High-intensity Low-volume Training Improves Glycemic Control and Functional Fitness in Type 2 Diabetics

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Background

- 29.1 million people (9.3% of the U.S. population) have diabetes.[1]
- 90-95% of diagnosed diabetes cases are Type 2 Diabetes (T2D).[1]
- 2012 estimates indicate that 86 million Americans ≥20 years of age have "prediabetes" (elevated but not diagnostic fasting plasma glucose or hemoglobin A_1C).[1]
- Diabetes and associated comorbid conditions (e.g., heart & kidney disease, stroke, blindness, and amputations) accounted for $245 billion in direct and indirect medical costs in 2012.[1]
- Diabetics are more likely to have severe functional impairment than non-diabetics, and diabetes is associated with mobility limitations (OR 2.1, *P*<0.001) after controlling for age and other comorbid conditions.[2]
- Innovative primary and secondary prevention strategies for T2D and prediabetes must be at the forefront of research and clinical practice.
- Recent evidence, has shown that low-volume high-intensity exercise training (HIT) rapidly improved skeletal muscle GLUT4 transporter function[3], and insulin sensitivity improved 21% in young healthy adults after 6 sessions of sprint-interval training.[4]
- Importantly, low-volume HIT appears to be well-tolerated, even in populations thought to be at increased risk, e.g., heart disease and T2D populations.[3]
- To date and particularly in disease populations, HIT has employed cycling or ambulatory modes of exercise and little has been done in the area of low-volume high-intensity resistance training.
- **bioDensity™** is a low-volume, high-intensity mode of resistance training designed to load the musculoskeletal system up to multiples of body weight.
  - bioDensity™ is being used in 200+ clinical and fitness sites internationally and addresses the often cited "lack of time to exercise" barrier by employing a low-volume approach (one 5-7 minute session per week).
- The combination of improved glycemic control via HIT exercise along with prolific evidence documenting improved functional fitness and mobility[5] via resistance training warrants investigating the bioDensity™ resistance training approach in T2D and prediabetes.

Purpose

To determine whether 24 weeks of bioDensity™ training improves risk factors, glycemic control, and functional fitness in T2D and prediabetes.

Methods

Participants:
- N=19: 10 T2D & 9 prediabetes; 7 male & 12 female
  - T2D = clinician diagnosed
  - Prediabetes = fasting plasma glucose 100-125 mg/dL or HbA_1C 5.7-6.4%
- Free from contraindications to high-intensity exercise & stable pharmacotherapy (N=17) at baseline and 24-weeks.

Study Design
- Quasi-experimental longitudinal (pre- versus post-intervention)
- Measures:
  - BMI, waist circumference, % body fat, fat-free mass, blood pressure
  - Senior Fitness Test, Y-Balance Test, muscular strength/endurance
  - Fasting plasma glucose (FPG) and hemoglobin A_1C (HbA_1C)

bioDensity™ Training Intervention (24 weeks):
- 4 limited-range of movement exercises performed for 5 seconds each, once per week at a maximal-voluntary contraction intensity
- Maximal strength measured by bioDensity equipment for 4 exercises: 1) Chest Press (CP); 2) Leg Press (LP); 3) Core Pull (Core); & 4) Vertical Lift (VL)

Statistical Analysis: Paired t-tests (baseline vs. 24-weeks); *P*<0.05

Results

Figure 1: bioDensity equipment (4 exercises: 3 seated and 1 standing).

Intervention
Frequency = once per week
Intensity = maximal-voluntary contraction
Time = one repetition sustained for 5 seconds
Type = four bioDensity™ exercises (CP, LP, Core, VL)

Figure 2: Strength change after 24 weeks of bioDensity™ training (N=19).

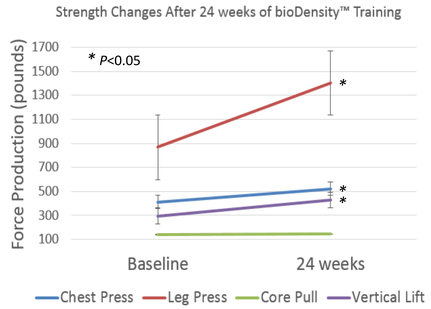

Figure 3: Fasting plasma glucose (FPG) and hemoglobin A_1C (HbA1C) after 24 weeks of bioDensity™ training (N=19).

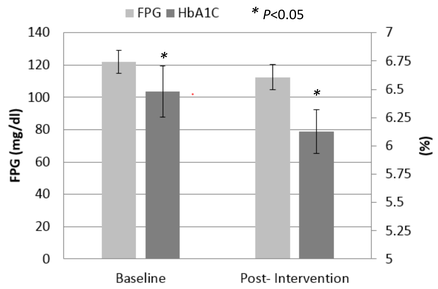

Table 1: Descriptive factors and risk factors: combined (T2D & prediabetes) & by group (N=19)

Descriptors & Risk Factors	*T2D & Prediabetes*			*T2D (N=10)*			*Prediabetes (N=9)*			T2D vs. Pre. *P*-value
	Baseline	24 weeks	*P*-value	Baseline	24 weeks	*P*-value	Baseline	24 weeks	*P*-value	
Age (yrs)	59.1±8.0	--	--	61.3±6.5	--	--	56.5±2.9	--	--	0.20
Weight (kg)	87.6±4.2	87.6±4.3	0.93	91.7±7.5	92.9±7.4	0.19	82.9±3.3	81.8±3.4	0.23	0.31
BMI (kg/m²)	31.1±1.1	31.1±1.2	0.77	32.3±1.8	32.7±1.9	0.19	29.7±0.9	29.4±0.9	0.41	0.30
Waist (cm)	104.9±3.0	105.8±3.0	0.18	111.9±4.1	112.0±4.2	0.91	97.2±2.5	98.9±2.7	0.09	<0.01
% Fat	42.5±1.8	42.4±1.5	0.83	40.2±1.6	40.8±1.6	0.19	45.1±3.3	44.2±2.8	0.24	0.19
FFM (kg)	52.0±3.4	51.8±3.3	0.54	56.6±5.3	56.3±5.1	0.57	46.9±3.7	46.9±3.6	0.8	0.16
SBP (mmHg)	134±4	135±4	0.66	142±5	139±4	0.63	125±6	131±8	0.14	0.031
DBP (mmHg)	72±2	72±2	0.72	73±2	73±3	1.0	71±3	72±2	0.56	0.70

Table 2: Functional fitness measures (muscular endurance, mobility/agility, flexibility, & balance) after 24 weeks of training

Variable(s)	Baseline (Mean ± S.D.)	24 Weeks (Mean ± S.D.)	*P*-Value
30 sec. Chair Stands (#)	12 ± 1	15 ± 1	<0.001
30 sec. Arm Curls (#)	19 ± 1	22 ± 1	<0.001
2 min. Step Test	92 ± 4	96 ± 6	0.51
Sit & Reach (cm)	-0.92 ± 2.4	0.45 ± 2.1	0.41
8 Foot Up & Go (sec.)	6.24 ± 0.3	5.88 ± 0.3	0.04
Back Scratch Stretch (cm)	-9.1 ± 3.2	-10.1 ± 2.0	0.79
Floor to Stand (sec.)	4.24 ± 0.6	3.7 ± 0.4	0.07
Max Effort Push-ups (#)	22 ± 3	24 ± 4	0.36
Max Effort Sit-ups (#)	8 ± 3	11 ± 3	0.03
Y-Balance Rt. (% leg length)	78.6 ± 5.8	85.5 ± 4.9	<0.01
Y-Balance Lt. (% leg length)	75.6 ± 5.3	81.0 ± 5.6	0.04

Conclusions & Limitations

- 24-weeks of bioDensity™ training significantly improved strength in 3 of 4 exercises (Chest Press = 30%; Leg Press = 87%; and Vertical Lift = 69%).
- Accompanying the improved strength were favorable changes in muscular endurance (chair stands, arm curls, sit-ups), mobility and agility (8 foot up & go), and balance (right and left sides).
- Surprisingly, measure of glycemic control, with no change in body weight/composition, improved: 7.4% reduction in FPG and 5.0% reduction in HbA_1C.
  - The study was not powered for between group comparisons (T2D vs. prediabetes), however the within group results are worth noting:
    - FPG changed from 140 to 129 mg/dL in T2D (*P*<0.05) and 104 to 93 mg/dL in prediabetics (not significant)
    - HbA_1C changed from 7.03 to 6.62% in T2D (*P*<0.05) and 5.87 to 5.57% in prediabetics (not significant)
- The collective results are encouraging considering the low weekly volume (once per week, 20 seconds maximal-voluntary effort) and suggest that further research via a randomized controlled trial is warranted due to the observed improvement in glycemic control and functional fitness measures.
- *Limitations* to this research that should be considered when interpreting the findings. First, in the absence of a non-exercise control group our findings cannot be solely attributed to bioDensity™ training. Second, while diabetes pharmacotherapy was stable (identical) at baseline and 24-weeks, it is possible that changes observed in FPG and HbA_1C were due, at least, in part to pharmacotherapy and the additive effect of bioDensity™ training is unknown. Finally, participants self-reported diet and no significant changes (baseline and 24-weeks) were noted; in the absence significant change in body weight/composition, it would appear that diet and other physical activity were constant. However, diet and physical activity outside of weekly bioDensity™ training were not objectively measured.