A pilot study of a wearable device with mobile app-assisted exercise training program in patients with type 2 diabetes

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❖ **Background:**

Exercise is a part of lifestyle intervention in diabetes treatment, however, adherence to regular exercise requires considerable effort that many patients fail to conform to health care providers' guidance. To improve exercise adherence, we proposed using a wearable device with mobile application (app) to aid patients engaging in exercise. The goal of this pilot study was to evaluate the effectiveness of a wearable optical heart rate monitor with app in assisting an exercise program for glycemic control in patients with type 2 diabetic mellitus (DM).

❖ **Methods:**

This study was a one-group pretest-posttest design with 10 subjects selected by convenience sampling from a diabetic clinic. Subjects consisted of 60.0% male with age 52.7 ± 10.9 years (mean ± SD), body mass index 26.6 ± 5.9 kg/m², DM duration 7.6 ± 6.7 years (table 1), and glycosylated hemoglobin (HbA1c) 7.0 ± 1.1% (table 2). Based on the current exercise guidelines of American Diabetes Association, the goal was for each subject to receive a 12-week, ≥150-minute per week, and moderate to vigorous intensity exercise intervention, which included bi-weekly one-hour supervised group-based aerobic and resistance exercise training and ≥10-minute home-based self-monitored aerobic exercise one-hour postmeal in most days of the week. Each subject was given the wearable device with mobile app (uGluco, Advanced Mediwatch co. Taiwan) to record and provide feedback on exercise data including heart rate, intensity, distance, caloric expenditure, frequency, and duration. Glycated hemoglobin, body weight, waist circumference were measured at baseline and after 12 weeks. Acute exercise-induced capillary blood glucose change was measured for each exercise session. Adverse events were also noted. The compliance rate of the six supervised sessions was 98%. During the intervention period, subjects exercised 5.6 ± 1.0 days per week, 579.3 ± 186.2 min per week, 312.8 ± 167.9 min moderate-high intensity per week, 4411.8 ± 1584.6 kcal per week, and performed self-monitored blood glucose 132.0 ± 41.8 times (range 74-194 times). The repeated measures t-test or nonparametric Wilcoxon signed-rank test was used to examine difference between two means.

❖ **Results:**

Seven subjects (70%) had improvement in HbA1c. A reduction of 0.7 ± 1.0% (7.0 ± 1.1% vs. 6.3 ± 0.6%, p<0.05) was found among all 10 subjects. The achieving rate for target <130 mg/dL premeal glucose level was 72.3 ± 23.2% (range 30.0 - 100.0%), for target < 180mg/dL pre-exercise, immediate postexercise, and 1-hour postexercise blood glucose level were 78.0 ± 23.0% (range 27.0 – 100.0%), 90.3 ± 16.4% (range 48.6 – 100.0%), and 93.7 ± 9.0% (range 72.0 – 100.0%) respectively. After the intervention, we found significant (p<0.05) reduction in body weight, body mass index and waist circumference, respectively by 1.3 ± 1.0 kg (68.8 ± 24.6 kg vs. 67.5 ± 24.7 kg), 0.5 ± 0.4 kg/m² (26.6 ± 5.9 kg/m² vs. 26.0 ± 5.9 kg/m²), and 3.9 ± 2.8 cm (84.4 ± 10.1 cm vs. 80.4 ± 9.8 cm) (table 2). No other adverse events, except 3 occasions of hypoglycemia among 2 patients, were seen during intervention.

❖ **Conclusions:**

Assisted by a wearable heart rate monitor with mobile app, diabetic patients exercising one-hour after meals for 12 weeks could improve glycemic control, postprandial blood glucose level and reduce body weight.

❖ **Reference:**

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., Tate, D. F. (2016). Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. *Diabetes Care*, 39(11), 2065-2079. doi:10.2337/dc16-1728

Table 1. Participant characteristics N=10

Variable	N (%)/ Mean ± SD	Range
Sex		
Male	4 (40.0%)	N/A
Female	6 (60.0%)	
Age	52.7 ± 10.9	38 - 66
Duration of DM(yrs)	7.6 ± 6.7	0 - 21
Medication regimen		
Biguanide	10 (100.0%)	N/A
SU	3 (30.0%)	
DPP4i	1 (10.0%)	
GLP1	2 (20.0%)	
Basal insulin	2 (20.0%)	
Type of exercise		
Brisk walking	8 (80.0%)	N/A
Jogging	3 (30.0%)	
Bicycling	2 (20.0%)	
Mountain climbing	1 (10.0%)	
Aerobic dance	3 (30.0%)	
Yoga	1 (10.0%)	
Frequency of SMBG*	132.0 ± 41.8	74 - 194
Post-meal exercise per time (min)	23.5 ± 4.4	17.7 - 31.5
Frequency of exercise (day/wk)	5.6 ± 1.0	3.5-6.8
Duration of exercise (min/wk)	579.3 ± 186.2	254.7-823.5
Duration of moderate-high intensity exercise (min/wk)	312.8 ± 167.9	34.3-555.2
Calorie expenditure (kcal/wk)	4411.8 ± 1584.6	1856.5-7212.3

Note. SMBG: Self-monitoring blood glucose

Table 2. Baseline and endpoints parameters N=10

Variable	N (%)/ Mean ± SD	Range	t value/ Wilcoxon signed-rank test	p value
A1C(%)				
Baseline	7.0 ± 1.1	5.7 - 9.5	z= -2.4	0.017
After 3 months	6.3 ± 0.6	5.4 - 7.3		
Changes in CapBG* during exercise				
Pre-exercise	145.8 ± 29.0	125.0 – 166.5	t= -7.6	< 0.001
Post-exercise	125.5 ± 27.0	106.2 – 144.9		
1 hr post-exercise	124.2 ± 19.2	110.6 – 139.8		
The rates of achieving glycemic targets				
Pre-meal (< 130 mg/dl)	72.3 ± 23.2 %	30.0 -100.0	N/A	N/A
Pre-exercise (< 180 mg/dl)	78.0 ± 23.0%	27.0-100.0		
Immediate post-exercise (< 180 mg/dl)	90.3 ± 16.4%	48.6-100.0		
1 hr post-exercise (< 180 mg/dl)	93.7 ± 9.0%	72.0-100.0		
BW(kg)				
Baseline	68.8 ± 24.6	48-90	t= -4.1	0.003
After 3 months	67.5 ± 24.7	46-88		
BMI (kg/m2)				
Baseline	26.6 ± 5.9	18.8 - 38.1	t= -4.2	0.002
After 3 months	26.0 ± 5.9	18.3 - 37.8		
Waist circumference (cm)				
Baseline	84.4 ± 10.1	69 - 100	t = -4.2	0.003
After 3 months	80.4± 9.8	73 - 100		
Frequency of hypoglycemia				
Pre-meal	0.4 ± 0.5	0-1	N/A	N/A
Post-exercise	0.2 ± 0.4	0-1		

Note. CapBG : Capillary blood glucose