# Weight Loss of Black, White, and Hispanic Men and Women in the Diabetes Prevention Program

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**Objective:** To provide the specific weight loss outcomes for African-American, Hispanic, and white men and women in the lifestyle and metformin treatment arms of the Diabetes Prevention Program (DPP) by race–gender group to facilitate researchers translating similar interventions to minority populations, as well as provide realistic weight loss expectations for clinicians.

**Methods and Procedures:** Secondary analyses of weight loss of 2,921 overweight participants (22% black; 17% Hispanic; 61% white; and 68% women) with impaired glucose tolerance randomized in the DPP to intensive lifestyle modification, metformin or placebo. Data over a 30-month period are examined for comparability across treatment arms by race and gender.

**Results:** Within lifestyle treatment, all race–gender groups lost comparable amounts of weight with the exception of black women who exhibited significantly smaller weight losses ($P < 0.01$). For example, at 12 months, weight losses for white men (–8.4%), white women (–8.1%), Hispanic men (–7.8%), Hispanic women (–7.1%), and black men (–7.1%) were similar and significantly higher than black women (–4.5%). In contrast, within metformin treatment, all race–gender groups including black women lost similar amounts of weight. Race–gender specific mean weight loss data are provided by treatment arm for each follow-up period.

**Discussion:** Diminished weight losses were apparent among black women in comparison with other race–gender groups in a lifestyle intervention but not metformin, underscoring the critical nature of examining sociocultural and environmental contributors to successful lifestyle intervention for black women.

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## INTRODUCTION

The Diabetes Prevention Program (DPP), a randomized, controlled, multicenter trial, examined the effects of intensive lifestyle and metformin, compared with placebo, in delaying or preventing type 2 diabetes in high-risk individuals with impaired glucose tolerance (1). Intensive lifestyle intervention was demonstrated to be significantly more effective than metformin in reducing the risk of developing diabetes (1). The lifestyle intervention arm produced an average 7% weight reduction (2) and reduced diabetes incidence by 58% compared to placebo (1). Metformin treatment produced a 31% reduction in type 2 diabetes compared with placebo (1), as well as an average modest weight loss of 2.1 kg (1). The success of this landmark trial in preventing diabetes onset and promoting meaningful weight loss has provided a platform for translation which has the potential to make substantive reductions in the concurrent diabetes (3) and obesity epidemics (4,5).

The DPP offers one of the few rigorous tests of different obesity treatment modalities in a large sample of ethnically and racially diverse individuals across the United States. Significant inequalities in weight loss, particularly among black individuals, have been demonstrated in lifestyle interventions in previous trials (6–8) but recent data are lacking, as are data for Hispanics. In addition, there have been no reports published which allow broad race–gender comparisons in weight loss produced by pharmacological and behavioral obesity treatments within a diverse population enrolled in a single trial. Although not included in the DPP as an obesity treatment agent *per se*, the pharmacological agent that was the intervention in one DPP study arm (metformin) has been widely discussed as a pharmacological approach to obesity management (an off-label indication that has generated particular interest for obese individuals with impaired glucose tolerance) (9). Thus, the DPP study permits a unique opportunity to evaluate the weight loss experiences of different racial/ethnic groups

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and genders engaged in different obesity treatment modalities within the same randomized trial.

Finally, as research emerges seeking to redress rising rates of overweight and obesity and improve available obesity interventions, sound estimates of outcomes achieved with the DPP treatment methods will be critical in informing the next generation of obesity treatment research. Available reports from the DPP offer baseline BMI by race–gender groups (10) and data on the proportion of individuals who met the study goal of a 7% weight loss (2), but do not provide the actual weight loss data by race/ethnic–gender groups. Research evaluating the translation of the DPP intervention methods to communities of color will find the detailed information of weight losses and variability within the race–gender groups to be of considerable assistance. Consequently, the current investigation examined the race–gender specific patterns of weight loss across two distinct treatment modalities in a large ethnically diverse sample using DPP data available from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) Data Repository (11).

## METHODS AND PROCEDURES

### Participants and procedures

Full details describing the DPP study protocol and methods have been published elsewhere (12,13) and therefore are reviewed only briefly in this report. The trial was conducted at 27 clinical centers and randomized 3,234 participants between June 1996 and May 1999. Main study eligibility criteria included a BMI (weight (kg)/height (m)$^2$) of ≥24, age ≥25 years, and impaired glucose tolerance, defined as plasma glucose concentration of 95–125 mg/dl (5.3–6.9 mmol/l) in fasting state and 140–199 mg/dl (7.8–11.0 mmol/l) 2 h after a 75-g oral glucose load (12). Written consent was obtained at clinical centers following guidelines of their respective institutions.

Standardized study protocols were followed at each site. Participants were weighed in street clothes without shoes on a calibrated scale. Height was assessed using a wall-mounted stadiometer. Measures were taken in duplicate and the average was used to calculate BMI. Body weight data were collected at 6-month intervals. Self-reported race or ethnicity, age, and gender were collected using interviewer-administered questionnaires at baseline only. Eligible participants were randomly assigned to one of the three intervention arms: standard lifestyle recommendations plus metformin (Glucophage) at a dose of 850 mg twice daily (metformin), standard lifestyle recommendations plus placebo twice daily (placebo), or an intensive program of lifestyle modification (lifestyle). The intensive lifestyle modification intervention has been outlined in detail in previous reports (13), as have the metformin and placebo treatment methods (1). In brief, the intensive lifestyle intervention followed a 16-session core curriculum that introduced behavior modification strategies to promote healthy dietary, and physical activity changes. The intensive core curriculum was delivered by case managers in individual sessions in a 6-month period and was followed by individual sessions (usually monthly) that reinforced behavioral changes and motivational campaigns with group and individual visits to sustain interest and maintain weight losses. Individual sessions continued bimonthly throughout the follow-up period. Intervention goals included 7% reduction in weight from baseline, at least 150 min moderate physical activity per week, and reduction of dietary fat to 25% of calories, with the addition of caloric restriction if weight loss was not achieved through fat reduction (14). Participants in the placebo and metformin groups had annual individual sessions focused on promoting healthy lifestyle behaviors which emphasized the importance of weight loss, recommended following a diet based on the Food Guide Pyramid and the National Cholesterol Education Program Step 1 diet guidelines and encouraged individuals to become more physically active, with written materials provided at the session. In addition, placebo and metformin participants attended quarterly visits to promote adherence and to obtain pill counts (1).

All DPP clinical sites provided de-identified data to the George Washington University Biostatistical Coordinating Center, which was then transferred to the NIDDK Data Repository at RTI International, Research Triangle Park, NC (11). The authors obtained the data in accordance with established policies. University of Arkansas for Medical Sciences Institutional Review Board approved this ancillary analysis of DPP data.

### Statistical analysis

DPP participants were followed at 6-month intervals for an average of 2.8 years (range, 1.8–4.6). This report focuses on weight change over a 30-month period to provide adequate sample sizes across the six race/ethnicity and gender groups under consideration. Weight loss outcomes up to 30-month follow-up were selected because two-thirds of all randomized participants reached this outcome data collection point. Retention rates to follow up body weight data collection were very high; 92.5% of the cohort attended a scheduled visit within 5 months of study end (1). Diminished sample sizes at the later follow-up points predominantly reflected study design rather than loss to follow up. Further, there was no differential attrition by study arm. Therefore, analyses were conducted using all available data, without imputation for values that might be missing or deleting incomplete observations. Only participants who self-identified as white, black, or Hispanic ($N$ = 2,921) were included in this analysis because sample sizes in other race/ethnic groups were very small after partitioning by gender (excluded $N$ = 313).

All analyses were performed using SAS v9 (SAS Institute, Cary, NC). Weight changes were calculated between baseline and every 6-month follow-up, up to 30 months, for all race and gender groups. Percent weight change with respect to baseline (calculated as 1.0 − (follow-up weight/baseline weight)) was compared by race/ethnicity and gender group across treatment conditions (metformin, lifestyle, and placebo). Percent weight change over time was modeled using a fixed-effects repeated measures model with unstructured covariance in SAS PROC MIXED, as that provided the best fit among several tested covariance structures. Quadratic time effect was tested and retained in all models as it was significant and improved model fit, particularly for subgroup models. Overall model was specified as follows:

$$\%\,\text{Weight change} = \text{treatment assignment} + \text{race} + \text{gender} + \text{time} + \text{time} \times \text{time} + \text{treatment assignment} \times \text{race} + \text{treatment assignment} \times \text{gender} + \text{treatment assignment} \times \text{race} \times \text{gender}.$$

We used the above specified model as well as several simplified versions to test all the interactions. As we also wanted to compare all race–gender groups, we subsequently combined the race and gender variables into one six-level variable, for pairwise contrasts. Those were performed using Tukey–Kramer adjustments for multiple comparisons. We also tested treatment effects within each race–gender category using a similar modeling strategy as described above with the same adjustments for multiple comparisons. All associations were considered significant at the α level of 0.05.

## RESULTS

Baseline characteristics of the 2,921 participants included in this report were similar across the three treatment conditions (Table 1).

Baseline weight by treatment group across the race–gender groups is presented in Table 2. Significant differences in proportion of obese participants were apparent by gender ($P$ < 0.0001) and racial groups ($P$ = 0.0076) such that women had higher proportion of obese participants than men (74% vs. 59%, respectively) and blacks had higher proportion of obese participants (74%) than Hispanics and whites

**Table 1 Baseline characteristics of overall sample and by race–gender groups**

| | Total | White men | White women | Black men | Black women | Hispanic men | Hispanic women |
|---|---|---|---|---|---|---|---|
| Overall | | | | | | | |
| Total (*n* (%)) | 2,921 (100.0) | 608 (20.8) | 1,160 (39.7) | 167 (5.7) | 341 (11.7) | 165 (5.6) | 480 (16.4) |
| Age (*n* (%)) | | | | | | | |
| <40 | 425 (14.6) | 53 (8.7) | 167 (14.4) | 28 (16.8) | 77 (22.6) | 12 (7.3) | 88 (18.3) |
| 40–49 | 1,017 (34.8) | 149 (24.5) | 442 (38.1) | 51 (30.5) | 138 (40.5) | 50 (30.3) | 187 (39.0) |
| 50–59 | 866 (29.7) | 186 (30.6) | 340 (29.3) | 56 (33.5) | 90 (26.4) | 58 (35.2) | 136 (28.3) |
| 60+ | 613 (21.0) | 220 (36.2) | 211 (18.2) | 32 (19.2) | 36 (10.6) | 45 (27.3) | 69 (14.4) |
| Weight (mean kg ± s.d.) | 95.4 ± 20.3 | 101.8 ± 19.5 | 93.7 ± 20.3 | 93.1 ± 17.3 | 84.5 ± 17.0 | 100.6 ± 19.6 | 98.4 ± 20.8 |
| BMI (*n* (%)) | | | | | | | |
| <30 | 903 (30.9) | 246 (40.5) | 324 (27.9) | 72 (43.1) | 94 (27.6) | 66 (40.0) | 101 (21.0) |
| 30–34.99 | 892 (30.5) | 204 (33.6) | 316 (27.2) | 58 (34.7) | 128 (37.5) | 62 (37.6) | 124 (25.8) |
| 35+ | 1,126 (38.6) | 158 (26.0) | 520 (44.8) | 37 (22.2) | 119 (34.9) | 37 (22.4) | 255 (53.1) |
| Follow up-sample size[a] | | | | | | | |
| 6 months | 2,782 | 581 | 1,117 | 159 | 315 | 154 | 456 |
| 12 months | 2,765 | 587 | 1,097 | 161 | 317 | 152 | 451 |
| 18 months | 2,681 | 570 | 1,071 | 156 | 310 | 145 | 429 |
| 24 months | 2,608 | 554 | 1,026 | 155 | 302 | 144 | 427 |
| 30 months | 1,970 | 425 | 781 | 119 | 226 | 107 | 312 |
| Lifestyle | | | | | | | |
| Total (*n* (%)) | 962 (100.0) | 199 (20.7) | 381 (39.6) | 58 (6.0) | 120 (12.5) | 50 (5.2) | 154 (16.0) |
| Age (*n* (%)) | | | | | | | |
| <40 | 159 (16.5) | 19 (9.6) | 65 (17.1) | 10 (17.2) | 27 (22.5) | 6 (12.0) | 32 (20.8) |
| 40–49 | 325 (33.8) | 44 (22.1) | 138 (36.2) | 20 (34.5) | 47 (39.2) | 10 (20.0) | 66 (42.9) |
| 50–59 | 258 (26.8) | 54 (27.1) | 107 (28.1) | 19 (32.8) | 29 (24.2) | 19 (38.0) | 30 (19.5) |
| 60+ | 220 (22.9) | 82 (41.2) | 71 (18.6) | 9 (15.5) | 17 (14.2) | 15 (30.0) | 26 (16.9) |
| Weight (mean kg ± s.d.) | 95.4 ± 20.8 | 100.5 ± 20.1 | 95.1 ± 21.2 | 95.7 ± 17.9 | 82.0 ± 14.8 | 104.4 ± 22.1 | 97.1 ± 20.8 |
| BMI (*n* (%)) | | | | | | | |
| <30 | 301 (31.3) | 92 (46.2) | 100 (26.3) | 25 (43.1) | 32 (26.7) | 15 (30.0) | 37 (24.0) |
| 30–34.99 | 298 (31.0) | 63 (31.7) | 101 (26.5) | 17 (29.3) | 50 (41.7) | 21 (42.0) | 46 (29.9) |
| 35+ | 363 (37.7) | 44 (22.1) | 180 (47.2) | 16 (27.6) | 38 (31.7) | 14 (28.0) | 71 (46.1) |
| Follow up-sample size[a] | | | | | | | |
| 6 months | 927 | 188 | 377 | 56 | 112 | 45 | 149 |
| 12 months | 911 | 192 | 367 | 54 | 111 | 43 | 144 |
| 18 months | 878 | 190 | 352 | 53 | 107 | 40 | 136 |
| 24 months | 857 | 182 | 344 | 53 | 106 | 41 | 131 |
| 30 months | 647 | 135 | 261 | 41 | 77 | 31 | 102 |
| Metformin | | | | | | | |
| Total (*n* (%)) | 985 (100.0) | 225 (22.8) | 377 (38.3) | 52 (5.3) | 110 (11.2) | 58 (5.9) | 163 (16.5) |
| Age (*n* (%)) | | | | | | | |
| <40 | 128 (13.0) | 14 (6.2) | 51 (13.5) | 12 (23.1) | 24 (21.8) | 4 (6.9) | 23 (14.1) |
| 40–49 | 338 (34.3) | 62 (27.6) | 141 (37.4) | 13 (25.0) | 43 (39.1) | 19 (32.8) | 60 (36.8) |
| 50–59 | 317 (32.2) | 77 (34.2) | 120 (31.8) | 18 (34.6) | 32 (29.1) | 16 (27.6) | 54 (33.1) |
| 60+ | 202 (20.5) | 72 (32.0) | 65 (17.2) | 9 (17.3) | 11 (10.0) | 19 (32.8) | 26 (16.0) |

**Table 1 continued on next page**

**Table 1 Baseline characteristics of overall sample and by race–gender groups (continued)**

| | Total | White men | White women | Black men | Black women | Hispanic men | Hispanic women |
|---|---|---|---|---|---|---|---|
| Weight (mean kg ± s.d.) | 95.1 ± 19.8 | 102.2 ± 19.3 | 92.1 ± 19.3 | 90.1 ± 15.0 | 86.4 ± 16.9 | 97.6 ± 18.7 | 99.1 ± 21.3 |
| BMI (*n* (%)) | | | | | | | |
| <30 | 311 (31.6) | 81 (36.0) | 113 (30.0) | 24 (46.2) | 30 (27.3) | 31 (53.5) | 32 (19.6) |
| 30–34.99 | 315 (32.0) | 81 (36.0) | 111 (29.4) | 20 (38.5) | 39 (35.5) | 21 (36.2) | 43 (26.4 () |
| 35+ | 359 (36.5) | 63 (28.0) | 153 (40.6) | 8 (15.4) | 41 (37.3) | 6 (10.3) | 88 (54.0) |
| Follow up-sample size[a] | | | | | | | |
| 6 months | 939 | 218 | 362 | 48 | 103 | 54 | 154 |
| 12 months | 931 | 218 | 345 | 52 | 105 | 55 | 156 |
| 18 months | 908 | 208 | 346 | 49 | 103 | 55 | 147 |
| 24 months | 880 | 203 | 323 | 48 | 101 | 53 | 152 |
| 30 months | 667 | 166 | 251 | 34 | 73 | 37 | 106 |
| Placebo | | | | | | | |
| Total (*n* (%)) | 974 (100.0) | 184 (18.9) | 402 (41.3) | 57 (5.9) | 111 (11.4) | 57 (5.9) | 163 (16.7) |
| Age (*n* (%)) | | | | | | | |
| < 40 | 138 (14.2) | 20 (10.9) | 51 (12.7) | 6 (10.5) | 26 (23.4) | 2 (3.5) | 33 (20.3) |
| 40–49 | 354 (36.3) | 43 (23.4) | 163 (40.6) | 18 (31.6) | 48 (43.2) | 21 (36.8) | 61 (37.4) |
| 50–59 | 291 (29.9) | 55 (29.9) | 113 (28.1) | 19 (33.3) | 29 (26.1) | 23 (40.4) | 52 (31.9) |
| 60+ | 191 (19.6) | 66 (35.9) | 75 (18.7) | 14 (24.6) | 8 (7.2) | 11 (19.3) | 17 (10.4) |
| Weight (mean kg ± s.d.) | 95.7 ± 20.3 | 102.8 ± 18.9 | 93.7 ± 20.3 | 93.0 ± 18.5 | 85.2 ± 19.1 | 100.5 ± 17.8 | 98.9 ± 20.2 |
| BMI (*n* (%)) | | | | | | | |
| <30 | 291 (29.9) | 73 (39.7) | 111 (27.6) | 23 (40.4) | 32 (28.8) | 20 (35.1) | 32 (19.6) |
| 30–34.99 | 279 (28.6) | 60 (32.6) | 104 (25.9) | 21 (36.8) | 39 (35.1) | 20 (35.1) | 35 (21.5) |
| 35+ | 404 (41.5) | 51 (27.7) | 187 (46.5) | 13 (22.8) | 40 (36.0) | 17 (29.8) | 96 (58.9) |
| Follow up-sample size[a] | | | | | | | |
| 6 months | 916 | 175 | 378 | 55 | 100 | 55 | 153 |
| 12 months | 923 | 177 | 385 | 55 | 101 | 54 | 151 |
| 18 months | 895 | 172 | 373 | 54 | 100 | 50 | 146 |
| 24 months | 871 | 169 | 359 | 54 | 95 | 50 | 144 |
| 30 months | 656 | 124 | 269 | 44 | 76 | 39 | 104 |

[a]Length of follow-up depended upon when enrolled, with an average follow-up length of 2.8 years (i.e., weight loss data available for up to the 30-month assessment); however, some participants had only 1.8 years of follow-up and could be included for weight loss analyses up to the 18-month data collection visit.

(67 and 68%, respectively). Absolute weight change from baseline at each 6-month follow-up point, as well as percent weight change with respect to baseline, is also provided. Absolute weight change is offered to assist future researchers seeking to translate the DPP methods to specific race–gender groups, and percent weight change was the primary outcome variable for the current analyses.

For the total sample randomized to lifestyle ($N$ = 962), mean weight losses were −7.05 (±5.79) kg at 6 months, −7.08 (±7.17) kg at 12 months, and −4.43 (±7.30) kg at 30 months. Weight losses among those randomized to the metformin arm ($N$ = 985) for the corresponding time points were −2.23 (±4.06) kg, −2.76 (±4.77) kg, and −1.59 (±5.98) kg, respectively. Modeling of the percent weight change over time did not yield significant three-way interaction between treatment, race and gender ($P$ = 0.5312) but it did show significant interactions between treatment assignment and race ($P$ = 0.0002), as well as gender ($P$ = 0.0396), indicating that race and gender factors responded differently in the treatment conditions. To explore this further, we simplified this model into two separate models by treatment assignment, allowing examination of race–gender groups separately for lifestyle and metformin participants. Race and gender main effects were examined within lifestyle and metformin groups only because weight loss within the placebo arm was not of interest here. Two-way interactions between race and gender were not significant in either model (both $P > 0.4$). After removal of interaction terms, race ($P < 0.0001$) and gender ($P = 0.0259$) main effects were significant within lifestyle treatment but not metformin treatment (both $P > 0.4$).

**Table 2 Weight loss experiences of race–gender groups in the three Diabetes Prevention Program intervention arms**

| | White men | | | | | White women | | | | | Black men | | | | | Black women | | | | | Hispanic men | | | | | Hispanic women | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | Δkg | s.d. | % Δkg | % s.d. | *n* | Δkg | s.d. | % Δkg | % s.d. | *n* | Δkg | s.d. | % Δkg | % s.d. | *n* | Δkg | s.d. | % Δkg | % s.d. | *n* | Δkg | s.d. | % Δkg | % s.d. | *n* | Δkg | s.d. | % Δkg | % s.d. |
| Lifestyle | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baseline | 199 | 100.5 | 20.1 | | | 381 | 95.1 | 21.2 | | | 50 | 104.4 | 22.1 | | | 154 | 97.1 | 20.8 | | | 58 | 95.7 | 17.9 | | | 120 | 82.0 | 14.8 | | |
| 6 months | 188 | –8.6 | 6.3 | –8.5 | 5.7 | 377 | –7.5 | 5.6 | –7.9 | 5.4 | 45 | –6.8 | 6.9 | –6.6 | 6.5 | 149 | –4.7 | 5.1 | –4.9 | 5.1 | 56 | –7.4 | 5.1 | –7.7 | 5.0 | 112 | –5.9 | 5.2 | –7.3 | 5.7 |
| 12 months | 192 | –8.3 | 7.9 | –8.4 | 7.1 | 367 | –7.8 | 7.4 | –8.1 | 7.1 | 43 | –7.6 | 6.9 | –7.1 | 5.6 | 144 | –4.4 | 6.0 | –4.5 | 5.9 | 54 | –7.5 | 6.1 | –7.8 | 5.9 | 111 | –5.8 | 6.1 | –7.1 | 6.4 |
| 18 months | 190 | –7.4 | 7.6 | –7.6 | 6.9 | 352 | –6.6 | 8.2 | –6.9 | 7.7 | 40 | –7.5 | 8.0 | –7.2 | 6.1 | 136 | –3.9 | 6.1 | –3.9 | 6.0 | 53 | –6.6 | 7.0 | –6.9 | 6.9 | 107 | –6.2 | 6.5 | –7.6 | 6.7 |
| 24 months | 182 | –7.1 | 7.7 | –7.2 | 7.2 | 344 | –5.7 | 8.7 | –5.9 | 8.1 | 41 | –6.2 | 8.4 | –5.9 | 6.5 | 131 | –3.2 | 5.8 | –3.3 | 5.8 | 53 | –6.8 | 6.4 | –7.2 | 6.4 | 106 | –5.5 | 6.9 | –6.6 | 7.2 |
| 30 months | 135 | –5.7 | 7.6 | –5.8 | 7.1 | 261 | –4.2 | 7.5 | –4.5 | 7.6 | 31 | –4.8 | 3.5 | –5.1 | 3.7 | 102 | –2.1 | 6.3 | –2.0 | 6.2 | 41 | –6.2 | 6.6 | –6.5 | 6.3 | 77 | –5.1 | 8.3 | –5.9 | 9.2 |
| Metformin | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baseline | 225 | 102.2 | 19.3 | | | 377 | 92.1 | 19.3 | | | 58 | 97.6 | 18.7 | | | 163 | 99.1 | 21.3 | | | 52 | 90.1 | 15.0 | | | 110 | 86.4 | 16.9 | | |
| 6 months | 218 | –2.3 | 4.2 | –2.3 | 3.9 | 362 | –2.3 | 4.2 | –2.5 | 4.7 | 54 | –2.1 | 3.0 | –2.2 | 3.0 | 154 | –2.1 | 3.6 | –2.2 | 3.8 | 48 | –2.6 | 3.9 | –2.8 | 4.4 | 103 | –1.8 | 4.5 | –2.1 | 5.0 |
| 12 months | 218 | –3.0 | 4.8 | –2.9 | 4.5 | 345 | –3.0 | 5.0 | –3.3 | 5.5 | 55 | –2.6 | 3.8 | –2.8 | 4.2 | 156 | –2.3 | 4.0 | –2.5 | 4.2 | 52 | –2.8 | 4.6 | –2.9 | 4.7 | 105 | –2.2 | 5.4 | –2.5 | 5.7 |
| 18 months | 208 | –2.3 | 5.2 | –2.3 | 4.8 | 346 | –2.6 | 5.6 | –2.8 | 6.1 | 55 | –2.0 | 4.0 | –2.2 | 4.2 | 147 | –1.8 | 4.6 | –1.9 | 4.6 | 49 | –2.9 | 6.6 | –3.0 | 6.5 | 103 | –1.7 | 6.1 | –2.0 | 6.5 |
| 24 months | 203 | –2.2 | 5.5 | –2.2 | 5.2 | 323 | –2.2 | 6.0 | –2.4 | 6.4 | 53 | –1.5 | 4.6 | –1.5 | 4.7 | 152 | –1.4 | 4.9 | –1.4 | 4.9 | 48 | –2.7 | 5.3 | –2.7 | 5.5 | 101 | –1.9 | 6.5 | –2.2 | 7.0 |
| 30 months | 166 | –1.5 | 6.1 | –1.5 | 5.6 | 251 | –1.8 | 6.2 | –1.9 | 6.7 | 37 | –1.0 | 4.3 | –1.0 | 4.5 | 106 | –1.7 | 6.5 | –1.8 | 6.4 | 34 | –1.6 | 5.1 | –1.4 | 5.4 | 73 | –1.1 | 5.4 | –1.3 | 5.9 |
| Placebo | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Baseline | 184 | 102.8 | 18.9 | | | 402 | 93.7 | 20.3 | | | 57 | 100.5 | 17.8 | | | 163 | 98.9 | 20.2 | | | 57 | 93.0 | 18.5 | | | 111 | 85.2 | 19.1 | | |
| 6 months | 175 | –0.4 | 3.9 | –0.4 | 3.8 | 378 | –0.5 | 4.4 | –0.6 | 4.6 | 55 | –0.6 | 4.8 | –0.3 | 4.4 | 153 | 0.2 | 3.7 | 0.1 | 3.8 | 55 | 0.2 | 3.5 | 0.2 | 3.6 | 100 | –0.8 | 3.9 | –0.9 | 4.3 |
| 12 months | 177 | –0.8 | 4.7 | –0.7 | 4.5 | 385 | –0.8 | 5.2 | –0.9 | 5.6 | 54 | –0.1 | 5.7 | 0.3 | 5.5 | 151 | 0.2 | 4.3 | 0.2 | 4.5 | 55 | 0.7 | 3.5 | 0.8 | 3.7 | 101 | –1.1 | 4.4 | –1.2 | 5.0 |
| 18 months | 172 | –0.6 | 5.3 | –0.5 | 5.1 | 373 | –0.5 | 5.8 | –0.5 | 6.1 | 50 | 0.0 | 5.0 | 0.4 | 4.8 | 146 | 0.5 | 5.6 | 0.6 | 5.5 | 54 | 1.0 | 3.1 | 1.2 | 3.4 | 100 | –0.5 | 4.7 | –0.5 | 5.4 |
| 24 months | 169 | –0.8 | 5.8 | –0.8 | 5.6 | 359 | –0.6 | 6.4 | –0.6 | 6.6 | 50 | 0.1 | 5.2 | 0.5 | 5.1 | 144 | 0.7 | 5.5 | 0.8 | 5.4 | 54 | 1.2 | 3.3 | 1.3 | 3.5 | 95 | 0.2 | 4.0 | 0.4 | 4.7 |
| 30 months | 124 | –0.7 | 5.2 | –0.6 | 5.0 | 269 | –0.9 | 7.0 | –0.9 | 7.2 | 39 | 0.5 | 5.2 | 0.7 | 5.2 | 104 | 1.3 | 5.3 | 1.5 | 5.3 | 44 | 1.2 | 3.3 | 1.4 | 3.5 | 76 | 0.7 | 4.3 | 0.8 | 5.3 |

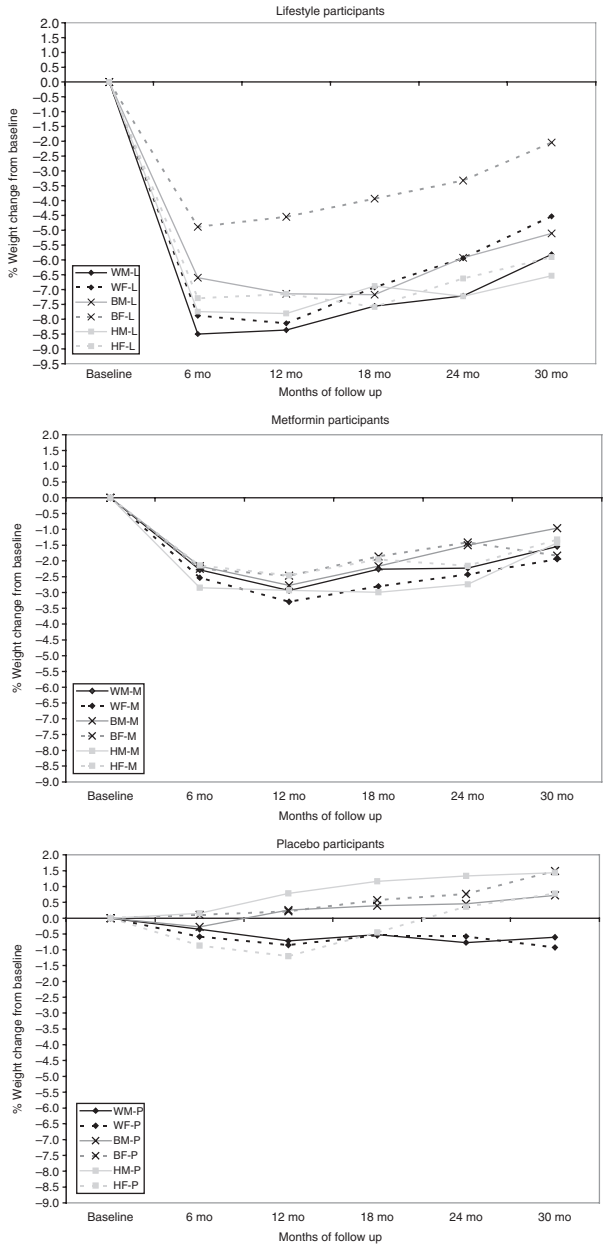


**Figure 1** Weight loss trajectories of race–gender groups in the three Diabetes Prevention Program intervention arms.

Within lifestyle treatment, blacks and women had significantly lower weight loss than their counterparts. As the focus of this report was to examine weight losses across individual race–gender groups by obesity treatment modality, race and gender variables were combined into one six-level variable. Consistent with the earlier model, within the metformin arm, when race–gender was considered a six-level variable, there were no significant contrasts between any race–gender groups treated using metformin (**Figure 1**) indicating that weight losses did not differ between any of the groups. In contrast, significant differences were noted between race–gender groups within the lifestyle treatment arm. Specifically, black women exhibited significantly lower weight loss than all other race–gender groups (all $P < 0.01$) with the exception of black men ($P = 0.3556$). Black men did not, however, differ significantly from any of the white or Hispanic gender categories. Indeed, as illustrated in **Figure 1**, weight loss trajectories were very similar among white men and women, Hispanic men and women and black men. Only black women presented a substantively different weight loss trajectory in the DPP lifestyle arm.

Evaluation of the weight losses for each of the active study arms in comparison with placebo was undertaken to determine whether significant weight losses were achieved across the race–gender groups within the two treatment modalities. Lifestyle and metformin interventions produced significantly larger percent weight loss than placebo, and also lifestyle achieved significantly greater percent weight loss than metformin across the race–gender groups (all $P < 0.05$). The only exception to this pattern was that Hispanic women within the metformin treatment arm did not experience significantly greater percent weight loss than those in the placebo arm ($P = 0.0547$). Black women in both the lifestyle and metformin arms achieved significantly greater weight loss than those in the placebo arm. Thus, although black women experienced attenuated weight losses in the lifestyle arm relative to other race–gender groups, black women in lifestyle had significantly greater weight losses than black women in the control group at every follow-up period, pointing to the initial and sustained efficacy of the lifestyle program within this high-risk subgroup.

## DISCUSSION

This report describes weight loss outcomes for black, white, and Hispanic men and women in the intensive lifestyle and metformin treatment arms of the DPP over a 30-month period, offering estimates of mean weight loss by race and gender at each 6-month assessment. The DPP affords a rare opportunity to examine weight loss responses to behavioral and pharmacological interventions for diverse participants in a national, multicenter trial that used standard protocols. In addition to updating results from earlier investigations of lifestyle intervention and weight loss for blacks and whites in hypertension trials (6–8), this report includes data for Hispanics and shows specific weight outcomes for both lifestyle and pharmacological treatment modalities and the control condition. As such, information is available to derive appropriate sample size and power calculations for future studies that address weight outcomes with respective race-ethnic and gender groups. These data are anticipated to be of particular value for efforts targeting translation of the highly effective DPP lifestyle intervention or a DPP-like program to high-risk, minority populations, such as black women. In addition, they provide realistic benchmarks for clinicians implementing the DPP lifestyle intervention or a similar approach with their minority patient populations. It must be recognized, however, that the participants in DPP were rigorously selected to be highly motivated. Further, the DPP lifestyle intervention program was resource intensive to deliver and implemented aggressive treatment fidelity procedures (which were ultimately more cost-effective for diabetes prevention despite the resources required) (15). Taken together, these factors suggest that outcomes achieved

in the DPP are likely greater than can be reasonably expected when intervention methods are translated into the community or by clinicians who apply the methods in their practice. Nonetheless, the relative efficacy across racial/ethnic and gender groups may still be pertinent.

Findings underscore the impressive effect of intensive lifestyle intervention in producing weight loss across all race-ethnic and gender groups, which have been reported previously (2,14), and also extend available data to demonstrate the variation in weight response. The substantial weight losses achieved by whites, black men, and Hispanics in the lifestyle arm did not significantly differ between groups, in contrast to findings for black women who lost significantly less weight than other race–gender groups. Although this standardized, culturally adapted intensive lifestyle intervention was highly successful for the most race/ethnic–gender groups, its effect among black women may have been tempered by powerful and ambient environmental and sociocultural factors. Such factors remain to be identified and understood as we strive to address obesity-related disparities and modest response to available behavioral treatments among black women, who bear a disproportionate burden from obesity (4).

Although significantly smaller weight losses were apparent among black women than other race–gender groups, absolute weight losses achieved by black women in the DPP lifestyle arm were among the most substantial weight losses reported to date in the literature. For example, in the Trials of Hypertension Prevention (6,16), as well as the PREMIER study (8), black women lost 1.9–3.2 kg after 6 months of a lifestyle intervention. Other recent controlled investigations of lifestyle modification weight management programs for black women report weight loss outcomes averaging 2.4–3.7 kg (17–19). Thus, weight losses of 4.7 kg at 6 months among black women in the DPP lifestyle arm are notable within the context of the existing literature. In previous reports of lifestyle intervention trials that included black men, sample sizes were small ($n$ = 10–37) and weight losses were between 2.1 and 5.1 kg at 6 months (6,8,16). With weight losses of 6.8 kg at 6 months and 7.6 kg at 12 months, the DPP lifestyle program produced much larger weight losses than previously observed, and these weight losses were associated with a significant decrease in progression of type 2 diabetes (14). The impressive weight losses achieved in the DPP lifestyle intervention in comparison with other behavioral weight control studies may reflect the cultural tailoring conducted in the development of the program so that it could be effective in diverse populations, such as the bilingual materials, the flexible pace of treatment delivery, multiple options for self-monitoring and the inclusion of food and cooking methods common in various ethnic groups (13). In addition, the DPP lifestyle intervention provided participants with meal replacements and menu planners, both of which have been shown to augment weight loss outcomes (20–22) and which have seldom been used in studies that include significant representation of black participants. Another salient difference was the delivery of the DPP lifestyle intervention on an individual basis rather than in a group format, allowing opportunities for increased customization to address individual needs and preferences, which may have contributed to the successful outcomes within minority populations.

Few data on the long-term outcomes of weight loss programs among Hispanic men and women are available to permit comparisons between other race–gender groups following a similar protocol over an extended period. Hispanic men and women have some of the highest rates of overweight and obesity in the United States (4) and the population group is growing at a rapid pace (23). Given the high-risk status of the group, there is likely to be more research into prevention and treatment of Hispanic individuals, as well as efforts to disseminate the highly effective DPP lifestyle program to this group. The findings presented here are among the first available to offer the mean weight losses of Hispanic men and women in a behavioral weight loss program with mean performance over two and a half years provided. Furthermore, it is the only report of which we are aware providing comparisons of mean weight losses between Hispanic, black, and white men and women. Such data will be needed to inform the design of future replications and translation of the DPP lifestyle program to these high-risk populations. Weight losses at the end of the first year for Hispanic men were 7.5 kg, and 5.8 kg for women, and are, to our knowledge, the only race–gender specific data available on weight loss among Hispanics from a randomized, controlled study with a lifestyle intervention alone arm or by gender for overweight Hispanics. Shorter term treatment by sibutramine among obese Hispanic individuals has been reported to be successful (24) but information on response by gender is not provided.

In comparison with intensive lifestyle, metformin treatment produced weight losses of significantly reduced magnitude, as has been reported previously (2). However, the current analysis provides the additional information that there were no significant differences observed across the race-ethnicity gender groups in weight loss in response to metformin. The lack of an attenuated weight loss among black women is notable and consistent with other studies that report pharmacological obesity treatment may not result in differential weight loss (25) but do not allow identification of the specific response by gender group. We are not aware of any other studies which provide outcome data on pharmacological agents for obesity treatment by race–gender that allow evaluation of potential differential response to pharmacotherapy. The identification of a pharmacological treatment which produces modest weight losses without reduced outcomes for black women is noteworthy. The magnitude of weight loss with metformin was small (–2.3 kg at 12 months) but comparable to weight loss achieved with other pharmacological antiobesity agents such as orlistat (26). However, because the intensive lifestyle treatment conferred greater benefit in reducing diabetes risk (1) and was more cost-effective compared to metformin (15), increased efforts to translate and disseminate the lifestyle intervention are more strongly warranted, particularly in public health contexts. These efforts would be an important step in addressing national health objectives to curb the obesity epidemic, particularly in

high-risk groups and populations in underserved and resource constrained environments.

To our knowledge, DPP is among the first, if not the only, investigation that provides data regarding independent behavioral lifestyle and pharmacological treatments on weight loss outcomes within the same multicenter trial. The lifestyle intervention is a highly successful, evidence-based obesity treatment across diverse groups. However, the fact that it was significantly less effective among black women, a group with a particularly high prevalence of obesity, is compelling rationale to intensify multidisciplinary research to disentangle and understand the complex sociocultural and contextual issues associated with the unrelenting obesity problem in black women.

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## DISCLOSURE

The authors declared no conflict of interest.



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