



## THE IMPACT OF 3 MONTHS OF COMBINED EXERCISES ON HUNGER, SATIETY AND FOOD CONSUMPTION IN PATIENTS WITH TYPE 2 DIABETES MELLITUS (T2DM): A RANDOMIZED CONTROLLED STUDY

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### INTRODUCTION

The global prevalence of T2DM continues to rise more rapidly in low- and middle-income countries than in high income countries (WHO, 2020). Among the several mechanisms used to achieve glycemic control, regular physical exercises are known to be an integral component in the life style of diabetics. Combination of both aerobic and resistance exercises are reported with better glycemic control compared to aerobic or resistance exercise modes alone (Sigal *et al.*, 2007). Although most previous studies have been centered around investigating the effect of regular exercise on glycemic control in T2DM, findings on the long-term effects of exercises on appetite regulation and food intake are inconclusive. Moreover, most studies have investigated the effects of exercises on hunger, satiety and food intake in healthy individuals who performed acute bouts of exercises. Consequently, the effects of exercises on these parameters are yet to be well established in T2DM. Thus, this study aims to investigate the impact of regular combined exercises on hunger, satiety and food consumption in T2DM.

### METHODOLOGY

This study is a part of a randomized controlled study conducted at the Department of Physiology, University of Sri Jayewardenepura. A sample of 72 patients, aged between 35- 60 years, with a history of T2DM for more than 5 years were recruited. Data on socio-demographic and clinical characteristics were obtained by an interviewer administered questionnaire after taking written informed consent. The participants were randomly assigned into an exercise group and a control group. Both groups were matched for age, sex and HbA1c%. The exercise group engaged in brisk walking 30 min/day, 4-5 days/week and resistance exercises 20min/day, 2-3days/week for three months. Adherence to the exercise protocol was assessed by regular telephone calls. Both groups were advised not to change their routine dietary practices and to maintain a 3-day diet diary. The dietary recall was assessed at the baseline and at three months. Prior instructions were given to each participant regarding accurate recording of diet diary in a given format. Hunger and satiety were assessed subjectively by using a visual analogue scale (VAS) at -30 min, +30 min and +60 min in relation to a standard breakfast meal at baseline and at three months. Food consumption was assessed by Nutrisurvey2007 (EBISPRO) software. The data were analyzed by paired sample t-test and independent sample t-test. The study was approved by the ethics review committee of the University of Sri Jayewardenepura.

### RESULTS AND DISCUSSION

The study sample consisted of 54% (n=39) males. Mean  $\pm$  SD age of the participants was 51 $\pm$ 5.8 years. Majority (64%) of them had a family history of diabetes. Mean  $\pm$  SD duration of diabetes was 8 $\pm$ 5.1 years and the HbA1c was 8.2 $\pm$ 1.9%. All patients were on anti-hyperglycemic agents. Two patients from the exercise group were dropped out at three months follow up. Table 1 shows the baseline socio-demographic characteristics of both study groups separately.

Table 1. Baseline socio-demographic characteristics of study participants



Variable	Combined group (n=36)	Control group (n=36)	p value
Age (years) (mean ± SD) *	52.8 +/-4.9	50.5 +/-5.0	0.140
Gender, n (%)			
Male	23 (63.9%)	16 (44.4%)	0.168
Female	13 (36.1%)	20 (56.6%)	
Duration of T2DM (years) (mean ± SD) *	6.9 +/- 2.4	8.3+/-4.7	0.122
Family history of T2DM n, (%)			
Yes	21 (58.3%)	25 (69.4%)	0.357
No	15 (41.7%)	11 (30.6%)	
Diet control, n (%)			
Yes	17 (47.3%)	22 (61.1%)	0.474
No	19 (52.7%)	14 (38.9%)	
HbA1c (%) * (mean ± SD)	7.2 +/- 1.0	8.2 +/-1.6	0.130

\* mean ± SD

When the two groups were compared (mean differences ± SD from baseline to three months), it was observed that hunger decreased and satiety increased in the exercise group with statistically significant findings for hunger at -30 min (Mean difference: exercise group; -15.85±3.19 vs controls; +2.10±2.16, p=0.005) and satiety at -30 min (Mean difference: +15.91±5.93 vs -0.71±2.84, p=0.01), +30 min (Mean difference: +10.81±3.53 vs +1.41±4.33, p=0.05) and +60 min (Mean difference: +17.71±3.57 vs -2.64±4.39) compared to the control group. As shown in Figure 1, within the group comparison also showed reduced hunger and increased satiety at three months in the exercise group compared to their baseline values (p<0.05).

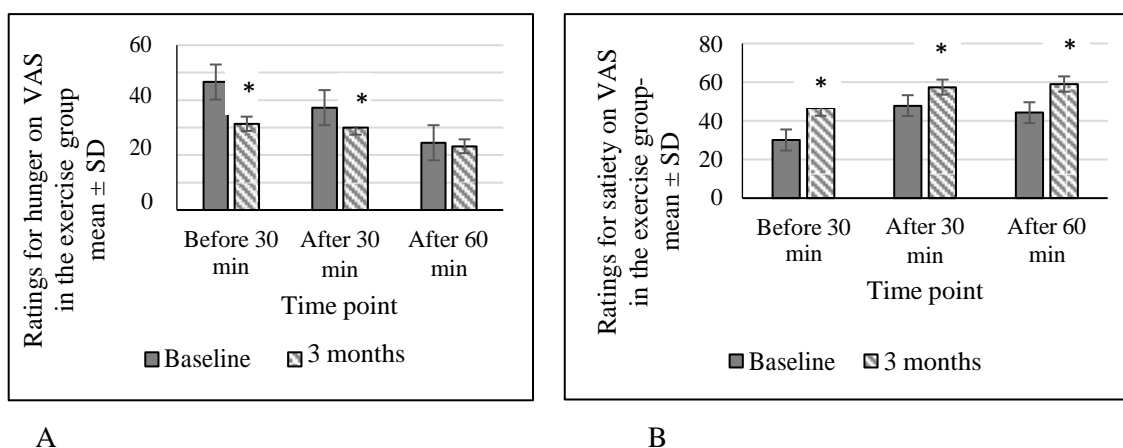


Figure 1. Ratings for perceived level of hunger (A) and satiety (B) assessed at -30 min, +30 min and +60 min in relation to a standard breakfast meal at baseline and at 3 months in the combined exercise group. Values are shown as mean ± SD, \* p<0.05.



Studies conducted to explore the impact of combined exercises on appetite sensation are sparse. In fact, most of the studies have investigated the effect of exercise on appetite in separate aerobic and resistance exercise sessions rather than combined sessions. Consistent with our findings, a randomized cross over study conducted by Broom *et al.*, (2009) showed suppressed hunger and increased satiety in a group of young healthy men who performed 60 minutes of treadmill running and 90 minutes of resistance exercises compared to a non-exercised control group (Broom *et al.*). Another study conducted with type 1 and type 2 diabetes patients who performed cycle ergometer for one hour showed a significant reduction in hunger in the type 2 diabetes group, compared to type 1 diabetes group. However, there was no significant difference in the satiety between the two diabetic groups (Dube *et al.*, 2013). In our study, the suppression of hunger persistent for a very short duration as no change in hunger was observed at 30 and 60 minutes after the test meal. In contrast to these findings, a study conducted among two groups of men, normal weight and overweight, who followed five days of aerobic exercises, 1 h/day showed no change in perceived hunger in both groups (Chanoine *et al.*, 2008). Further, this experiment suggested that overweight men tend to have reduced satiety due to lower Glucagon Like Peptide-1 (GLP-1) concentration compared to normal weight men (Chanoine *et al.*, 2008).

According to the findings many previous studies, it can be postulated that hunger is transiently suppressed following exercises due to suppression of acylated plasma ghrelin concentrations, increased peptide tyrosine (PYY), pancreatic polypeptide (PP) and GLP-1 (King *et al.*, 2010, Balaguera *et al.*, 2011, Broom *et al.*, 2009). Although the mechanism responsible for the change in hunger and satiety in T2DM patients following long-term exercise has not been studied extensively, findings of previous studies imply that GLP-1 has a physiological role in enhancing satiety in T2DM patients (Gutzwiller *et al.*, 1999). Thus, we assume that the decrease in hunger and the increase in satiety in patients with T2DM is mediated by hormonal changes.

### Total calorie and macronutrient consumption

Total calorie and macronutrient intake in the study participants at baseline and at three months are shown in Table 2. According to the results, combined exercise group showed significantly reduced total calorie and carbohydrate consumption at three months compared to the baseline. However, the control group showed a significantly increased fat consumption at three months compared to their baseline.

When the two groups were compared, combined exercise group showed reduced total calorie (Difference in median/IQR: -172.2/35.7 vs 0.0/ 8.9, U=443.0, p=0.015) and carbohydrate intake (Difference in median/IQR: -30.3/8.0 vs 0.0/5.8, U=424.0, p=0.013) compared to controls. Although both exercise groups showed increase in protein intake at three months, none of the group comparisons were significant, while the fat intake was significantly decreased in the combined group (Difference in median/IQR: -1.7/7.7 vs +7.3/7.4, U=361.5, p=0.001) compared to control group.

Table 2. Total calorie and macronutrient consumption by study participants (within the group comparison)

		Baseline	3 months	p value
Combined exercise group (n=34)	Total calorie (kcal)	1736.0 (767.6)	1523.7 (484.3)	0.009*
	Carbohydrates (g)	217.8 (75.5)	200.5 (71.8)	0.009*
	Protein (g)	56.0 (15.2)	57.2 (19.7)	0.442
	Fat (g)	31.6 (32.7)	32.7 (4.1)	0.063
Control group	Total calorie (kcal)	1941.0 (792.5)	2189.9 (792.5)	0.214



(n=36)	Carbohydrates (g)	198.4 (128.8)	211.7 (113.4)	0.089
	Protein (g)	56.8 (9.3)	53.4 (51.1)	0.342
	Fat (g)	28.0 (5.3)	36.0 (3.5)	0.001*

Data were shown as median/ (inter-quartile range), \* Level of significance <0.05

The present study showed significant changes in total calorie and macronutrient intake in T2DM patients who performed regular combined exercise for three months. An eight-month randomized trial conducted with obese, previously sedentary healthy individuals who performed aerobic exercises, resistance exercises or combined exercises reported significant decrease in total energy, carbohydrate, fat and protein intake compared to their baseline in the aerobic and combined exercise groups based on food frequency questionnaire suggesting that regular exercises influence the food intake (Bales *et al.*, 2012). Even though the exact mechanism of exercise induced reduction in food intake is not well established, few experimental data on placebo controlled randomized cross over studies have shown the physiological effects of GLP-1 in significantly reducing the energy intake in T2DM patients (Gutzwiller *et al.*, 1999) as well as in healthy individuals (Flint *et al.*, 1998). The inconsistency in findings is likely due to dissimilarities in participant characteristics and study methods.

### CONCLUSIONS/RECOMMENDATIONS

In conclusion, regular combined exercises for a period of three-months causes a reduction in the subjective level of hunger and improve satiety leading to reductions in the total calorie and macronutrient intake in T2DM patients. Thus, it is imperative to understand the changes in appetite in patients with T2DM who perform regular exercises and future experiments should focus on changes in appetite related hormones in long term combined exercises and explore their contribution on increasing insulin sensitivity in diabetics.

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