

# How to Perform an Easy Welch's t-Test in SAS

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## RECOMMENDED CITATION

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The Welch's t-Test is a vital statistical tool, specifically designed to compare the means of two independent groups when the assumption of equal population variances--a prerequisite for the standard Student's t-test--cannot be met. Implementing this test within SAS is streamlined through the powerful PROC TTEST procedure.

This procedure efficiently processes input data from two independent samples and rigorously calculates the differences between their means. Crucially, the PROC TTEST procedure provides built-in mechanisms to adjust for unequal variances, relying on the robust Satterthwaite approximation for degrees of freedom. Furthermore, the use of the OUTPUT statement allows analysts to save the comprehensive test results into a new dataset for subsequent, deeper analysis.

## Understanding When to Use Welch's t-Test

The Welch's t-Test is essential when comparing the means of two distinct groups where we suspect or confirm that the variability (variance) within those groups differs significantly. Unlike the traditional Student's t-test, which assumes homogeneity of variances, the Welch test provides a more accurate and conservative assessment of mean differences under conditions of unequal variances, thereby preventing inflated Type I error rates.

This tutorial focuses specifically on the practical execution of the Welch's t-Test within the SAS environment. By following the steps outlined below, users can efficiently generate, run, and interpret the necessary statistical output to determine if a significant difference exists between their group means, especially in scenarios where sample sizes or variances are dissimilar.

## Example Scenario: Comparing Exam Preparation Methods

Consider a practical scenario in educational statistics: a teacher wishes to evaluate the effectiveness of an exam preparation booklet. The objective is to compare the exam scores of two independent cohorts of students. The first group comprises 12 students who utilized the prep booklet, while the second group consists of 12 students who did not use the booklet.

The following data represents the raw exam scores for the students in each respective group. We aim to use Welch's t-Test to formally determine if the mean exam score is statistically equal or different between these two groups, accounting for potential differences in score variability.

**Booklet Group Scores:** 90, 85, 88, 89, 94, 91, 79, 83, 87, 88, 91, 90

**No Booklet Group Scores:** 67, 90, 71, 95, 88, 83, 72, 66, 75, 86, 93, 84

The subsequent steps detail the process required to implement this analysis in SAS, starting with data creation and culminating in the interpretation of the statistical results.

## Step 1: Data Preparation and Creation in SAS

The first critical step involves structuring the raw data into a format that SAS can process effectively. We use the familiar DATA step to create a dataset named exam\_scores. This dataset will contain two primary variables: group (a character variable indicating whether the booklet was used) and score (a numeric variable representing the student's exam score).

The following SAS code block demonstrates the necessary syntax for defining the dataset structure and inputting the scores listed above using the DATALINES statement. It is essential that the data is correctly entered to ensure the validity of the subsequent statistical testing.

```
/*create dataset*/  
data exam_scores;  
input group $ score;  
datalines;  
booklet 90  
booklet 85  
booklet 88  
booklet 89  
booklet 94  
booklet 91  
booklet 79  
booklet 83  
booklet 87  
booklet 88  
booklet 91  
booklet 90  
no_booklet 67  
no_booklet 90  
no_booklet 71  
no_booklet 95  
no_booklet 88  
no_booklet 83  
no_booklet 72  
no_booklet 66  
no_booklet 75  
no_booklet 86  
no_booklet 93  
no_booklet 84  
;
```

**run;**

## Step 2: Executing Welch's t-Test using PROC TTEST

Once the data set is successfully created and loaded into the SAS session, we proceed directly to statistical analysis using the PROC TTEST procedure. This procedure is specifically designed for t-tests, and it automatically incorporates the necessary calculations for Welch's t-Test when variances are found to be unequal.

In the syntax below, we specify the input data (data=exam\_scores), set the significance level (alpha=0.05), and crucially define the variables: the grouping variable using the CLASS statement (group), and the measurement variable using the VAR statement (score). Executing this code will produce detailed output tables necessary for drawing conclusions about the mean scores.

```
/*perform Welch's t-test*/  
proc ttest data=exam_scores alpha=0.05;  
class group;  
var score;  
run;
```

The resulting output from the PROC TTEST execution includes several key tables, starting with descriptive statistics for each group and culminating in the actual t-test results and tests for variance equality. We must carefully examine these sections to arrive at a statistically sound conclusion.

## The TTEST Procedure

Variable: score

group	Method	N	Mean	Std Dev	Std Err	Minimum	Maximum
booklet		12	87.9167	4.0330	1.1642	79.0000	94.0000
no_bookl		12	80.8333	10.2055	2.9461	66.0000	95.0000
Diff (1-2)	Pooled		7.0833	7.7594	3.1678		
Diff (1-2)	Satterthwaite		7.0833		3.1678		

group	Method	Mean	95% CL Mean	Std Dev	95% CL Std Dev
booklet		87.9167	85.3542 90.4791	4.0330	2.8570 6.8476
no_bookl		80.8333	74.3491 87.3176	10.2055	7.2295 17.3276
Diff (1-2)	Pooled	7.0833	0.5138 13.6529	7.7594	6.0011 10.9823
Diff (1-2)	Satterthwaite	7.0833	0.3048 13.8618		

Method	Variances	DF	t Value	Pr >  t
Pooled	Equal	22	2.24	0.0358
Satterthwaite	Unequal	14.354	2.24	0.0417

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	11	11	6.40	0.0046

## Interpreting the Equality of Variances Output

The first crucial step in analyzing the PROC TTEST results is to examine the table titled "**Equality of Variances**." This table presents the results of an F-test, designed to rigorously determine if the population variances are equal between the two independent samples (Booklet vs. No Booklet). The outcome of this preliminary test dictates which row of the subsequent t-test table we should rely upon.

The F-test operates under the following formalized null and alternative hypotheses:

**H<sub>0</sub>**: The population variances are equal ( $\sigma^2 = \sigma^2$ ).

**H<sub>A</sub>**: The population variances are not equal ( $\sigma^2 \neq \sigma^2$ ).

In our example, inspecting the output reveals a p-value of **.0046** for the F-test. Since this p-value is significantly less than our chosen alpha level of 0.05, we must reject the null hypothesis (H<sub>0</sub>). This statistical evidence confirms that the variances of the exam scores are indeed unequal between the students who used the booklet and those who did not. Consequently, we are justified in using

the adjusted statistics provided by Welch's t-Test.

## Drawing Conclusions from the Unequal Variance Test

Because the test for the Equality of Variances indicated a significant difference ( $p < 0.05$ ), we must now focus on the row titled "**Unequal**" in the primary t-test output table. This row provides the t-statistic and the corresponding p-value calculated using the Satterthwaite approximation, which is the core of Welch's t-Test. The relevant metrics from the output are:

**t Value: 2.24**

**p-value: .0417**

We now recall the fundamental null and alternative hypotheses for the t-test itself, which addresses the equality of the population means:

**H0:**  $\mu_1 = \mu_2$  (The mean scores are equal between the two groups.)

**HA:**  $\mu_1 \neq \mu_2$  (The mean scores are not equal between the two groups.)

Since the calculated p-value of **.0417** is less than the predetermined significance level ( $\alpha = 0.05$ ), we decisively reject the null hypothesis (H0). This outcome provides statistically sufficient evidence to conclude that there is a significant difference in the mean exam scores between the students who used the preparation booklet and those who did not. The preparation method appears to have had a tangible impact on performance.

## Further Exploration and Related Statistical Procedures

For those interested in conducting quick calculations or verifying results, several online calculators are available that automatically perform Welch's t-Test for any two samples. Using these tools can be a valuable supplement to statistical software outputs, particularly for understanding the input variables and resulting degrees of freedom.

In addition to the Welch test, SAS offers extensive capabilities for various statistical methods. Analysts frequently utilize other procedures for different research designs.

The following tutorials explain how to perform other common statistical tests in SAS: