of Arora, Shenoy, and Sandhu (2009) and Lightenberg, Hoekstra, Bol, Zonderland and Erkelans (1999) who used higher frequency, longer duration of exercise and study accounting for the improvement in blood lipids especially total cholesterol and triglycerides [14,37]. Contrary to our findings, Patel et al., (2015) reported in a pilot study that an 8-week resistance training programme did not improve lipid profile in obese/overweight peri-pubertal boys [38]. However, it has been shown by various authors that the outcome of low-to moderate-intensity resistance training leads to greater reduction in lipid profiles than high-intensity resistance training among [39,40].

The American College of Sports Medicine (2002) states that improved muscle fitness (i.e. muscle strength and endurance) is proportionate to improved or maintained glucose tolerance, fat free mass and resting metabolic rate and ability to carry out activities of daily living [21]. The outcome of our study is in line with ACSM (2002) submission because of the significant improvements in muscle fitness and at the same time significant decrease in blood glucose concentration and blood lipids [21]. The use of exercise in the prevention and management of type 2 diabetes mellitus has been well supported. American Diabetes Association (ADA, 2002) opined that promotion of exercise in the prevention and management of type 2 diabetes mellitus must be viewed as a high priority [41]. Plyometric exercise is a form of exercise that is easy, cheap, less instructive and requires minimal supervision, which is suitable for patients from with scarcity of health resources.

This study, therefore, concludes that among the concomitants of fitness, plyometric exercise is effective only in improving muscle fitness and body composition.

Low-moderate intensity plyometric exercise for 2 times per week should be incorporated in the treatment regimen for type 2 diabetes patients or as home program so as to improve their level of physical fitness.

- Further research should employ longer duration, larger sample size, and higher frequency and intensity of plyometric exercise to determine its effect on blood lipids.

- Further research should be conducted to investigate the impact of plyometric exercise on blood glucose concentration ensuring their control for dietary intake and no change in medications during the period of the study.

REFERENCES

[1] Hu, A.M., Lakka, S.A., Kilpelainen, I. Tuomilehto, Y.A. Epidemiology of noninsulin dependent diabetes. Diabetes Care. 2007; 4 (2), 7-9.

[2] La Monte, M.J., Blair S.N., Church, T.S. (2000). Physical activity and diabetes prevention. Journal of applied physiology.

[3] The improved Diabetes Atlas. 3rd ed. International Diabetes Federation; 2006.

[4] Motala, A.A. Diabetes Trends in African. Diabetes Metab Res Rev 2002; 18:514-520.

[5] Akinkingbe OO (editor). Non-communicable Diseases in Nigeria: National Survey (Final Report) on Hypertension, Coronary Heart Disease, Diabetes mellitus, Haemoglobinopathy, G6PD Deficiency and Anaemia National Expert Committee on Non-Communication Disease. Federal Ministry of Health and Social services. Lagos 1997.

[6] Wild,S., Roglic, G., Sicree, R., King, H. Global prevalence of diabetes: estimates for 2000 and projection for 2030. Journal of American Diabetes Association. 2004; 27: 1047-1053.

[7] Benson, A.C., Torode, M.E., Singh, M.A.F. Muscular Strength and Cardiorespiratory fitness is associated with higher insulin sensitivity in children and adolescents. International Journal of Pediatric Obesity. 2006; 1(4): 222-231.

[8] Albright, A., Franz, M., Hornsby, G., Kriska, A. Marrero, D., Ulrich, I. & Verty, L.S.Exercise and type 2 diabetes mellitus. Med Sci Sports Exerc.2000; 3(7): 1345-1360.

[9] Corbin, C.B., Welk, G.J., Corbin, W.R. & Welk, K.A. (2006). Performance benefit of physical activity. In Sport physiology (6the Ed.) . Concept of fitness and wellness: A comprehensive lifestyle approach. Newyork: Mc Grawhill.

[10] American Diabetes Association (2002). Diabetes mellitus and exercise. Diabetes Care. 2002; 25(Suppl 1): S64-S68.

[11] Larose,J.,Sigal,R.J.,Boule,N.G.,Wells,G.A.,Prud'Homme,D.,Fortier,M.S.,Reid,R.D.,Tulloch,H.,Coyle D., Phillips, P., Jennings A., Khanwala, F., Kenny G. P. Effect of Exercise Training on Physical Fitness in Type II Diabetes Mellitus. Journal of Medicine and Science in Sports and Exercise.2010; 42(8): 1439-1447.

[12] Mahler,R. J.L & Adler, M.L.Type 2 Diabetes Mellitus: Update on Diagnosis, Pathophysiology, and Treatment. Journal of Clinical Endocrinology & Metabolism. 1999; 84(4): 1165-1171.

[13] Steele, R.M., Brage, S., Corder, K., Wareham, N.J., Ekelunde, U.L.F. Physical activity, Cardio respiratory Fitness and the metabolic syndrome in youth. Journal of Applied Physiology. 2008; 105: 342-351.

[14] Arora, E., Shenoy, S. Sanhu, J.S. Effect of resistance training on metabolic profile of adults with Type 2 diabetes. Indian Journal of Medical Research. 2009; 129(5): 515-519.

[15] Blair, S.N., &Church,T.S. The importance of physical activity and cardiorespiratory fitness for patients with Type 2 Diabetes. Diabetes Spectrum. 2003; 16 (4): 236-240.

[16] Chmielewski, T.L., Myer, G.D., Kauffman, D. & Tillman, S.M.Plyometric exercise in the rehabilitation of Athletes: Physiologic Responses and clinical Application. Journal of Orthopaedic and Sports Physical therapy.2006; 36(5): 308-319.

[17] Faigenbaum, A.D., McFarland, J.E., Keiper, F.B., Tevlin, W., Ratamass, N.A., Kang, J.I, Ivrang, N., James, B. & Frank, D. Effect of short-term plyometric and resistance training program on fitness performance in boys age 12 to 15 years. Journal of Sports Science and Medicine. 2007; 6(4): 519-525.

[18] Diallo, O., Dore, E., Duche, P., Van Praagh, E. Effect of plyometric training followed by a reduced program on physical fitness performance in prepubescent soccer players. Journal of Sport Medicine and Physical Fitness. 2001; 41(3): ,342-348.

[19] Matavulj,D.,Kukolj,M.,Ugarkovic, D., Tihanyi, J. Jaric,S. Effect of plyometric training on jumping performance in junior basketball players. Journal of Sport Medicine and Physical Fitness. 2001; 41(2): 159-164.

[20] Keir, P.J. Jamnik, V.K. Gledhi, N. Technical methodological report. A nomogram for peak leg power output in the vertical jump. The Journal of Strength and Conditioning Research. 2003; 17(4): 701-703.

[21] American College of Sport Medicine. ACSM Fitness Book, 3rd Edition, Champaign, II: Human kinetics Publishers, 2003.

[22] Aylin, K., Arzu, D. & Sabri, S.A.The effect of combined resistance and home-based walking exercise in type 2 diabetes patients. International Journal of Diabetes in Developing Countries. 2009: 29(4): 159–165.

[23] Shivananda, N., Maiya, A. & Hande, M. Influence of Aerobic Treadmill exercise on blood glucose homeostasis in non-insulin dependent diabetes patients. Indian Journal of Clinical Biochemistry. 2005; 20(1): 47-51.

[24] Maiorana, A., ODriscoll G., Goodman, C.,Taylor, R. and Green D. Combined exercise improves glycemic control and fitness in Type 2 Diabetes. Diabetes Research and Clinical Practice. 2002; 56(2): 115–123.

[25] Masamoto, N., Larson,R.,Gates,T. & Faigenbaum, A. Acute Effect of Plyometric exercise on maximum squat performance in male Athletes. Journal of Strength and Conditioning Research. 2003; 17 (1): 68-71.

[26] Kelley, G.A. and Kelley, K.S. Progressive resistance exercise and resting blood pressure. A meta-analysis of randomised controlled trials. Hypertension.2000; 35: 838-843.

[27] Cornelissen VA, Fagard RH. Effect of resistance on

resting blood pressure: a meta-analysis of randomized controlled trials. J Hypertens. 2005;23: 251–259.
[28] Braith RW, Stewart KJ. Resistance exercise training: its role in the prevention of cardiovascular disease. Circulation. 2006; 113:2642–2650.
[29] Williams MA, Haskell WL, Ades PA, Amsterdam EA, Bittner V, Franklin BA, Gulanick M, Laing ST, Stewart KJ. American Heart Association Council on Clinical Cardiology; American Heart Association Council on Nutrition, Physical Activity, and Metabolism. Resistance exercise in individuals with and without cardiovascular disease: 2007 update: a scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity and Metabolism. Circulation. 2007;116(5):572–584.
[30] Tresierras, M.A., Balady, G.J. Resistance training in the treatment of diabetes and obesity–mechanisms and outcomes. Journal of Cardiovascular Rehabilitation and Prevention. 2009; 29: 67–75.
[31] Gordon, L. A.,Morrison, E. Y., Mc Crowder, D.A., Young, R., Fraser, Y.T.P., Zamora, E.M., Alexandrar-Lindo,R.L. & Iriving, R.R Effect of exercise therapy on lipid profile and oxidative stress indicators in patients with type 2 diabetes. BMC Complementary Alternative Medicine. 2008; 8: 21.
[32] Baum, K., Votteler, T. Schiab, J.Efficiency of vibration exercise for glycemic control in type 2 diabetes patients. International Journal of Medical Sciences. 2007; 4(3): 159-163.
[33] Brooks, N., Layne, J.E. Gordon, P.L. Roubenoff, R., Nelso, ME., Castaneda-Sceppa, C. Strength training improves muscle quality and insulin sensitivity in Hispanic older adults with type 2 diabetes. International Journal of Medicine and Science. 2007; 4(1): 19 – 27.
[34] Ng, C.L.W., Goh, S.Y., Malhotra, R. Ostbye, T. Tai, E.S. Minimal difference between aerobic and progressiveresistance exercise on metabolic profile and fitness in olderadults with diabetes mellitus: a randomised trial. Journal of Physiotherapy. 2010; 56:163-170.
[35] U.S. Department of Health and Human Services: Physical Activity and Health: A Report of the Surgeon General. Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Washington, DC, U.S. Govt. Printing Office, 1996
[36] Bemben, D.A. and Bemben M. G. Effects of resistance exercise and body mass index on lipoprotein-lipid patterns of postmenopausal women. Journal of Strength and Conditioning Research.2000; 14(1): 80-85.
[37] Ligtenberg P.C., Hoekstra J.B., Bol E., Zonderland M.L., & Erkelans, D.W. Effects of physical training on metabolic control in elderly type 2 diabetes mellitus patients. Clinical Science. 1997; 93(2): 127–135.
[38] Patel, S.J., Hanks, L.J., Ashraf, A.P., Gutierrez, O.M., Bamman, M.M. and Casazza, K. Effects of 8 week resistance training on lipid profile and insulin levels in overweight/obese peri-pubertal boys-a pilot study. Journal of Diabetes Research & Clinical Metabolism.2015;4:2.
[39] Lira, F.S., Yamashita, A.S., Uchida, M.C., Zanchi, N.E., Gualano, B., Martins Jr, E. et al., Low and moderate, rather than high intensity strength exercise induces benefit regarding plasma lipid profile Diabetology & Metabolic Syndrome 2010, 2:31.
[40] Vatani SD, Ahmadi S, Ahmadi Dehrashid K, et al. Changes in cardiovascular risk factors and inflammatory markers of young, healthy, men after six weeks of moderate or high intensity resistance training. Journal of Sports Medicine and Physical Fitness. 2011;51(4):695–700.
[41] American Diabetes Association. Diabetes mellitus and exercise. Diabetes Care. 2002;25(Suppl 1): S64-S68.

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