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ODS Statistical Graphics for Clinical Research

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ABSTRACT

Graphical representations to illustrate the effects and safety of treatments are often more easily understood and remembered than tabular forms. Statistical graphics play an important role in clinical research. Beginning with SAS®9, a number of SAS/STAT procedures can use the Output Delivery System (ODS) to create statistical graphics automatically. You can use the ODS Graphics Template Language (GTL) to generate statistical graphics of your own layout design. This new facility which is referred to as ODS Statistical Graphics greatly enhances the ability to produce statistical graphs for clinical research. This paper describes how to create commonly used statistical graphs for clinical research using ODS Statistical Graphics:

- Create statistical graphs from SAS procedures;
- Customize statistical graphs using ODS templates and ODS styles;
- Create statistical graphs using ODS Graphics Template Language.

INTRODUCTION

Graphs usually have greater impact and thus wider reception than tabular representations. Advanced technology of information visualization has resulted in the generation of more graphs with better quality. When we prepare the statistical summaries and analysis for clinical research, graphical displays help statisticians and clinicians more efficiently understand the data and the analysis. This paper presents how to apply the ODS Statistical Graphics (or ODS Graphics for short), which is a new data visualization facility available in SAS 9.1, to assist clinical research.

To understand many parts of this paper requires some statistical knowledge and clinical research background. This paper is for SAS programmers who are involved in clinical research, and it focuses on presenting analysis of clinical data graphically. The data sets for the examples in this paper are taken from Glenn A. Walker's book "Common Statistical Methods for Clinical Research with SAS® Examples" (Walker, 2002). Even though HTML file format is used as the ODS destination for the examples, other ODS destinations are supported by ODS Graphics such as RTF, PDF, etc.

ODS Statistical Graphics are experimental in SAS 9.1. It is not recommended for production work. In SAS 9.2, the ODS Graphics Template Language will become production software.

CREATE STATISTICAL GRAPHS FROM SAS PROCEDURES

A number of SAS/STAT procedures such as BOXPLOT and LIFETEST can produce high-resolution graphical images since SAS Version 7. In SAS 9.1, in addition to these GRSEG-based graphs, over 15 SAS/STAT procedures can produce graphical displays that are template-based. The layout and appearance of ODS Graphics are controlled by ODS templates and styles. They support popular image formats GIF, JPEG, PNG, PS, EPSI, etc. ODS Graphics integrate the graphical displays fully with the tabular output. Graph production is automated by the procedure, and all ODS Graphics are governed by the standard ODS statements such as SELECT and EXCLUDE, just like ODS tables. ODS Graphics can generate different plot types with complex graphical layouts, and they are integrated with common file formats HTML, PDF, RTF, LATEX, etc.

ODS GRAPHICS BASICS

ODS GRAPHICS statement Enables ODS automatic graphic capabilities. The basic syntax is

```
ODS GRAPHICS ON
            </  IMAGEFMT = image-file-type | STATIC | STATICMAP
                IMAGENAME = filename
                RESET >;

        procedures or data steps

ODS GRAPHICS OFF;
```

Where

ODS GRAPHICS < OFF | ON > turns off / on the automatic ODS graphic generation;
IMAGEFMT specifies the image format to display graphics in ODS output, i.e. GIF, PNG, etc.;

IMAGENAME specifies the base image filename;
RESET resets the index counter that is appended to static image files.

Common statistical methods for clinical research include the t-test, analysis of variance (ANOVA), regression, analysis of covariance (ANCOVA), the Chi-Square test, and the Log-Rank test, etc. Following examples are based on actual clinical trials (Walker, 2002).

EXAMPLE 1: REGRESSION ANALYSIS OF ANTI-ANGINAL RESPONSE VS. DISEASE HISTORY (WALKER, 2002 P178)

"Treadmill stress tests were administered to patients with angina pectoris before and 4 weeks after once-daily dosing with an experimental anti-anginal medication. The investigator wanted to know if the improvement in exercise duration is related to the patient's disease history.Is there a significant linear relationship between improvement on medication and disease duration?"

PROGRAM 1.1

```
data angina;
   input pat x_dur y_impr @@;
   datalines;
   1 1   40  2 1   90   3 3 30   4 2   30
   5 1   80  6 5   60   7 1 10   8 4 -10
   9 2   50 10 6   40  11 1 60  12 4    0
  13 2   50 14 2 110  15 3 20  16 3   70
  17 5 -30 18 3   20  19 1 40  20 6    0
   ;
run;

ods html;
ods graphics on / imagename = 'regression';

proc reg data = angina;
   model y_impr = x_dur;
run;
quit;

ods graphics off;
ods html close;
```

The REG procedure in the preceding program produces a scatter plot of the input data overlaid with the fitted regression line, confidence band, and prediction limits, as shown in Figure 1.1; a plot of the residuals versus the regressor in the model, as shown in Figure 1.2; and a summary panel, as shown in Figure 1.3, which consists of eight fit diagnostics plots:

- Residuals versus the predicted values
- Studentized residuals versus the predicted values
- Studentized residuals versus the leverage
- Normal quantile plot of the residuals
- Dependent variable values versus the predicted values
- Cook's D versus observation number
- Histogram of the residuals
- A "Residual-Fit" (or RF) plot consisting of side-by-side quantile plots of the centered fit and the residuals.

To display the plots individually instead of the default summary panel, specify the PLOTS(UNPACK) option in the PROC REG statement as follows:

PROGRAM 1.2

```
ods html;
ods graphics on;

proc reg data = angina plots(unpack);
   model y_impr = x_dur;
run;
quit;
```

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```
ods graphics off;
ods html close;
```
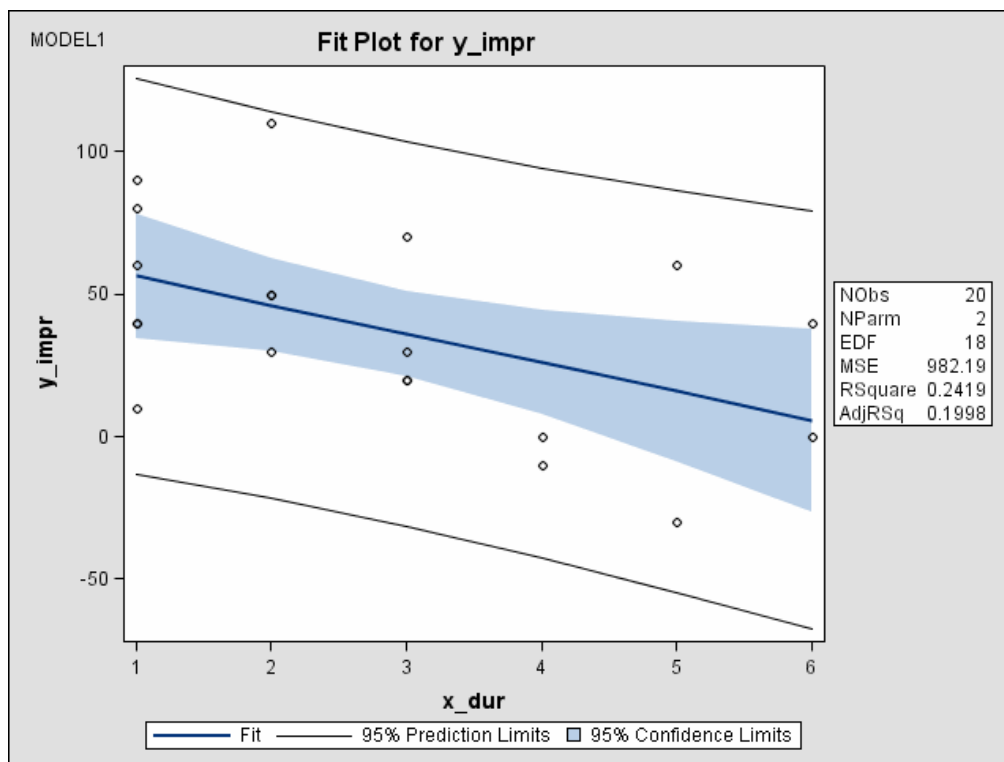
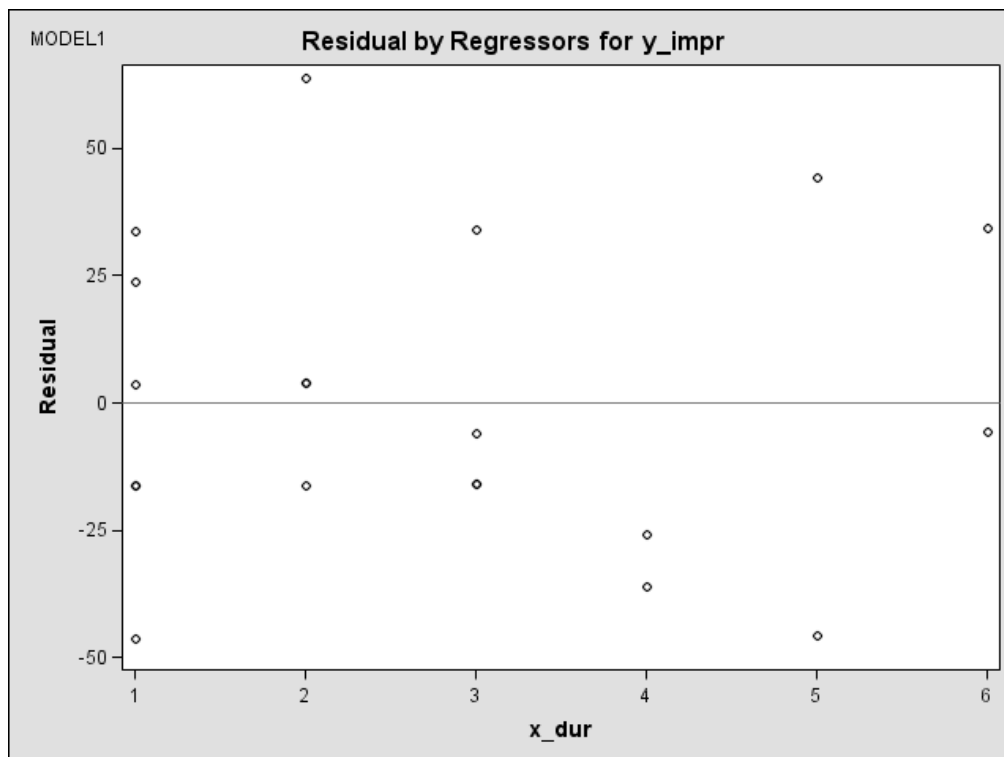**FIGURE 1.1**
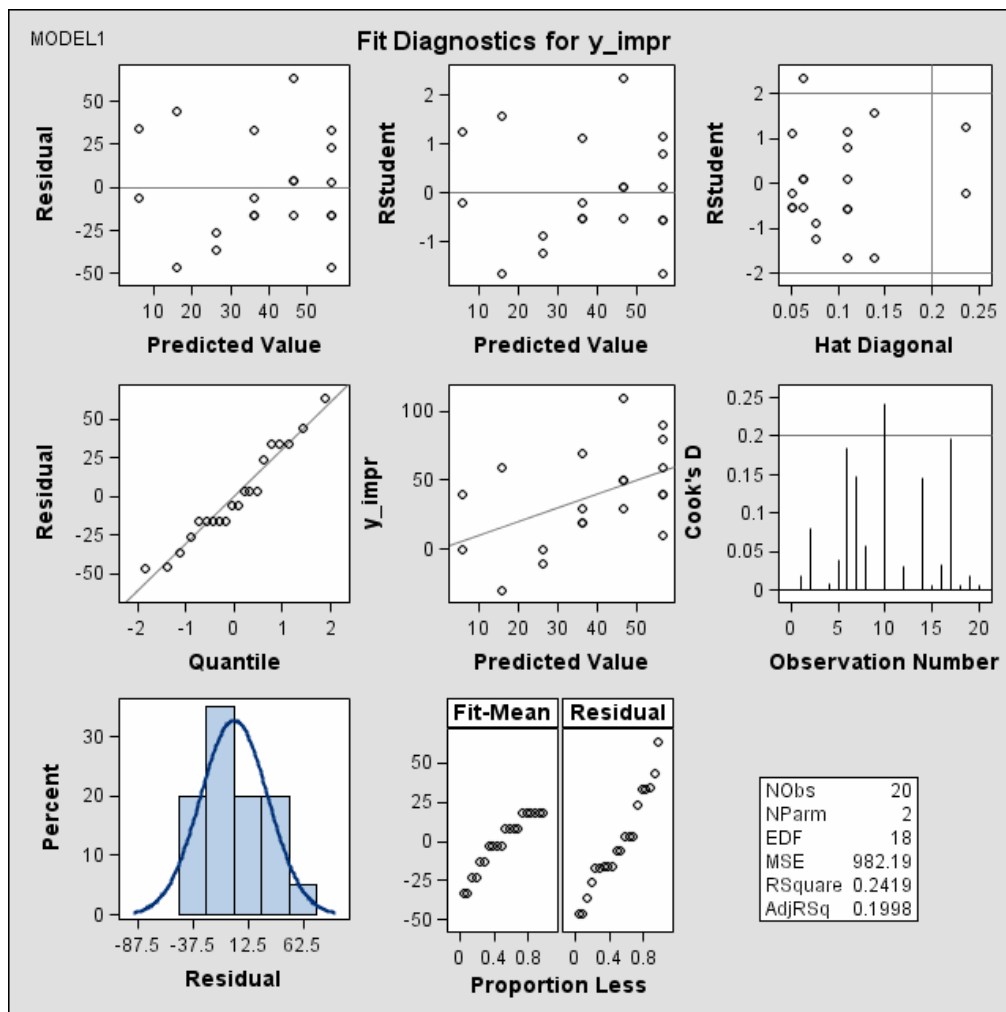

FIGURE 1.2

FIGURE 1.3

You can use the ODS SELECT statement to select a particular subset of ODS graphs. The following statements will display the fit plot only, which is shown in Figure 1.1.

PROGRAM 1.3

```
ods html;
ods graphics on;
ods select fit;

proc reg data = angina;
    model y_impr = x_dur;
run;
quit;

ods graphics off;
ods html close;
```

When you specify the HTML destination and the IMAGEFMT=STATICMAP option in the ODS GRAPHICS statement, the HTML output file is generated with tool tips.
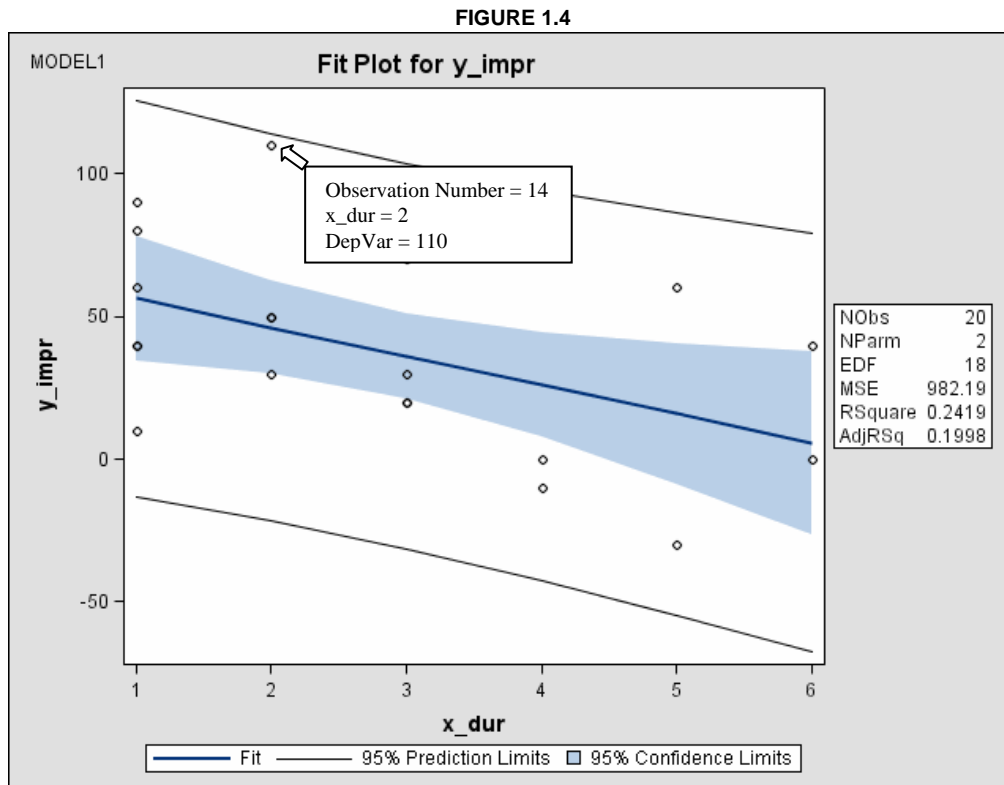
PROGRAM 1.4

```
ods html;
ods graphics on / imagefmt = staticmap;
ods select fit;
```

```
proc reg data = angina;
    model y_impr = x_dur;
run;
quit;

ods graphics off;
ods html close;
```

Moving the mouse over a scatter plot displays a tool tip with detailed information for the corresponding patient, as shown in Figure 1.4.

FIGURE 1.4

You can use the GLM procedure to produce a grouped box plot of the response values versus the classification levels of the independent variable. The box plot can be generated by specify a one-way analysis of variance model with just one independent classification variable. Figure 1.5 is generated by the following program:
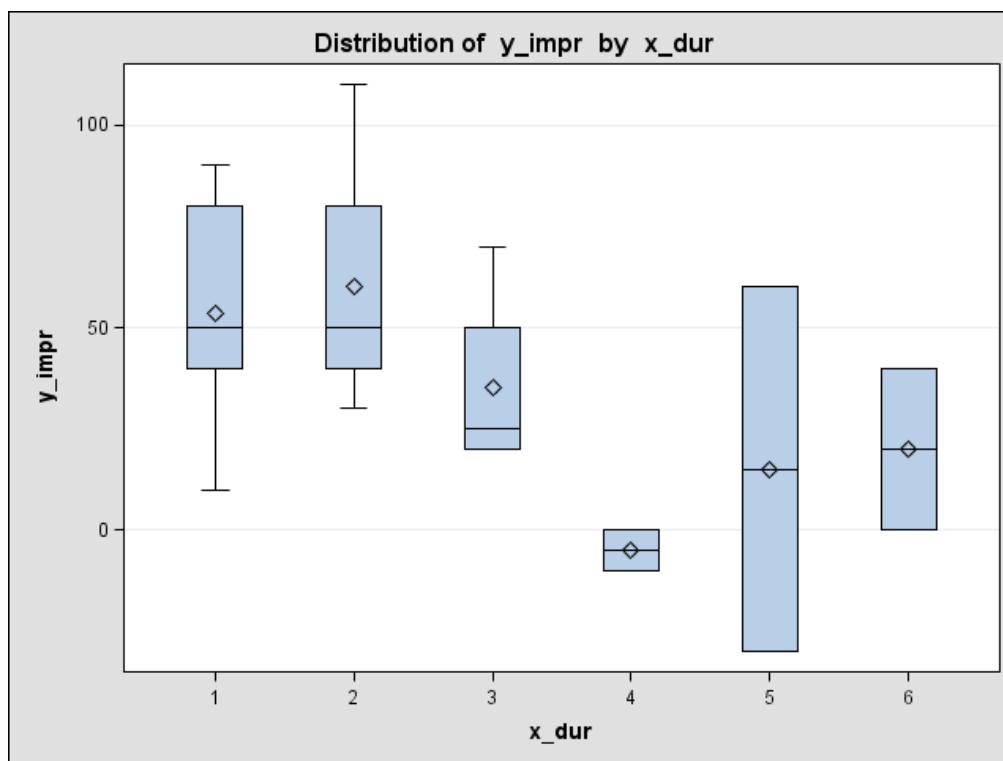
PROGRAM 1.5

```
ods html;
ods graphics on;

proc glm data = angina;
    class x_dur;
    model y_impr = x_dur;
run;
quit;

ods graphics off;
ods html close;
```

FIGURE 1.5

Distribution of y_impr by x_dur

EXAMPLE 2: ANALYSIS OF COVARIANCE (ANCOVA) OF TRIGLYCERIDE CHANGES ADJUSTED FOR GLYCEMIC CONTROL (WALKER, 2002 P203)

"The new cholesterol-lowering supplement, Fibralo, was studied in a double-blind study against the marketed reference supplement, Gemfibrozil, in 34 non-insulin dependent diabetic (NIDDM) patients. One of the study's objectives was to compare the mean decrease in triglyceride levels between groups. The degree of glycemic control, measured by hemoglobin A_{1c} levels (HbA_{1c}) was thought to be an important factor in response to the treatment. This covariate was measured at the start of the study, with the percentage changes in triglycerides from pre-treatment to the end of the 10-week trial. Is there a difference in mean responses between supplements?"

Data are first analyzed using the one-way ANOVA, ignoring the covariate, by the following program. A box plot (Figure 2.1) will be generated, showing a non-significant treatment effect ($p = 0.2858$ from SAS output).
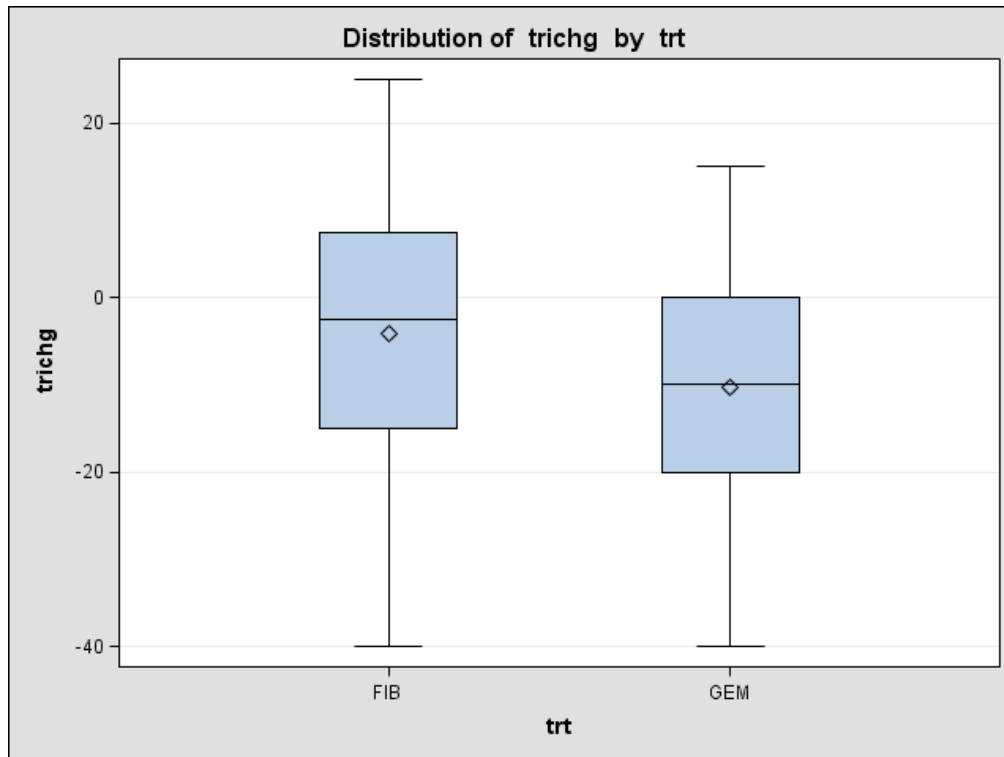
PROGRAM 2.1

```
data tri;
    input trt $ pat hgba1c trichg @@;
    datalines;
FIB  2 7.0   5 FIB  4 6.0  10 FIB  7 7.1  -5
FIB  8 8.6 -20 FIB 11 6.3   0 FIB 13 7.5 -15
FIB 16 6.6  10 FIB 17 7.4 -10 FIB 19 5.3  20
FIB 21 6.5 -15 FIB 23 6.2   5 FIB 24 7.8   0
FIB 27 8.5 -40 FIB 28 9.2 -25 FIB 30 5.0  25
FIB 33 7.0 -10 GEM  1 5.1  10 GEM  3 6.0  15
GEM  5 7.2 -15 GEM  6 6.4   5 GEM  9 5.5  10
GEM 10 6.0 -15 GEM 12 5.6  -5 GEM 14 5.5 -10
GEM 15 6.7 -20 GEM 18 8.6 -40 GEM 20 6.4  -5
GEM 22 6.0 -10 GEM 25 9.3 -40 GEM 26 8.5 -20
GEM 29 7.9 -35 GEM 31 7.4   0 GEM 32 5.0   0
GEM 34 6.5 -10
;
run;
```

```
ods html;
ods graphics on / imagename = 'anova';

proc glm data = tri;
   class trt;
   model trichg = trt / ss3;
run;
quit;

ods graphics off;
ods html close;
```

FIGURE 2.1

PROC GLM is then used to conduct the ANCOVA, using the treatment (TRT) effect as a class variable and HGBA1C as a numeric covariate. An analysis of covariance plot is generated after submit the following program, as shown in Figure 2.2. The end result is a large difference in mean responses between supplements based on the adjusted values ($p = 0.0048$ from SAS output).
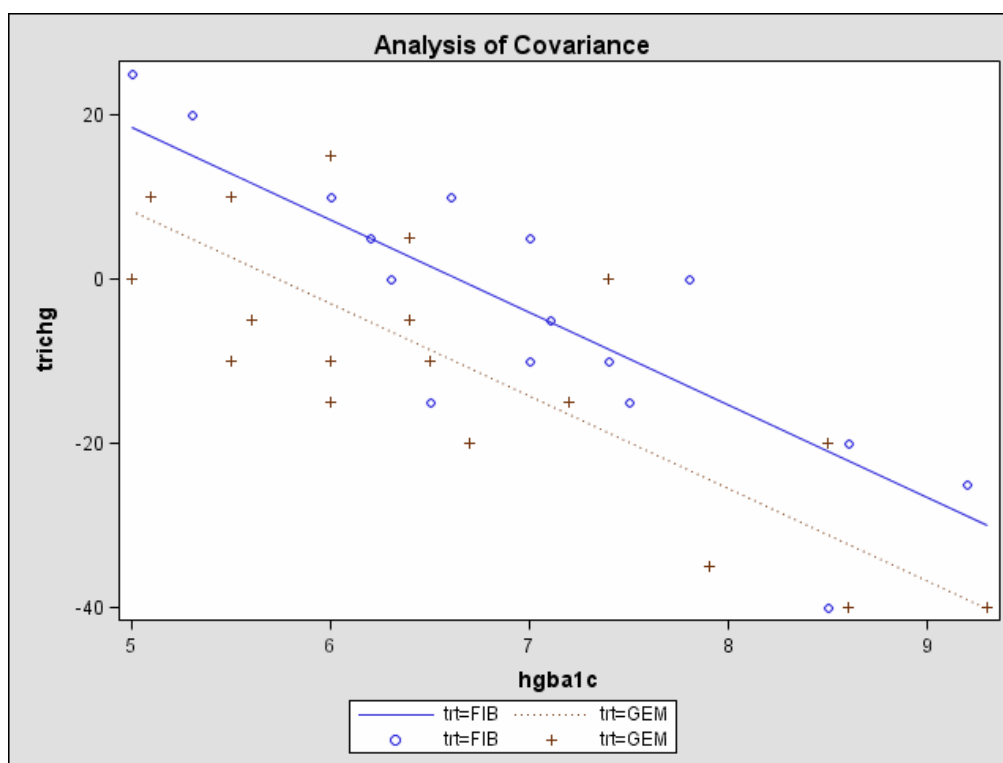
PROGRAM 2.2

```
ods html;
ods graphics on / imagename = 'ancova';

/* Use glycemic control as covarite */
proc glm data = tri;
   class trt;
   model trichg = trt hgba1c / solution;
run;
quit;

ods graphics off;
ods html close;
```

FIGURE 2.2

EXAMPLE 3: THE LOG-RANK TEST OF HSV-2 EPISODES FOLLOWING GD2 VACCINE (WALKER, 2002 P351)

"Forty-eight patients with genital herpes (HSV-2) were enrolled in a study of a new recombinant herpes vaccine based on the antigen glycoprotein, gD2. Patients were required to have a history of at least 6 HSV-2 episodal outbreaks in the 12 months prior to enrollment in the study and be in remission at the time of vaccination. Patients were randomly assigned to receive either a single gD2 vaccine injection (n=25) or placebo (n=23), and their conditions were followed for 1 year. Is there evidence that the distributions of the times to recurrence differ between the groups?"

The SAS/STAT procedure LIFETEST is used to perform the log-rank test in the following program:

PROGRAM 3.1

```
data hsv;
    input vac $ pat wks x @@;
    cens = (wks < 1);
    wks = abs (wks);
    trt = (vac = 'GD2');
    datalines;
GD2  1    8 12        GD2  3 -12 10        GD2  6 -52   7
GD2  7   28 10        GD2  8   44   6      GD2 10   14   8
GD2 12    3  8        GD2 14 -52   9       GD2 15   35 11
GD2 18    6 13        GD2 20   12   7      GD2 23   -7 13
GD2 24 -52   9        GD2 26 -52 12        GD2 28   36 13
GD2 31 -52   8        GD2 33    9 10       GD2 34 -11 16
GD2 36 -52   6        GD2 39   15 14       GD2 40   13 13
GD2 42   21 13        GD2 44 -24 16        GD2 46 -52 13
GD2 48   28   9       PBO  2   15   9      PBO  4 -44 10
PBO  5   -2 12        PBO  9    8   7      PBO 11   12   7
PBO 13 -52   7        PBO 16   21   7      PBO 17   19 11
PBO 19    6 16        PBO 21   10 16       PBO 22 -15   6
PBO 25    4 15        PBO 27   -9   9      PBO 29   27 10
PBO 30    1 17        PBO 32   12   8      PBO 35   20   8
PBO 37 -32   8        PBO 38   15   8      PBO 41    5 14
```

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```
      PBO 43  35 13        PBO 45  28  9       PBO 47   6 15
;
run;

ods html;
ods graphics on / imagename = 'lifetest';

proc lifetest data = hsv;
   time wks * cens (1);
   strata vac;
run;

ods graphics off;
ods html close;
```
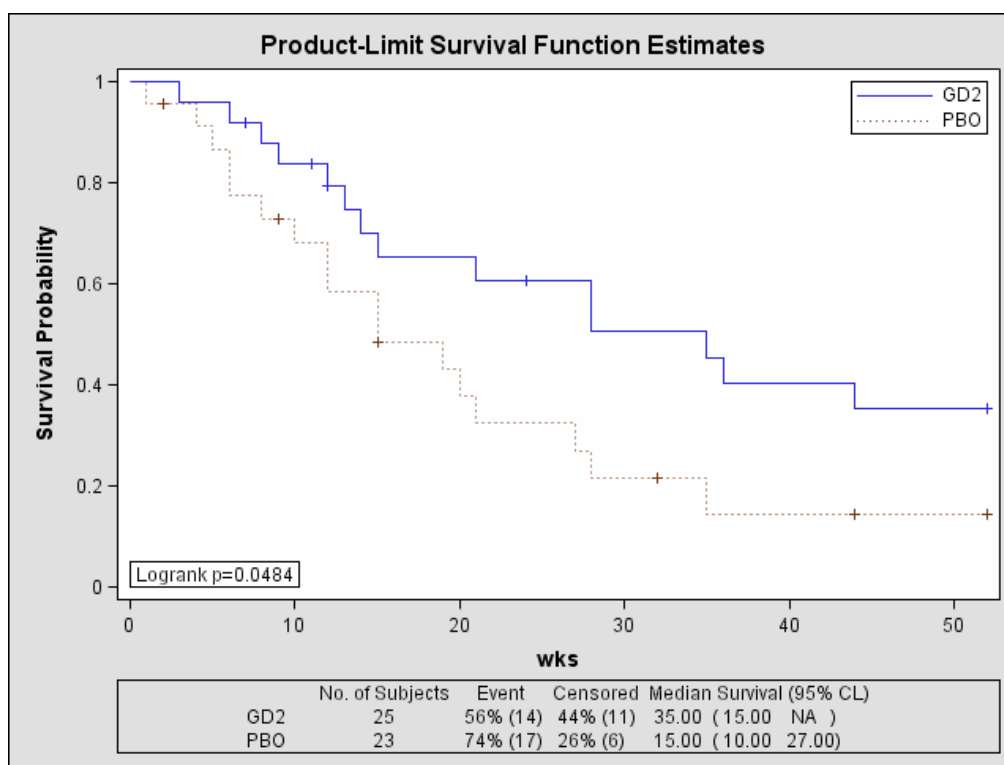
Figure 3.1 displays the graph of the product-limit survival function estimate versus the time (in weeks) to first recurrence of HSV-2 following immunization, as well as the summary statistics, generated from the preceding program:

FIGURE 3.1

If you want to view the other graphical displays of the survival distribution and related function estimates that PROC LIFETEST can produce, you can specify the PLOTS = option in the SURVIVAL statement:

PROGRAM 3.2

```
ods html;
ods graphics on;

proc lifetest data = hsv;
   time wks * cens (1);
   strata vac;
   survival plots = ( survival
                    , density
                    , epb
                    , hazard
                    , loglogs
```

```
                    , logsurv
                    , hwb
                    , cl
                    , stratum)
        ;
run;

ods graphics off;
ods html close;
```

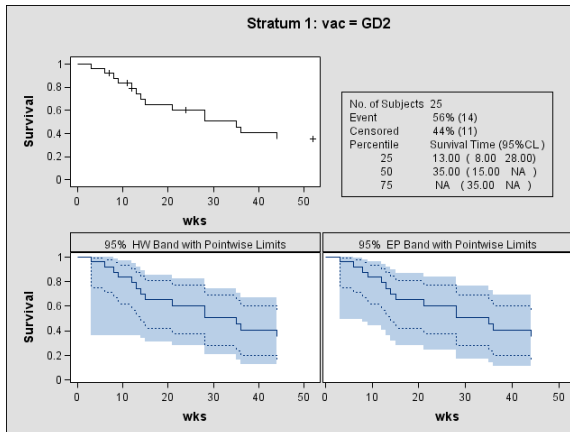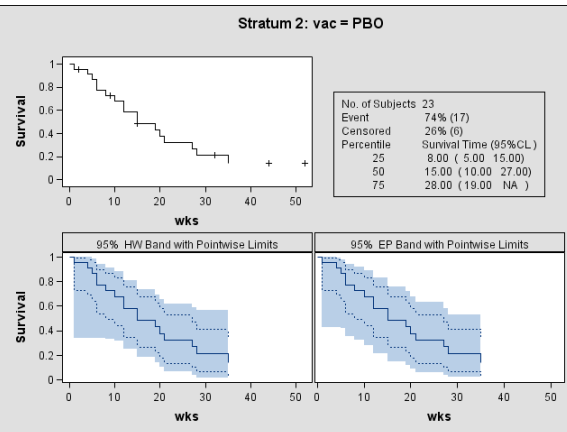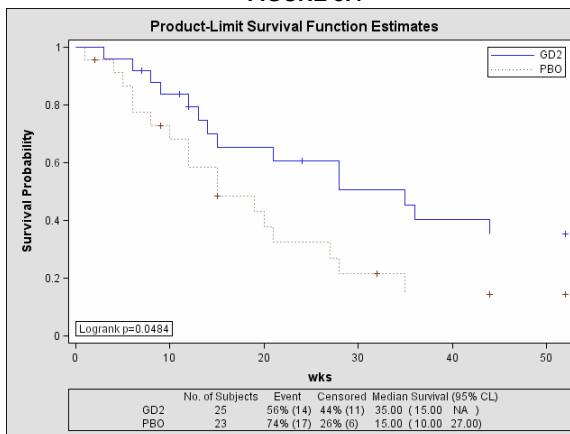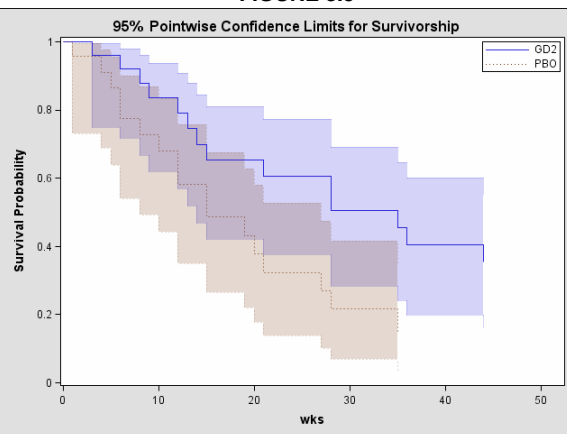**FIGURE 3.2**   **FIGURE 3.3**

FIGURE 3.4   **FIGURE 3.5**

FIGURE 3.6   **FIGURE 3.7**

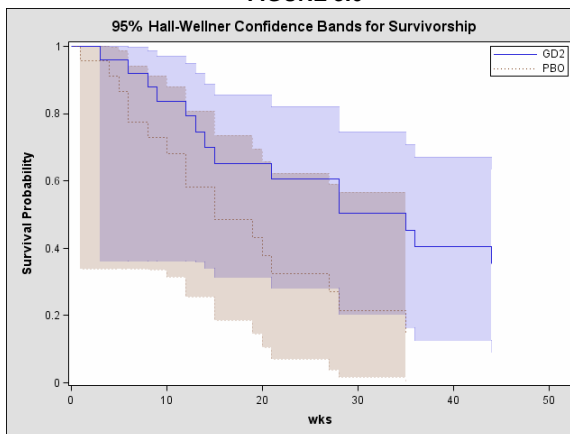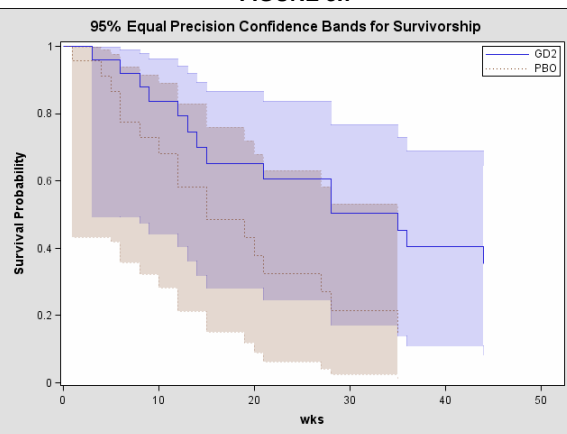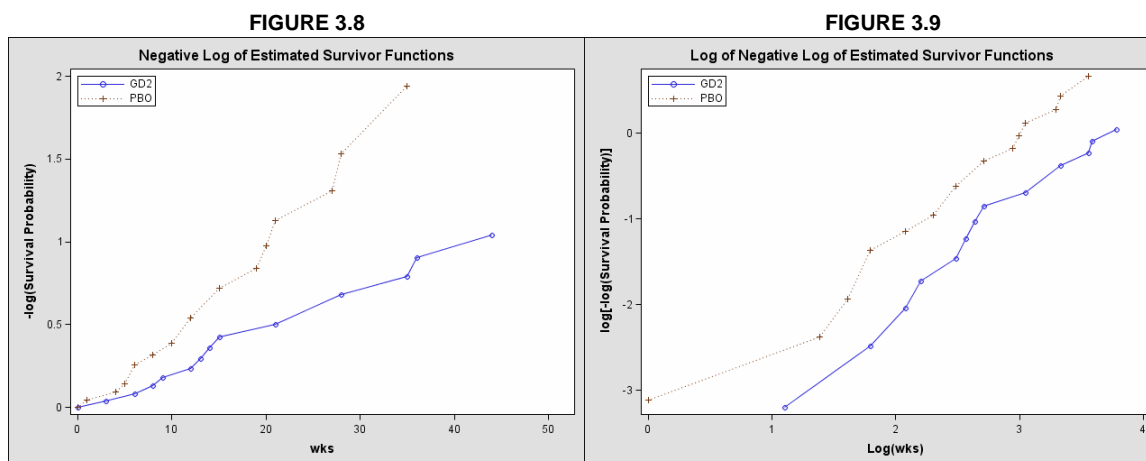| FIGURE 3.8	FIGURE 3.9

Figures 3.2 to 3.9 are statistical graphics generated by the preceding program. They include a panel of plots for each stratum, a plot of the survival functions estimates for all strata, a plot of the Hall-Wellner bands for all strata, a plot of the equal precision bands for all strata, a plot of negative log of the estimated survival functions, and a plot of the log of the negative log of the estimated survival functions.

CUSTOMIZE STATISTICAL GRAPHS USING ODS TEMPLATES AND ODS STYLES

The layout and details of graphs produced with ODS Graphics are controlled by graph template definitions (or graph definition for short). The graph definitions are written in the graph template language. The default graph templates supplied by SAS should suffice in most common applications of ODS Graphics. However, ODS Graphics enables you to modify the default template to customize the graphics when modifications are needed. The overall appearance of ODS Graphics is coordinated by style definitions, like ODS tables. Style definitions specify features such as fonts, sizes, color scheme, and line styles. You can create your own style definition or modify a style definition supplied by SAS to customize the appearance of ODS Graphics.

Example 4 demonstrates how to customize the layout of statistical graphs with templates. Example 5 demonstrates how to modify the appearance of the statistical graphs produced by SAS procedures.

EXAMPLE 4: CUSTOMIZING LAYOUT OF ODS GRAPHICS

The REG procedure in Program 1.3 produces a scatter plot of the input data overlaid with the fitted regression line, confidence band, and prediction limits, as shown in Figure 1.1. This graph is controlled by the graph template Stat.Reg.Graphics.Fit. If you want to move the summary statistics (the box at the right) to the bottom of the graph, move the legend from the bottom to the top, and remove the title "Fit Plot for y_impr", you can modify the template as Program 4.

For more examples of customizing the statistical graphs produced by SAS procedures, please refer to this author's SUGI 30 paper (Cheng, 2005).

PROGRAM 4

```
proc template;
   define statgraph Stat.Reg.Graphics.Fit;
      notes "Modified Fit Plot";
      dynamic _MODELLABEL _DEPLABEL _NObs _NParm _EDF _MSE _RSquare _AdjRSq
             _PREDLIMITS _CONFLIMITS _XVAR;
      layout lattice / rows=1 columns=1;
         ColumnHeader;
            layout gridded;
               DISCRETELEGEND "Fit" "Prediction" "Confidence" / across=3
                  HALIGN=CENTER VALIGN=BOTTOM BORDER=ON background=
                  GraphWalls:background;
            endlayout;
         EndColumnHeader;
```

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```
        layout Overlay / yaxisopts=( label=_DEPLABEL );
           BAND ylimitupper=UPPERCL ylimitlower=LOWERCL x=_XVAR / fill=false
               lines=true sort=x fillcolor=StatGraphPredictionLimit:foreground
               name="Prediction" LegendLabel=_PREDLIMITS;
           BAND ylimitupper=UPPERCLMEAN ylimitlower=LOWERCLMEAN x=_XVAR /
               fill=true lines=false sort=x fillcolor=
               StatGraphConfidence:foreground name="Confidence" LegendLabel=
               _CONFLIMITS;
           SCATTERPLOT y=DEPVAR x=_XVAR / markersymbol=
               GraphDataDefault:markersymbol markercolor=
               GraphDataDefault:contrastcolor markersize=
               GraphDataDefault:markersize tip=( OBSERVATION _XVAR DEPVAR );
           SERIES y=PREDICTEDVALUE x=_XVAR / linecolor=
               StatGraphFitLine:contrastcolor linethickness=
               StatGraphFitLine:linethickness linepattern=
               StatGraphFitLine:linestyle sort=x name="Fit" LegendLabel="Fit";
        endlayout;
        Column2Header;
           layout gridded / columns=6 border=true background
                            =GraphWalls:background;
              entry "NObs";
              entry "NParm";
              entry "EDF";
                 entry "MSE";
              entry "RSquare";
              entry "AdjRSq";
              if (_NOBS=.) entry "  NA   ";
              else entry _NOBS / halign=center valign=bottom format=best3.;
              endif;
              if (_NPARM=.) entry "  NA   ";
              else entry _NPARM / halign=center valign=bottom format=best3.;
              endif;
              if (_EDF=.) entry "  NA   ";
              else entry _EDF / halign=center valign=bottom format=best3.;
              endif;
              if (_MSE=.) entry "  NA   ";
              else entry _MSE / halign=center valign=bottom format=best6.;
              endif;
              if (_RSQUARE=.) entry "  NA   ";
              else entry _RSQUARE / halign=center valign=bottom format=best6.;
              endif;
              if (_ADJRSQ=.) entry "  NA   ";
              else entry _ADJRSQ / halign=center valign=bottom format=best6.;
              endif;
           EndColumn2Header;
        endlayout;
     end;
run;

ods html;
ods graphics on / imagename = 'modreg';
ods select fit;

proc reg data = angina;
   model y_impr = x_dur;
run;
quit;

ods graphics off;
ods html close;
```
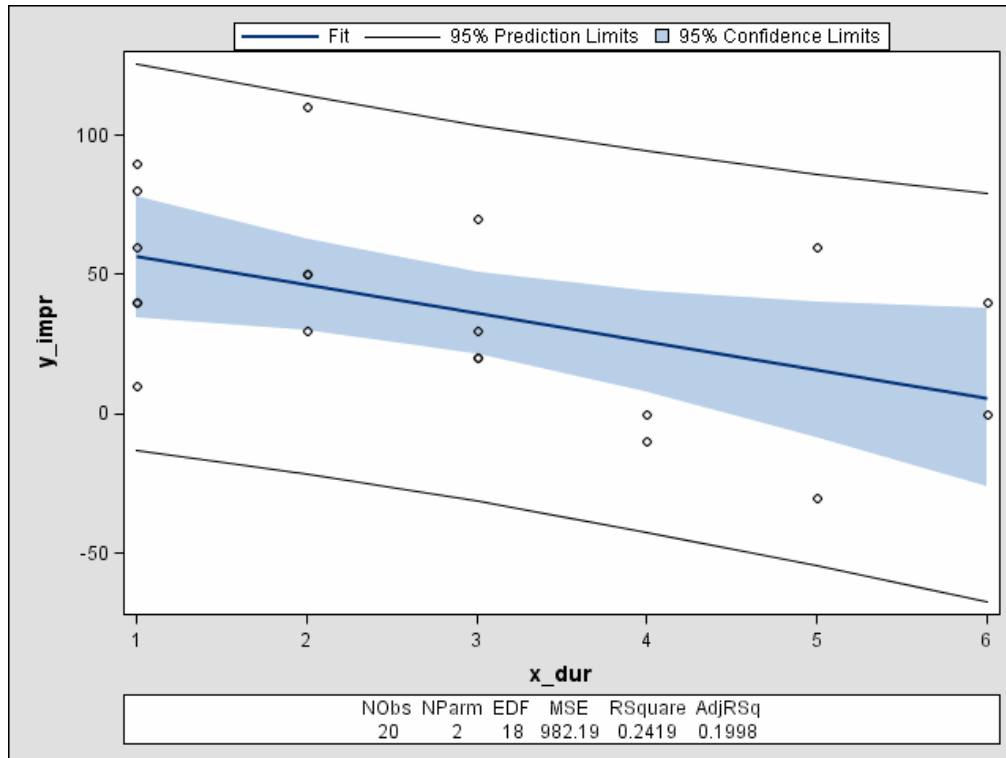
The result of the change, after submitting the modified template definition and the program in Program 4, is displayed in Figure 4:

FIGURE 4

EXAMPLE 5: CUSTOMIZING APPEARANCE OF ODS GRAPHICS

You can modify a style to customize the appearance of ODS Graphics in the same way as customizing the appearance of ODS tables. Four styles supplied by SAS are recommended for use with ODS Graphics: Analysis, Default, Journal, and Statistical. The style Default is used in this paper. Example 5 shows how to enlarge the fonts for the axis value (tick mark) labels, axis labels, titles, and footnotes if you want to emphasize them in the graph. The fit plot from REG procedure is used as an example.

PROGRAM 5

```
proc template;
    define style bigfont;
    parent = styles.default;
    replace GraphFonts /
         'GraphDataFont'     = ("Arial",8pt)
         'GraphFootnoteFont' = ("Arial",18pt,Bold)
         'GraphTitleFont'    = ("Arial",16pt,Bold)
         'GraphValueFont'    = ("Arial",12pt,Bold)
         'GraphLabelFont'    = ("Arial",16pt,Bold);
    end;
run;

ods html style = bigfont;
ods graphics on / imagename = 'modfont';
ods select fit;

proc reg data = angina;
   model y_impr = x_dur;
run;
quit;
```
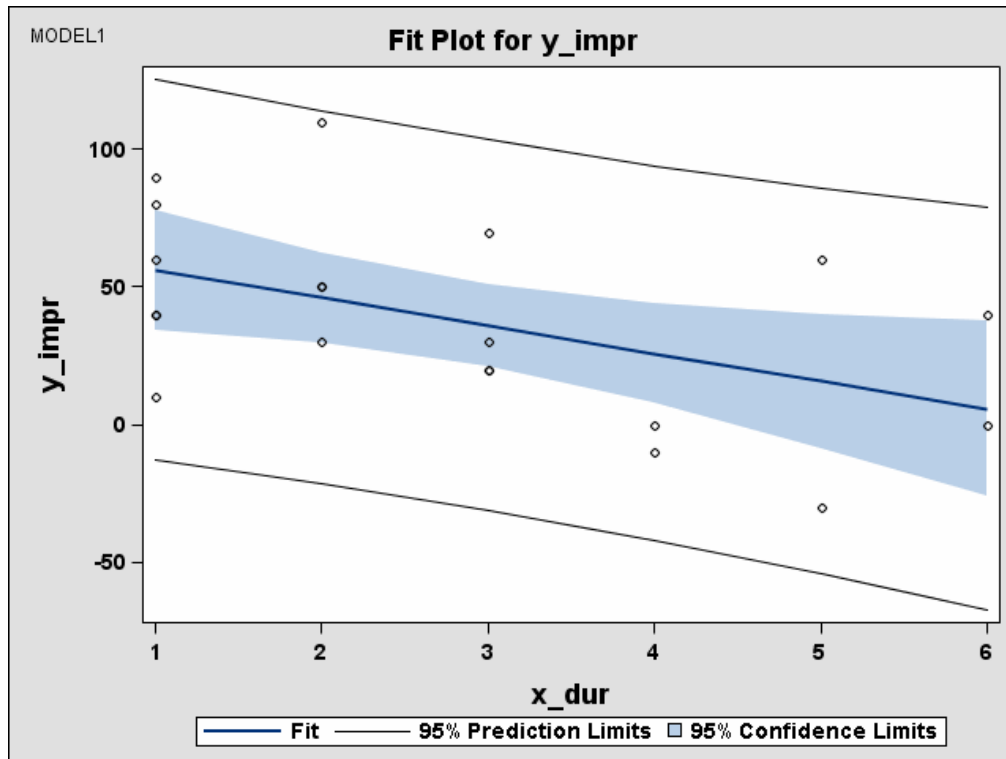
```
ods graphics off;
ods html close;
```

Submit the preceding program to display the fit plot with modified style, as shown in Figure 5:

FIGURE 5

CREATE STATISTICAL GRAPHS USING ODS GRAPHICS TEMPLATE LANGUAGE

Starting in SAS 9.1, a new template type STATGRAPH, which describes the layout and appearance of a graph, was added to the ODS template type family. A stand alone graphics template can be defined, unassociated with any procedure. It's useful when a procedure does not produce a graph that you would like to see. You can define the graphics template, compile the template, use SAS procedures to create output data sets with analyzed results, and finally use a data step to feed the data to the graphics template via FILE and PUT statements.

ODS GTL BASICS

In SAS 9.1, ODS GTL is a new language for defining graphs. The syntax is part of PROC TEMPLATE:

```
PROC TEMPLATE;
        DEFINE STATGRAPH name-of-graph-definition;
                <declaration-statements;>
                <layout-statements;>
                <plot-statements;>
                <text-statements;>
        END;
RUN;
```

The syntax of binding a graphics template to a SAS data set likes binding a table template to the DATA step to produce the table, ODS GRAPHICS statement is specified to request ODS Graphics:

ODS GRAPHICS ON;

```
DATA _NULL_;
        SET my-data;
        FILE PRINT
        ODS = (TEMPLATE = "my-graphics-template");
        PUT _ODS_;
RUN;
```

The following two examples demonstrate how to use ODS GTL to create statistical graphics templates and generate statistical graphics from DATA step.

EXAMPLE 6: TWO-SAMPLE T-TEST OF FEV1 CHANGES (WALKER, 2002 P68)

"A new compound, ABC-123, is being developed for long-term treatment of patients with chronic asthma. Asthmatic patients were enrolled in a double-blind study and randomized to receive daily oral doses of ABC-123 or a placebo for 6 weeks. The primary measurement of interest is the resting FEV_1 (forced expiratory volume during the first second of expiration), which is measured before and at the end of the 6-week treatment period. Does administration of ABC-123 appear to have any effect on FEV_1?"

In Program 6, a graphics template MEANCHG is defined by ODS GTL in PROC TEMPLATE. PROC SUMMARY is used to compute the mean change of FEV_1 and their confidence limits. Because computations are performed independent of the template, different statistics can be included or computed.

PROGRAM 6

```
proc format;
    value $trt 'A' = 'Active'
              'P' = 'Placebo';
run;

data fev;
    length trtgrp $ 7;
    input patno trt $ fev0 fev6 @@;
    chg = fev6 - fev0;
    if chg = . then delete;
    trtgrp = put(trt, $trt.);
    datalines;
    101 A 1.35  .    103 A 3.22 3.55 106 A 2.78 3.15
    108 A 2.45 2.30 109 A 1.84 2.37 110 A 2.81 3.20
    113 A 1.90 2.65 116 A 3.00 3.96 118 A 2.25 2.97
    120 A 2.86 2.28 121 A 1.56 2.67 124 A 2.66 3.76
    102 P 3.01 3.90 104 P 2.24 3.01 105 P 2.25 2.47
    107 P 1.65 1.99 111 P 1.95  .    112 P 3.05 3.26
    114 P 2.75 2.55 115 P 1.60 2.20 117 P 2.77 2.56
    119 P 2.06 2.90 122 P 1.71  .    123 P 3.54 2.92
;
run;

proc template;
    define statgraph mygraphs.meanchg;
            layout gridded;
                    entrytitle 'Bar Chart of Mean Change by Treatment Group' ;
                    entrytitle 'with Upper and Lower CLM' ;
                    barchartparm x = trtgrp  y = chg_mean
                                / yerrorupper=uclm
                                  yerrorlower=lclm;
            endlayout;
        end;
run;

ods html;
ods graphics on / imagename='meanchange';

proc summary data = fev nway;
    class trtgrp;
```

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```
      var chg;
      output out = meanchg (drop = _type_ _freq_)
             mean = chg_mean  lclm = lclm uclm = uclm;
   run;
   data _null_;
       set meanchg;
       label chg_mean = "Mean Change"
             trtgrp = "Treatment Group";
       uclm = uclm - chg_mean;
       lclm = chg_mean - lclm;
       file print ods = (template='mygraphs.meanchg');
       put _ods_;
   run;

   ods graphics off;
   ods html close;
```

The two-sample t-test can be carried out by using PROC TTEST. The bar chart generated by the preceding program, as shown in Figure 6, can help to compare the mean changes visually.

FIGURE 6

Bar Chart of Mean Change by Treatment Group with Upper and Lower CLM
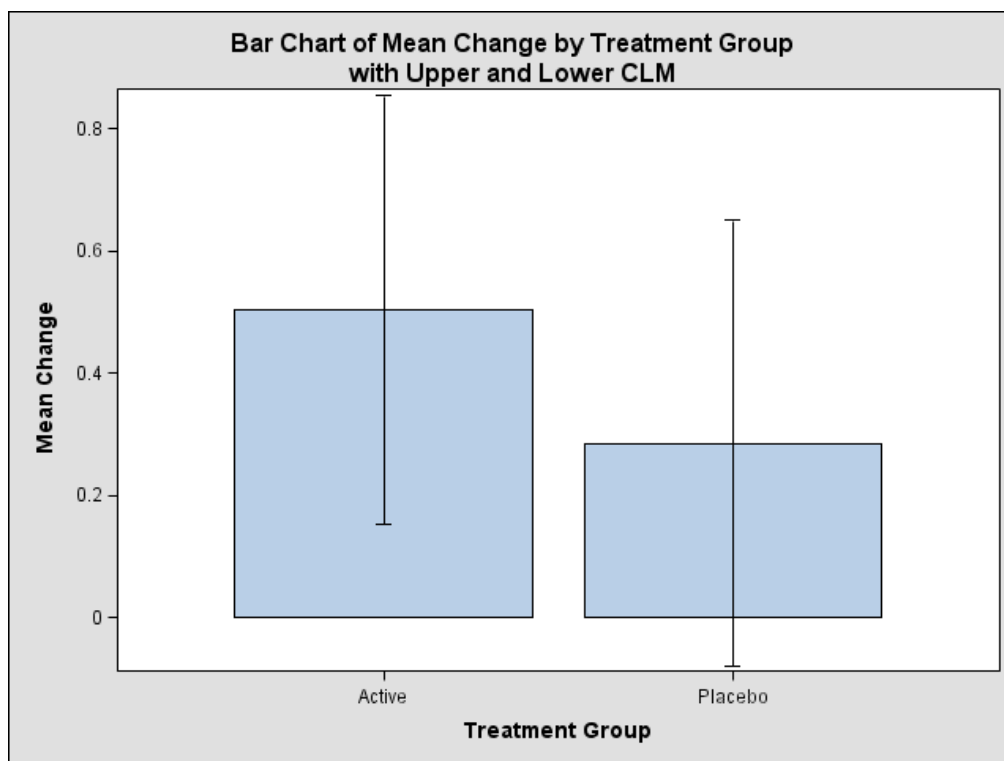
EXAMPLE 7: MEAN WALKING DISTANCE OVER TIME (WALKER, 2002 P127)

"Patients were randomly assigned to receive either the new drug Novafylline, thought to reduce the symptoms of intermittent claudication, or a placebo in a 4-month double-blind study. The primary measurement of efficacy is the walking distance on a treadmill until discontinuation due to claudication pain. In two study centers, 38 patients underwent treadmill testing at baseline (Month-0) and at each of 4 monthly, follow-up visits. Is there any distinction in exercise tolerance profiles between patients who receive Novafylline and those on placebo?"

Graph of mean measurement over time is one of the most commonly used statistical graphs to examine safety or efficacy of treatments. The following program uses the data from this study, computes summary statistics from PROC SUMMARY, defines a graphics template OVERTIME by ODS GTL, and generates a mean distance over time plot as shown in Figure 7.

PROGRAM 7

```
data wdvis;
    input trt $ pat wd0 wd1 wd2 wd3 wd4;
    datalines;
    ACT 101 190 212 213 195 248
    ACT 102  98 137 185 215 225
    ACT 104 155 145 196 189 176
    ACT 105 245 228 280 274 260
    ACT 107 182 205 218 194 193
    ACT 110 140 138 187 195 205
    ACT 111 196 185 185 227 180
    ACT 113 162 176 192 230 215
    ACT 116 195 232 199 185 200
    ACT 117 167 187 228 192 210
    ACT 118 123 165 145 185 215
    ACT 120 105 144 119 168 165
    ACT 202 161 177 162 185 192
    ACT 204 255 242 330 284 319
    ACT 205 144 195 180 184 213
    ACT 208 180 218 224 165 200
    ACT 209 126 145 173 175 140
    ACT 211 175 155 154 164 154
    ACT 214 227 218 245 235 257
    ACT 215 175 197 195 182 193
    PBO 103 187 177 200 190 206
    PBO 106 205 230 172 196 232
    PBO 108 165 142 195 185 170
    PBO 109 256 232 252 326 292
    PBO 112 197 182 160 210 185
    PBO 114 134 115 150 165 170
    PBO 115 196 166 166 188 205
    PBO 119 167 144 176 155 158
    PBO 121  98 102  89 128 130
    PBO 201 167 175 122 162 125
    PBO 203 123 136 147 130 135
    PBO 206  95 102 154 105 112
    PBO 207 181 177 140 212 230
    PBO 210 237 232 245 193 245
    PBO 212 144 172 163 158 188
    PBO 213 182 202 254 185 173
    PBO 216 165 140 153 180 155
    PBO 217 196 195 204 188 178
    ;
run;

proc format;
    value $trt 'ACT' = 'Active'
               'PBO' = 'Placebo';
run;

data wdvisv;
    length treatmnt $ 7;
    set wdvis;
    keep treatmnt pat month distance;
    treatmnt = put(trt, $trt.);
    distance = wd0; month = 0; output;
    distance = wd1; month = 1; output;
    distance = wd2; month = 2; output;
    distance = wd3; month = 3; output;
```

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```
        distance = wd3; month = 4; output;
run;


proc sort data = wdvisv;
    by treatmnt;
run;

proc summary data = wdvisv nway;
   class month;
   var distance;
   by treatmnt;
   output out = meandis (drop = _type_ _freq_)
          mean = dis_mean  stderr = stderr;
run;

data meandis;
    set meandis;
    label month = "Month"
          dis_Mean = "Mean Distance";
    elower = dis_mean - stderr;
    eupper = dis_mean + stderr;
run;

proc template;
    define statgraph mygraphs.overtime;
            layout gridded;
                    entrytitle "Mean Distance Over Time" ;
                    entrytitle '(Error Bars show ± SE)';
                    layout overlay;
                            scatterplot x = month y = dis_Mean
                                    / group = treatmnt
                                       name = "treat"
                                       yerrorlower = elower
                                       yerrorupper = eupper;
                            seriesplot  x = month y = dis_Mean
                                    / group = treatmnt;
                    endlayout;
                    discretelegend "treat";
            endlayout;
    end;
run;

ods html;
ods graphics on / imagename='overtime';

data _null_;
  set meandis;
  file print ods = (template='mygraphs.overtime');
  put _ods_;
run;

ods graphics off;
ods html close;
```
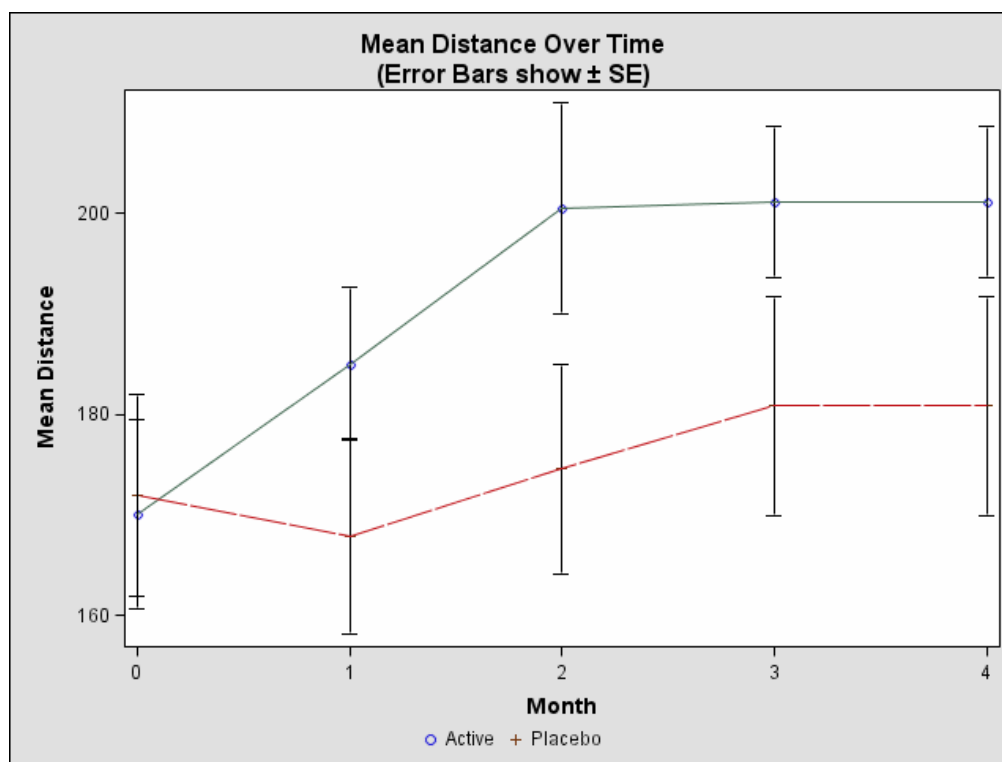
FIGURE 7

CONCLUSION

Graphical displays to illustrate the effects and safety of treatments in clinical research are very helpful to effectively present clinically relevant findings embedded in large volumes of data or complex study design. There are numerous types of statistical graphs which can assist statisticians and clinicians to interpret the results of a study easily and quickly. ODS Statistical Graphics is an exciting new facility provided by SAS 9. It greatly enhances the ability of graphical representations for clinical research. This paper only covers a few examples of statistical graphs commonly used in clinical research; the programs can be adapted to other statistical graphics with the same principle.

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