

# Effect of a Low-Resource-Intensive Lifestyle Modification Program Incorporating Gymnasium-Based and Home-Based Resistance Training on Type 2 Diabetes Risk in Australian Adults

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**OBJECTIVE** — The purpose of this study was to assess the effectiveness of a low-resource-intensive lifestyle modification program incorporating resistance training and to compare a gymnasium-based with a home-based resistance training program on diabetes diagnosis status and risk.

**RESEARCH DESIGN AND METHODS** — A quasi-experimental two-group study was undertaken with 122 participants with diabetes risk factors; 36.9% had impaired glucose tolerance (IGT) or impaired fasting glucose (IFG) at baseline. The intervention included a 6-week group self-management education program, a gymnasium-based or home-based 12-week resistance training program, and a 34-week maintenance program. Fasting plasma glucose (FPG) and 2-h plasma glucose, blood lipids, blood pressure, body composition, physical activity, and diet were assessed at baseline and week 52.

**RESULTS** — Mean 2-h plasma glucose and FPG fell by 0.34 mmol/l (95% CI -0.60 to -0.08) and 0.15 mmol/l (-0.23 to -0.07), respectively. The proportion of participants with IFG or IGT decreased from 36.9 to 23.0% ( $P = 0.006$ ). Mean weight loss was 4.07 kg (-4.99 to -3.15). The only significant difference between resistance training groups was a greater reduction in systolic blood pressure for the gymnasium-based group ( $P = 0.008$ ).

**CONCLUSIONS** — This intervention significantly improved diabetes diagnostic status and reduced diabetes risk to a degree comparable to that of other low-resource-intensive lifestyle modification programs and more intensive interventions applied to individuals with IGT. The effects of home-based and gymnasium-based resistance training did not differ significantly.

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**R**eductions in diabetes incidence of 42–58% in lifestyle modification groups compared with control groups have been reported in randomized controlled studies of individuals with impaired glucose tolerance (IGT) (1–3). All subjects in these studies had IGT, but

those with other recognized risk factors such as elevated BMI, elevated waist circumference, a history of high plasma glucose, physical inactivity, and poor diet (4,5) but without IGT were excluded. These studies involved considerable intervention efforts including individual-

ized counseling, tailored physical activity guidance, individual case manager meetings, supervised group exercise, home visits, additional group classes, loans of exercise equipment, exercise club membership, and inter-session support (1–3,6), which may not be sustainable in clinical practice (6).

The applicability of these findings needs testing in “real-world” clinical settings using less resource-intensive interventions (6,7). Recent studies of the effectiveness of low-resource-intensive lifestyle modification interventions (8,9) have yielded inconsistent findings. The Good Ageing in Lahti Region (GOAL) study (8) with individuals at risk of type 2 diabetes but not necessarily with IGT reported reductions in many diabetes risk factors at 12 months but no beneficial effect on fasting plasma glucose (FPG) or postload glucose (2-h plasma glucose) levels. In the Greater Green Triangle Study (GGTS) significant reductions were reported (for program completers only) in FPG, 2-h plasma glucose, weight, and waist circumference (9). Also, in contrast to the landmark Finnish Diabetes Prevention Study (FDPS), which provided gym memberships for regular resistance training, neither the GOAL study nor the GGTS included structured resistance training. This difference is important because resistance training has been shown to reduce plasma glucose levels in individuals with IGT (10) and type 2 diabetes (11).

Previously effective interventions (1–3,8,9) were based in clinical settings, which may reduce access for socioeconomically disadvantaged or geographically isolated groups, both of whom have a relatively high risk of diabetes (12). Home-based interventions with appropriate professional support could address these barriers (13).

The primary goal of the Ballarat Diabetes Prevention Pilot Initiative (BDPPI) was to assess the effectiveness of a low-

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resource-intensive lifestyle modification program incorporating resistance training on diabetes diagnosis status and risk in individuals at elevated risk of diabetes (but not necessarily with IGT). The secondary goal was to compare the effectiveness of gymnasium-based and home-based resistance training programs.

## RESEARCH DESIGN AND METHODS

The BDPPPI methodology was based on National Evidence Based Guidelines for the Management of Type 2 Diabetes Mellitus developed by the Australian National Health and Medical Research Council (NHMRC) (7). When the NHMRC guidelines provided only general guidance, other appropriate methods and targets were adopted (14–16). University and health service human research ethics committees approved the study.

A total of 122 adults were recruited from the regional city of Ballarat (population 86,977) in the state of Victoria, Australia. The 52-week BDPPPI used a quasi-experimental two-group repeated-measures design.

### Recruitment and eligibility

Participants were recruited through a media campaign and promotional materials distributed in socioeconomically disadvantaged localities. Primary health care professionals were encouraged to refer eligible participants.

Eligibility criteria were based on the NHMRC guidelines on diabetes case detection and diagnosis (7) and included individuals with IGT or impaired fasting glucose (IFG), Aboriginal or Torres Strait Islanders aged  $\geq 35$  years, individuals from the Pacific Islands or Indian subcontinent or of Chinese origin aged  $\geq 35$  years, individuals aged  $\geq 45$  years who were either obese (BMI  $\geq 30$  kg/m<sup>2</sup>) or hypertensive or both, individuals with clinical cardiovascular disease (myocardial infarction, angina, or stroke), obese women with polycystic ovary syndrome, women with previous gestational diabetes mellitus, individuals aged  $\geq 55$  years, and individuals aged  $\geq 45$  years who had a first-degree relative with type 2 diabetes (7). Participants with medically unstable conditions, those with uncorrected visual or hearing impairment, and those unable to attend regularly were excluded.

### Intervention

Consistent with previous diabetes prevention trials (1,2,9), the 12-month inter-

vention had participant goals of loss of  $>5\%$  of body weight,  $\geq 150$  weighted minutes and  $\geq 5$  sessions of at least moderate physical activity each week (in addition to the resistance training program), and a diet with a fat content  $<30\%$  and saturated fat content  $<10\%$  of total energy intake.

**Self-management education program (weeks 1–6).** The intervention started with six 1.5-h group education sessions conducted in a regional, clinical outpatient facility. This program used self-management principles (17) to develop participant problem-solving, decision-making, self-monitoring, goal-setting, and thought/emotion management skills (17,18). Motivational interviewing components (e.g., decisional balance and motivational scaling) were also used to strengthen commitment to change (19). This program was group based, consistent with self-management principles, which propose that modeling and social persuasion can enhance self-efficacy and therefore the capacity of individuals to maintain behavior change (17).

Sessions included physical activity and dietary components prepared and presented jointly by a dietitian, a psychologist, and an exercise therapist to groups of 15–20. Following the Australian National Physical Activity Guidelines (15), the aerobic physical activity component of the program focused on encouraging participants to achieve  $\geq 5$  sessions and  $\geq 150$  weighted minutes per week of physical activity of at least moderate intensity. The dietary component was based on the principles of the Commonwealth Scientific and Industrial Research Organisation's Total Well Being Diet (16). Participants were provided with a booklet describing the diet and tools to use to promote compliance with the diet. Strategies to assist participants to achieve the nutrition recommendations included food label reading, meal planning, and recipe modification (supplemental Table A, available in an online appendix at <http://dx.doi.org/10.2337/dc08-0152>.)

**Resistance training programs (weeks 7–18).** Participants were assigned to either a gymnasium-based or a home-based 12-week resistance training program after the self-management education program. For convenience, family members were assigned to the same resistance training setting. Allocation of individuals/families to resistance training settings was randomized. Participants were advised to do at least two, but ideally three, resistance

training sessions per week and to achieve the aerobic physical activity goals for the BDPPPI.

The gymnasium-based resistance training program was conducted in the clinical outpatient facility of a hospital and was informed by the protocol of Dunstan et al. (11), consisting of 45 min of high-intensity resistance training and 5 min each of low-intensity aerobic warm-up and cool-down and stretching exercises. The program used eight exercise stations, each focused on selected major muscle groups. One-repetition maximum (1RM) chest and leg press tests were conducted during weeks 7–8 to determine training load. The program was offered up to 12 times per week; the average staff-to-participant ratio was 1:15.

During weeks 7–10, gymnasium-based participants increased their workload to three sets of 10 repetitions, at 60% 1RM or rating of perceived exertion (RPE) (20) of 3–6. In weeks 11–14, participants progressed to four sets of 10 repetitions, at 75–85% 1RM or RPE of 7–9. During weeks 15–18, participants increased the weight lifted as tolerated and were encouraged to achieve four sets of 10 repetitions at 85% 1RM. Participants rested for up to 30 s between sets. Ongoing progress review was provided. During weeks 16–18, participants planned their postprogram aerobic and resistance training activities.

In the home-based program, resistance training was made comparable to that of the gymnasium-based program through careful selection of exercises and exercise progressions, using body weight exercises and conveniently available hand-held weights (e.g., cans of food, weighing  $\sim 500$  g). During weeks 7–12, home-based participants progressed to four sets of 10 repetitions with RPE of 3–6. During weeks 13–18, Theraband and Swiss Ball exercises were introduced. Participants attempted these more challenging exercises when their existing exercise RPE was  $<5$ . Home-based participants were telephoned in week 8 (exercise therapist), week 10 (dietitian), and week 15 (psychologist) to review progress. They also attended a 2-h review in week 12.

**Maintenance program (weeks 19–52).** The intervention included a 34-week maintenance program. Participants were encouraged to continue the recommended regimen and to attend three 2-h group reinforcement sessions. They were also sent two newsletters containing self-

management, healthy eating, and physical activity advice (supplemental Table B, available in the online appendix).

### Assessment tools

Assessments were conducted at baseline (week 1) and at week 52 using the following tools. Intermediate assessments of all but the plasma glucose and dietary indicators were also conducted at week 6 and/or week 18.

**Plasma glucose.** FPG and 2-h plasma glucose levels were determined through a standard 75-g oral glucose tolerance test (OGTT). Samples were analyzed using standard laboratory methods in two nationally accredited laboratories.

**Cardiovascular disease indicators.** Blood pressure was measured in a resting seated position. Blood lipids were assessed using standard laboratory methods in two nationally accredited laboratories.

**Body composition measures.** The following were measured: height (centimeters), weight (kilograms) using electronic scales (Transcell Technology T1500), BMI (weight in kilograms divided by the square of height in meters), and waist circumference (centimeters) using nonelastic measuring tape at the midpoint between the lower border of the rib cage and iliac crest.

**Physical activity measures.** A questionnaire-based self-report was used to monitor sessions per week and weighted minutes per week (15).

**Dietary measures.** Participants completed a food frequency questionnaire, including total energy intake (kilojoules per day), total fat (percent), saturated fat (percent), and fiber (grams) (21).

**Diabetes status.** Following the NHMRC guidelines (7), diabetes classification was based on FPG and 2-h plasma glucose, with one variation: all but four BDPPi participants were administered the OGTT regardless of their FPG (according to the NHMRC guidelines an OGTT is done only if FPG  $\geq 5.5$  mmol/l). Consequently, 19 participants with FPG  $< 5.5$  mmol/l, who would have been classified as "diabetes unlikely" according to the NHMRC guidelines, were classified as having IGT on the basis of the measured 2-h plasma glucose. The categories and respective criteria (in millimoles per liter) used in the BDPPi were the following: diabetes unlikely (FPG  $< 5.5$  and 2-h plasma glucose unknown or FPG  $< 6.1$  and 2-h plasma glucose  $< 7.8$ ), IFG (6.1  $\leq$  FPG  $\leq 6.9$  and 2-h plasma glucose  $< 7.8$ ), IGT (FPG  $\leq 6.9$  and 7.8  $\leq$  2-h plasma glucose

$\leq 11.0$ ), and diabetes (FPG  $\geq 7.0$  or 2-h plasma glucose  $\geq 11.1$ ).

### Statistical design and analysis

The recruitment target was set at 128. By assuming an SD of 2.0 mmol/l (2), with a two-sided significance level of 0.05, this provided power of 0.80 for detecting a mean change of 0.5 mmol/l in 2-h plasma glucose from baseline to postintervention, representing an effect size of 0.25, and power of 0.80 for detecting a difference of 1.0 mmol/l in the mean change in 2-h plasma glucose between two resistance training settings (each  $n = 64$ ), representing an effect size of 0.5.

Baseline to postintervention changes in key indicators were tested using repeated-measures ANOVAs. Resistance training group differences were tested using independent samples *t* tests at baseline and for baseline to postintervention changes. Changes in proportions were tested using McNemar-Bowker  $\chi^2$  tests. Differences between proportions in resistance training groups were tested using Pearson  $\chi^2$  tests.

The basis of the analysis was intention to treat (ITT). The designated postintervention data collection point was week 52. In individuals for whom no week 52 data were available (lost to follow-up), the last available data were carried forward. The extent to which this was done is indicated under COMPLIANCE AND ADHERENCE.

## RESULTS

### Baseline participant characteristics

A total of 122 participants (78% women) with a mean  $\pm$  SD age of 52.6  $\pm$  8.6 years commenced the program. Participants had completed 13.6  $\pm$  2.9 years of full-time education and had occupational classifications of managers and administrators (7.3%), professionals and associate professionals (51.1%), and trades/clerical and other (41.6%) (22).

The diabetes risk score of participants was 16.0  $\pm$  3.5 ( $n = 122$ ), equating to a one in three chance of developing type 2 diabetes during the following 10 years (5). The baseline FPG and 2-h plasma glucose classified 63.1% of the participants as being diabetes unlikely, 4.9% as having IFG, and 32.0% as having IGT ( $n = 122$ ). One individual with diabetes was referred to a diabetes education program and excluded from the study.

### Changes in key measures

Table 1 shows the changes in the key measures of interest from baseline to postint-

ervention. For 2-h plasma glucose and FPG, results are also shown for participants with and without IGT at baseline. As a consequence of the real-world setting, not all baseline measurements were obtained for all participants and so even with baseline data being carried forward in the ITT analysis, the full sample size of  $n = 122$  was not achieved for all measures.

### Changes in proportions of participants in key clinical categories

Table 2 shows the proportions of participants who achieved clinically significant targets or fell into particular clinical categories at baseline and postintervention. Key changes included significant reductions in the proportion of participants who had IFG or IGT or who were obese class II or III, insufficiently physically active, or hypertensive. There were also significant increases in the proportions who met body composition and dietary goals.

### Resistance training groups

The two resistance training groups were gymnasium-based ( $n = 62$ ) and home-based ( $n = 60$ ). The only statistically significant difference between resistance training groups was in systolic blood pressure, which was reduced significantly more for gymnasium-based than for home-based participants (mean changes  $-13.98$  and  $-7.07$ ;  $P = 0.046$ ). For all key variables except HDL cholesterol, the difference between the mean change scores of the two resistance training groups was smaller in magnitude than (and in most cases  $< 50\%$  of) the mean change from baseline to postintervention. Furthermore, the differences were not all in the same direction. For 14 of the 18 key variables the gymnasium-based group achieved better results than the home-based group, and the reverse occurred for 4 variables, including 1 of the primary outcome measures (fasting blood glucose) (supplemental Table C, available in the online appendix). There were no statistically significant differences between the resistance training groups with regard to key clinical targets or categories at either baseline or postintervention (supplemental Table D, available in the online appendix).

### Compliance and adherence

Program adherence was assessed by proxy on the basis of compliance with participation in clinical measurements

Table 1—Changes in key measures

Measure	n*	Week	Mean ± SD	Change from baseline	95% CI for change in the mean	P value
Plasma glucose						
All participants FPG (mmol/l)	122	Baseline	5.30 ± 0.52			
		Postintervention	5.15 ± 0.58	−0.15	−0.23 to −0.07	0.001
2-h plasma glucose (mmol/l)	118	Baseline	6.73 ± 1.75			
		Postintervention	6.39 ± 1.83	−0.34	−0.60 to −0.08	0.011
Participants with IGT at baseline						
FPG (mmol/l)	39	Baseline	5.52 ± 0.55			
		Postintervention	5.33 ± 0.65	−0.19	−0.39 to 0.01	0.063
2-h plasma glucose (mmol/l)	39	Baseline	8.82 ± 0.85			
		Postintervention	7.88 ± 1.79	−0.94	−1.46 to −0.42	0.001
Participants without IGT at baseline						
FPG (mmol/l)	83	Baseline	5.20 ± 0.47			
		Postintervention	5.07 ± 0.53	−0.13	−0.22 to −0.05	0.003
2-h plasma glucose (mmol/l)	79	Baseline	5.70 ± 0.98			
		Postintervention	5.66 ± 1.35	−0.04	−0.32 to 0.23	0.763
Cardiovascular						
Systolic blood pressure (mmHg)	119	Baseline	148.21 ± 22.82			
		Postintervention	137.72 ± 19.42	−10.50	−13.94 to −7.05	<0.001
Diastolic blood pressure (mmHg)	119	Baseline	82.12 ± 11.85			
		Postintervention	78.09 ± 11.04	−4.03	−5.92 to −2.15	<0.001
Total cholesterol (mmol/l)	120	Baseline	5.53 ± 1.09			
		Postintervention	5.30 ± 1.03	−0.23	−0.36 to −0.10	0.001
Triglycerides (mmol/l)	120	Baseline	1.74 ± 0.83			
		Postintervention	1.58 ± 0.75	−0.17	−0.28 to −0.05	0.004
HDL cholesterol (mmol/l)	101	Baseline	1.32 ± 0.35			
		Postintervention	1.34 ± 0.35	0.02	−0.03 to 0.06	0.422
LDL cholesterol (mmol/l)	98	Baseline	3.44 ± 0.97			
		Postintervention	3.23 ± 0.93	−0.21	−0.36 to −0.06	0.005
Cholesterol-to-HDL ratio	100	Baseline	4.40 ± 1.22			
		Postintervention	4.20 ± 1.26	−0.21	−0.34 to −0.07	0.003
Body composition						
Weight (kg)	122	Baseline	96.19 ± 21.11			
		Postintervention	92.12 ± 21.71	−4.07	−4.99 to −3.15	<0.001
BMI (kg/m <sup>2</sup> )	122	Baseline	35.03 ± 6.80			
		Postintervention	33.57 ± 7.13	−1.46	−1.81 to −1.11	<0.001
Waist circumference (cm)	120	Baseline	109.76 ± 15.02			
		Postintervention	105.08 ± 16.05	−4.68	−5.89 to −3.47	<0.001
Physical activity						
Physical activity (sessions/week)	116	Baseline	4.65 ± 3.85			
		Postintervention	7.73 ± 11.33	3.09	0.98 to 5.19	0.004
Physical activity (weighted min/week)	116	Baseline	253.10 ± 297.20			
		Postintervention	334.98 ± 314.36	81.88	22.93 to 140.83	0.007
Dietary						
Total energy intake (kJ/day)	121	Baseline	8,987 ± 4,457			
		Postintervention	7,929 ± 4,037	−1,057	−1,570 to −544	<0.001
Total fat (%)	121	Baseline	35.54 ± 4.78			
		Postintervention	33.41 ± 5.44	−2.13	−2.96 to −1.30	<0.001
Saturated fat (%)	121	Baseline	14.08 ± 2.75			
		Postintervention	12.65 ± 2.83	−1.43	−1.88 to −0.97	<0.001
Fiber (g)	121	Baseline	25.17 ± 10.97			
		Postintervention	24.91 ± 9.42	−0.25	−1.72 to 1.21	0.732

\*ITT analysis. Postintervention values were from week 52 wherever available. Otherwise, the last available data (week 18, week 6, or baseline) were used. Sample sizes <122 indicate that data were not collected for all participants at baseline.



Table 2—Changes in proportions of participants in key clinical categories

	n*	Proportions (%)		
		Baseline	Postintervention	P value
Diabetes diagnostic status	122			0.006
Diabetes unlikely		63.1	77.0	
IFG		4.9	1.6	
IGT		32.0	20.5	
Diabetes		0.0	0.8	
BMI criteria	122			<0.001
Normal (18.5–24.9 kg/m <sup>2</sup> )		4.1	9.8	
Overweight (25.0–29.9 kg/m <sup>2</sup> )		18.0	22.1	
Obesity class I (30.0–34.9 kg/m <sup>2</sup> )		32.8	34.4	
Obesity class II (35.0–39.9 kg/m <sup>2</sup> )		24.6	17.2	
Obesity class III (>40 kg/m <sup>2</sup> )		20.5	16.4	
Weight decreased by at least 5%	122	—†	39.3‡	—†
Waist circumference ≤100 cm (men) or ≤90 cm (women)	120	9.2	20.8	<0.001
Physical activity (≥5 sessions/week and ≥150 weighted min/week)	116	29.3	55.2	<0.001
Hypertensive (SBP ≥140 or DBP ≥90 or BP medication)	117	75.2	65.8	0.007
All fat (<30% of total energy intake)	121	11.6	20.7	0.003
Saturated fat (<10% of total energy intake)	121	5.0	18.2	<0.001

\*ITT analysis. Postintervention values were from week 52 wherever available. Otherwise, the last available data (week 18, week 6, or baseline) were used. Sample sizes <122 indicate that data were not collected for all participants at baseline. †The weight target was framed, not in absolute terms, but in terms of a decrease from the baseline weight. Hence there was no baseline proportion with which to compare the proportion who achieved the target postintervention. Instead, a CI is provided for the proportion postintervention. ‡95% CI 30.5–47.7%. SBP, systolic blood pressure; DBP, diastolic blood pressure; BP, blood pressure.

and completion of questionnaires at week 52. Of 122 participants at baseline, 98 (80.3%) participated in clinical assessments at week 52 and 84 (68.9%) completed questionnaires ( $P < 0.001$ ). This difference in clinical and questionnaire compliance rates may have been due to participants having greater personal responsibility for completion and return of questionnaires and hence a lower level of compliance. The clinical compliance rate is considered to be more indicative of adherence to the program per se than the questionnaire compliance rate. There were no significant differences between compliers and noncompliers in key measures at baseline.

There were significant differences between gymnasium-based and home-based resistance training groups in clinical (55 individuals [88.7% of  $n = 62$ ] vs. 43 individuals [71.7% of  $n = 60$ ];  $P = 0.016$ ) and questionnaire (48 individuals [77.4% of  $n = 62$ ] vs. 36 [60.0% of  $n = 60$ ];  $P = 0.030$ ) compliance. These differences in compliance may have been greater than the actual differences in adherence to the intervention because the gymnasium-based group may have been more willing to attend the facility for mea-

surement purposes than the home-based group, as they were more familiar with the facility and program staff. If we assume “positive” (i.e., beneficial) changes in key measures in both resistance training groups, this differential compliance is also likely to bias the ITT-based comparisons between resistance training groups in favor of the gymnasium-based group because calculated mean changes will be more attenuated for the home-based group than for the gymnasium-based group owing to the higher proportion of baseline data being carried forward in the case of the home-based group.

**CONCLUSIONS**— Given the previous inconsistency of findings about the effect of low-resource-intensive lifestyle modification diabetes preventions on diabetes risk among those with an already elevated diabetes risk (8,9), the findings of the BDPPI study should provide practitioners with greater confidence in offering such programs in real-world clinical settings. These findings also support those of previous randomized controlled studies that were more resource intensive (1–3).

The methodology used in the BDPPI

was substantially informed by the FDPS (2) and was similar to that used in the GGTS (9). However, there were several important differences between the BDPPI and the FDPS or the GGTS. First, the baseline diabetes status of BDPPI and FDPS participants differed (in FDPS all had IGT and in BDPPI 32.0% had IGT and 4.9% had IFG). Second, fewer intervention resources were used for the BDPPI than were used for the FDPS. Compared with the GGTS, although both studies included six structured 90-min group sessions, the BDPPI sessions were conducted over 6 weeks compared with the GGTS program of five sessions within the first 3 months and the sixth session at 8 months. In addition, both the BDPPI and the FDPS included resistance training and the BDPPI incorporated a three-session and two-newsletter maintenance program. Statistical analyses were based on ITT for BDPPI and FDPS and on completers for FDPS and GGTS.

Methodological differences aside, the BDPPI, the FDPS (2), and the GGTS (9) all reported significant decreases in mean FPG (BDPPI 0.15 mmol/l for all participants and 0.19 mmol/l for participants with IGT at baseline, FDPS 0.22 mmol/l, and GGTS 0.14 mmol/l) and mean 2-h plasma glucose (BDPPI 0.34 mmol/l for all participants and 0.94 mmol/l for participants with IGT at baseline, FDPS 0.84 mmol/l, and GGTS 0.58 mmol/l). The 95% CIs for the changes in both measures in the BDPPI (Table 1), the FDPS (2), and the GGTS (9) suggest that there were no significant differences among the plasma glucose concentration outcomes achieved in participants with IGT in the three studies over a similar 12-month period.

In addition, all three studies demonstrated significant reductions in mean values of body weight, BMI, and waist circumference (2,9,23). The published means suggest that the changes achieved in mean body weight and BMI were considerably greater for BDPPI participants (4.2% in each case) than for GGTS participants (2.7% and 2.8%, respectively) (9).

With one exception (systolic blood pressure), the changes measured in the two resistance training groups did not exhibit statistically significant differences. Although it is acknowledged that the power to detect a difference between the two groups was limited, for most key variables, the differences between the changes in the two groups were considerably smaller in magnitude than the overall change from baseline to postintervention,

and the group differences were not consistently in one direction. This lack of substantial differences in outcomes suggests that home-based participation has an effect similar to that of gymnasium-based participation in reducing diabetes risk. This result is encouraging for anyone unwilling or unable to attend gymnasium-based programs and for service providers without the capacity to offer gymnasium-based programs. These results support those reported by King et al. (13), who found that home-based older adult exercise training participants achieved improvement in treadmill exercise test performance similar to those of community facility-based participants. However, the BDPPI home-based participants displayed lower compliance levels than the gymnasium-based participants. This finding contrasts with the findings of King et al. (13) that home-based exercise training participants had better 12-month adherence rates than community facility-based participants and suggests that the home-based BDPPI participants did not receive sufficient ongoing support to maximize adherence.

The BDPPI results are potentially important within a broader public health context. In addition to reducing diabetes risk, the intervention had a positive impact on a range of clinical indicators pertaining to obesity and cardiovascular disease. These results have implications for other aspects of public health, above and beyond the demonstrated reduction in diabetes risk.

As with other studies (9,24), a “no treatment” control was not included in the BDPPI study design because it was considered inappropriate to do so given existing evidence that lifestyle modifications effectively reduce diabetes risk (1–3,9). Rather, a novel treatment (home-based resistance training) was compared with a traditional treatment (gymnasium-based resistance training). However, it should be noted that changes in the proportions of BDPPI participants in some key diabetes risk categories were counter to Australian population trends reported for a similar period. From 1999/2000 to 2004/2005, the incidence of obesity (BMI  $\geq 30$  kg/m<sup>2</sup>) in Australia increased by 1.9% per year (95% CI 1.8–2.1), and the incidence of hypertension increased by 3.0% per year (95% CI 2.8–3.2) (25). Clearly, the decreases in obesity and hypertension among BDPPI participants were substantially different from these Australian community trends. In addition,

the proportion of BDPPI participants who undertook sufficient physical activity rose from 29.3 to 55.2% and was counter to the trend for the Australian adult population aged 45–59 years from 1997 to 2000, which saw the proportion of individuals undertaking sufficient physical activity decrease from 53.8 to 49.7% (15).

The study design did not enable a test of the relative contributions of different intervention components (e.g., self-management education, dietary change, physical activity change, or weight loss) to the reduction in diabetes risk. Furthermore, it is acknowledged that the findings of this study are only directly applicable to the Australian health care system and that individuals with low socioeconomic position were underrepresented. Nevertheless, the underlying principles of reducing costs and improving access by providing less-resource-intensive lifestyle modification diabetes prevention programs incorporating group-based self-management education and home-based resistance training are widely generalizable.

It is also acknowledged that the use of carried forward data in the ITT analysis assumes no further change after the last observation, which may result in an under- or overestimate of the true outcome, depending on the subsequent unobserved behavior of the noncomplier. A noncomplier may have either adhered or not adhered to the intervention program and either improved or worsened their profile.

The BDPPI findings regarding the effectiveness of home-based resistance training settings may lead to the provision of less-resource-intensive and therefore more cost-effective (24) diabetes prevention interventions. They also offer the potential to overcome some of the access barriers (e.g., dislike of gymnasiums, cost, or transport) for participants, particularly those with limited financial resources or those who are geographically isolated, by enabling home-based participation using relatively inexpensive equipment. However, in future similar programs strategies to improve adherence among home-based participants should be implemented and evaluated.

This low-resource-intensive group program, conducted in a real-life setting and focused upon the development of self-management skills to improve participants' capacity to engage in evidence-

based nutrition and physical activity (walking plus resistance training) programs, reduced diabetes risk. Further, there was no evidence that supervised resistance training offered greater benefits than those achieved in home-based programs. This finding may increase the access of individuals at risk of diabetes to effective risk reduction programs.

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