

How to Easily Create a Bland-Altman Plot in Excel

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The Bland-Altman Plot is a fundamental tool in biostatistics and clinical research, specifically designed to assess the agreement between two different measurement techniques or instruments. Unlike correlation analyses, which only measure association, the Bland-Altman method focuses on quantifying the magnitude and consistency of the differences between paired observations. This detailed guide demonstrates how to leverage the powerful charting features of Excel to construct this crucial visualization accurately and efficiently.

The process of generating a reliable Bland-Altman Plot involves several precise steps: preparing the dataset, calculating the mean and difference for each pair of measurements, determining the limits of agreement, and finally, using the scatter plot function in Excel to visualize these results. Mastery of this technique is essential for researchers needing to validate new instruments against established standards or compare different protocols.

Introduction to Bland-Altman Analysis

A Bland-Altman Plot, also known as a difference plot, serves as a graphical representation of the agreement between two quantitative measurements. Its primary purpose is to visually and statistically determine if two methods of measurement--whether they are two separate devices, two observers, or two different sampling protocols--are interchangeable. It plots the difference between the two measurements (Y-axis) against the average of the two measurements (X-axis).

Understanding the plot's structure is key. If the two methods agree perfectly, all points would cluster around the horizontal zero line. However, in reality, slight discrepancies always exist. This plot helps identify systematic bias (when the mean difference is significantly non-zero) and proportional bias (when the differences increase or decrease as the magnitude of the measurement increases).

This tutorial provides a systematic, step-by-step example of how to execute the necessary calculations and charting procedures to create a fully functional and interpretable Bland-Altman plot within the Excel environment.

Step 1: Setting Up the Measurement Data

The foundation of any Bland-Altman analysis is paired data. You must have simultaneous measurements taken on the same subjects or samples using both Method 1 (Instrument A) and Method 2 (Instrument B). For demonstration purposes, consider a scenario where a biologist is comparing two different instruments (A and B) used to measure the weight of a sample set of 20 different frogs, recorded in grams.

It is crucial that your data is organized cleanly in a spreadsheet. Create three columns: one for the

subject identifier (e.g., Frog ID), one for the measurement from Instrument A, and one for the measurement from Instrument B. Ensuring accurate data entry is the prerequisite for all subsequent statistical methods.

The raw data, showing the weight measurements for 20 subjects as recorded by each instrument, should look similar to the arrangement shown below:

	A	B	C	D	E	F	G
1	A	B					
2	5	4					
3	5	4					
4	5	5					
5	6	5					
6	6	5					
7	7	7					
8	7	8					
9	7	6					
10	8	9					
11	8	7					
12	9	7					
13	10	11					
14	11	13					
15	13	13					
16	14	12					
17	14	13					
18	15	14					
19	18	19					
20	22	19					
21	25	24					
22							
23							
24							
25							

Step 2: Calculating Averages and Differences

The next critical step involves transforming the raw measurement data into the specific coordinates required for the Bland-Altman plot: the average of the two measurements (X-coordinate) and the difference between the two measurements (Y-coordinate). These values must be calculated for every paired observation in your dataset.

We will introduce two new columns, typically labeled "Average" and "Difference." The "Average" column represents the mean weight calculated across Instrument A and Instrument B for each frog. The "Difference" column represents the raw discrepancy ($A - B$) in measurements.

Maintaining a consistent order (A minus B) is vital to correctly interpret any systematic bias.

To perform these calculations efficiently, utilize the following formulas in Excel:

For the Average (X-axis value): $\text{=(Measurement A + Measurement B) / 2}$

For the Difference (Y-axis value): $\text{=Measurement A - Measurement B}$

These calculations are applied row-by-row, creating the paired coordinates for the final visualization. The resulting table demonstrates the initial statistical transformation of the data:

	A	B	C	D	E	F	G
1	A	B	Average	Difference			
2	5	4	=AVERAGE(A2:B2)	=A2-B2			
3	5	4					
4	5	5					
5	6	5					
6	6	5					
7	7	7					
8	7	8					
9	7	6					
10	8	9					
11	8	7					
12	9	7					
13	10	11					
14	11	13					
15	13	13					
16	14	12					
17	14	13					
18	15	14					
19	18	19					
20	22	19					
21	25	24					
22							
23							
24							

Once the formulas are entered into the first row of the "Average" and "Difference" columns, use Excel's autofill feature (copy and paste the formulas down) to quickly apply these calculations to all 20 data points, ensuring computational accuracy across the entire dataset:

	A	B	C	D	E	F	G
1	A	B	Average	Difference			
2	5	4	4.5	1			
3	5	4	4.5	1			
4	5	5	5	0			
5	6	5	5.5	1			
6	6	5	5.5	1			
7	7	7	7	0			
8	7	8	7.5	-1			
9	7	6	6.5	1			
10	8	9	8.5	-1			
11	8	7	7.5	1			
12	9	7	8	2			
13	10	11	10.5	-1			
14	11	13	12	-2			
15	13	13	13	0			
16	14	12	13	2			
17	14	13	13.5	1			
18	15	14	14.5	1			
19	18	19	18.5	-1			
20	22	19	20.5	3			
21	25	24	24.5	1			
22							
23							
24							
25							

Step 3: Determining the Limits of Agreement

The power of the Bland-Altman Plot lies in its ability to define the "Limits of Agreement" (LoA). These limits define the range within which 95% of the differences between the two methods are expected to fall, assuming the differences are normally distributed. This provides a clear statistical threshold for determining if the measurement discrepancies are clinically or practically acceptable.

First, calculate the overall average difference across all subjects (the Mean Difference). This value represents the systematic bias, showing whether one instrument consistently measures higher or lower than the other. Second, calculate the standard deviation (SD) of the differences.

The standard formula for the 95% Limits of Agreement is:

LoA = Mean Difference $\pm$ 1.96 $\times$ SD of Differences.

In Excel, you would use the following functions for calculation:

Mean Difference: `=AVERAGE(Difference Column)`

Standard Deviation of Differences: $\text{=STDEV.S}(\text{Difference Column})$

Upper Limit of Agreement (ULoA): $\text{=Mean Difference} + 1.96 * \text{STDEV.S}(\text{Difference Column})$

Lower Limit of Agreement (LLoA): $\text{=Mean Difference} - 1.96 * \text{STDEV.S}(\text{Difference Column})$

The results of these critical calculations are typically displayed separately from the main data table, providing the necessary boundaries for the visualization:

	A	B	C	D	E	F	G
1	A	B	Average	Difference			
2	5	4	4.5	1			
3	5	4	4.5	1			
4	5	5	5	0			
5	6	5	5.5	1			
6	6	5	5.5	1			
7	7	7	7	0			
8	7	8	7.5	-1			
9	7	6	6.5	1			
10	8	9	8.5	-1			
11	8	7	7.5	1			
12	9	7	8	2			
13	10	11	10.5	-1			
14	11	13	12	-2			
15	13	13	13	0			
16	14	12	13	2			
17	14	13	13.5	1			
18	15	14	14.5	1			
19	18	19	18.5	-1			
20	22	19	20.5	3			
21	25	24	24.5	1			
22			Avg. Diff	0.5	=AVERAGE(D2:D21)		
23			Lower	-1.921	$\text{=D22}-1.96*\text{STDEV.S(D2:D21)}$		
24			Upper	2.921	$\text{=D22}+1.96*\text{STDEV.S(D2:D21)}$		
25							

Based on our example data, the average difference turns out to be **0.5**. The 95% confidence interval for the average difference (the LoA) is calculated to be . This range suggests that for 95% of the frogs, the measurement from Instrument A will differ from Instrument B by no more than 1.921g below the mean difference or 2.921g above the mean difference.

Step 4: Initial Scatter Plot Creation

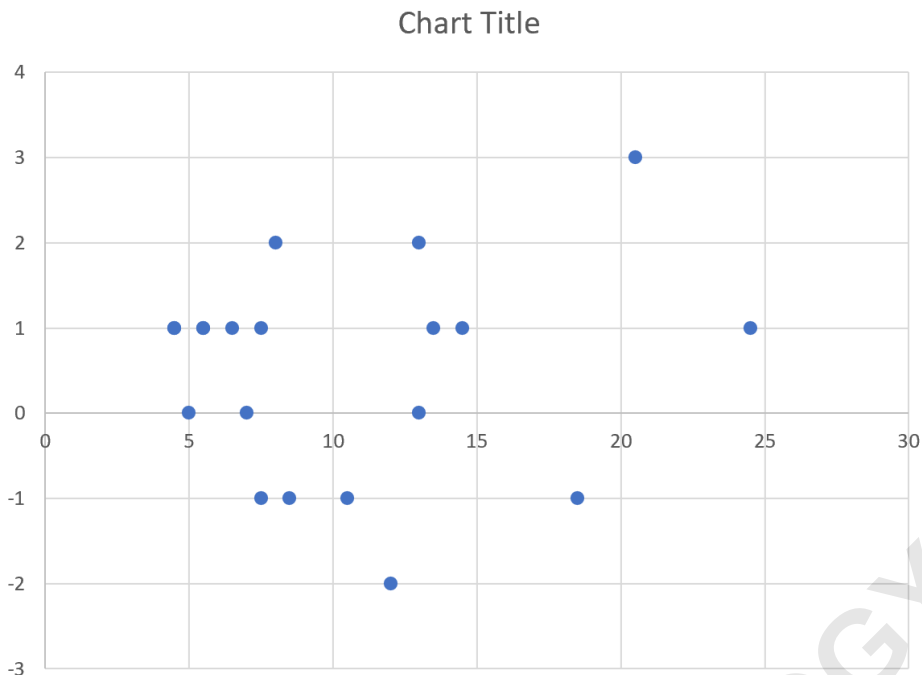
With all necessary numerical components calculated, the next step is generating the base scatter

plot. This plot will map the individual agreement points using the paired Average (X-axis) and Difference (Y-axis) columns created in Step 2.

To initiate the charting process, highlight the two key columns: the "Average" column and the "Difference" column. Ensure you do not include the header rows in this selection, only the numerical data points.

	A	B	C	D	E	F
1	A	B	Average	Difference		
2	5	4	4.5	1		
3	5	4	4.5	1		
4	5	5	5	0		
5	6	5	5.5	1		
6	6	5	5.5	1		
7	7	7	7	0		
8	7	8	7.5	-1		
9	7	6	6.5	1		
10	8	9	8.5	-1		
11	8	7	7.5	1		
12	9	7	8	2		
13	10	11	10.5	-1		
14	11	13	12	-2		
15	13	13	13	0		
16	14	12	13	2		
17	14	13	13.5	1		
18	15	14	14.5	1		
19	18	19	18.5	-1		
20	22	19	20.5	3		
21	25	24	24.5	1		
22			Avg. Diff	0.5		
23			Lower	-1.921		
24			Upper	2.921		
25						

Navigate to the top ribbon in Excel, click the **Insert** tab, and then locate the **Charts** group. Select the first option within the **Insert Scatter (X, Y) or Bubble Chart** section. Excel will automatically generate the foundational visualization, plotting the differences against the mean measurements:



At this stage, the chart provides a clear view of the agreement data. The X-axis represents the average measurement of the instruments, spanning from the lowest to the highest average weight recorded. The Y-axis shows the raw difference between the measurements from the two instruments. The scatter of points indicates the consistency (or lack thereof) across the measurement range.

Step 5: Preparing Data for Horizontal Reference Lines

To complete the Bland-Altman Plot, we must graphically represent the three calculated values: the Mean Difference, the Upper Limit of Agreement (ULoA), and the Lower Limit of Agreement (LLoA). Since Excel scatter plots cannot automatically draw horizontal lines based on a single Y-value across the entire X-axis range, we must create separate data series for each line.

For each reference line (Mean, ULoA, LLoA), we need two data points that span the entire X-axis range of the plot. Identify the minimum (Min X) and maximum (Max X) average measurement values observed in your data (e.g., 0 and 30). Then, create a small table for the reference lines:

Mean Difference Series: Paired coordinates (Min X, Mean Difference) and (Max X, Mean Difference).

ULoA Series: Paired coordinates (Min X, ULoA) and (Max X, ULoA).

LLoA Series: Paired coordinates (Min X, LLoA) and (Max X, LLoA).

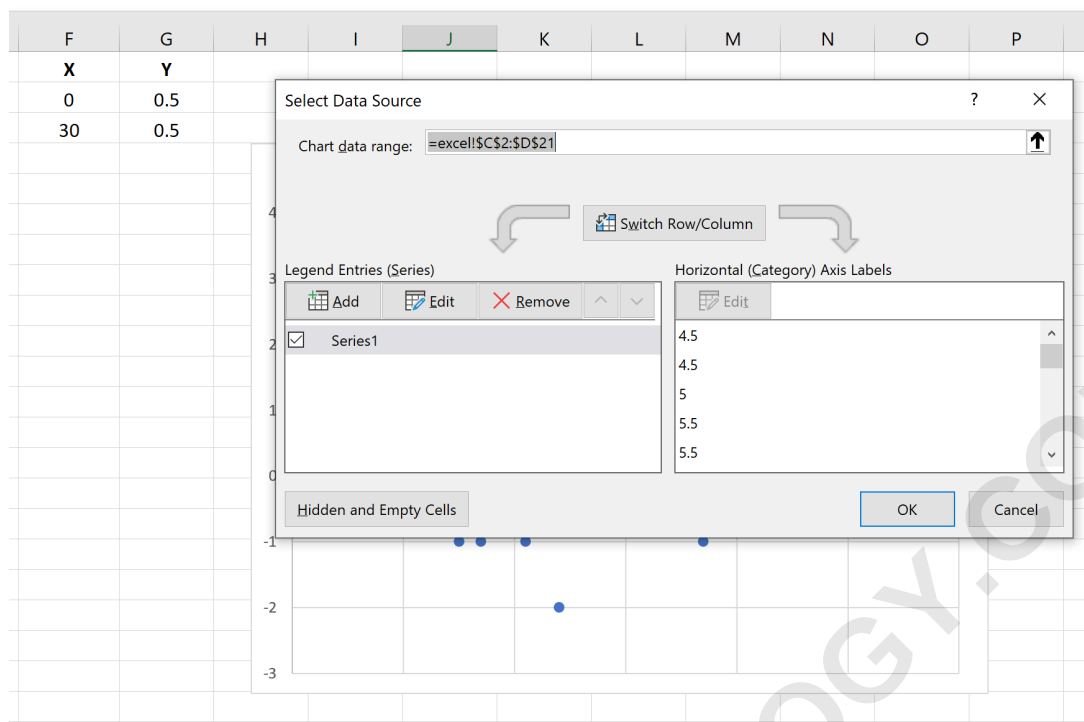
The necessary data structure to add the Mean Difference line is organized as follows, using 0 and 30 as representative minimum and maximum X-values:

	A	B	C	D	E	F	G
1	A	B	Average	Difference		X	Y
2	5	4	4.5	1		0	0.5
3	5	4	4.5	1		30	0.5
4	5	5	5	0			
5	6	5	5.5	1			
6	6	5	5.5	1			
7	7	7	7	0			
8	7	8	7.5	-1			
9	7	6	6.5	1			
10	8	9	8.5	-1			
11	8	7	7.5	1			
12	9	7	8	2			
13	10	11	10.5	-1			
14	11	13	12	-2			
15	13	13	13	0			
16	14	12	13	2			
17	14	13	13.5	1			
18	15	14	14.5	1			
19	18	19	18.5	-1			
20	22	19	20.5	3			
21	25	24	24.5	1			
22			Avg. Diff	0.5			
23			Lower	-1.921			
24			Upper	2.921			

Step 6: Adding the Mean Difference Line

We now add the first reference line to the existing scatter plot. This line represents the average bias between the two measurement methods (0.5 in our example). Right-click directly on the chart area and select **Select Data** from the context menu.

In the "Select Data Source" window that appears, click the **Add** button located under the **Legend Entries (Series)** section. This action opens the "Edit Series" dialogue box, allowing us to input the coordinates for the mean line.



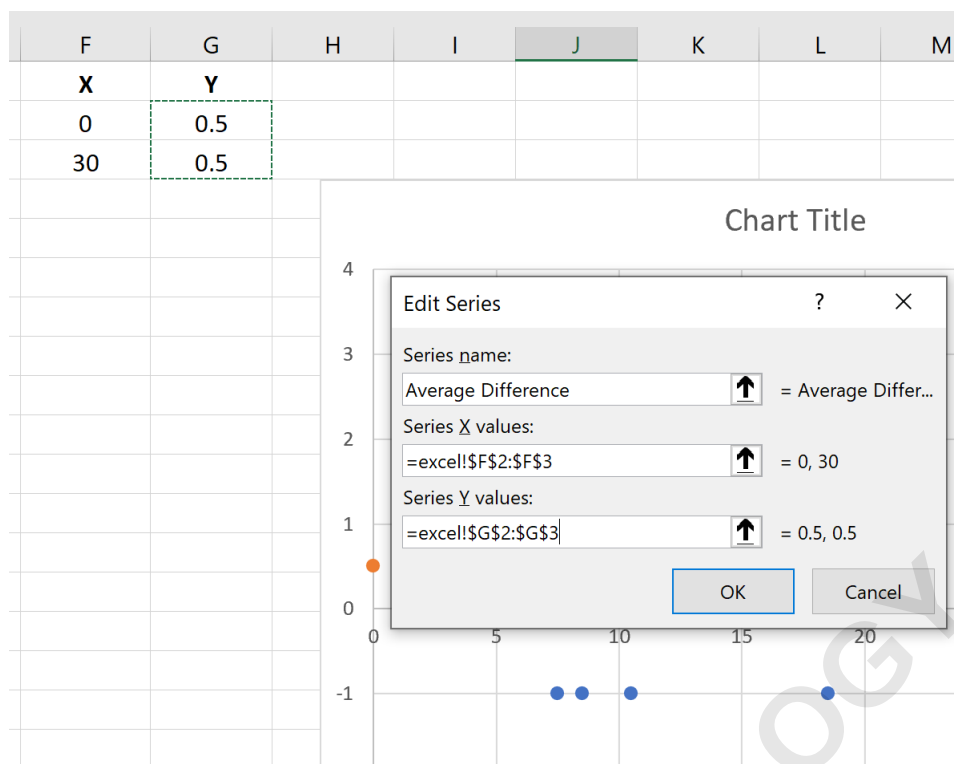
Fill in the required fields using the data series prepared in Step 5:

Series Name: Enter "Mean Difference" or "Bias."

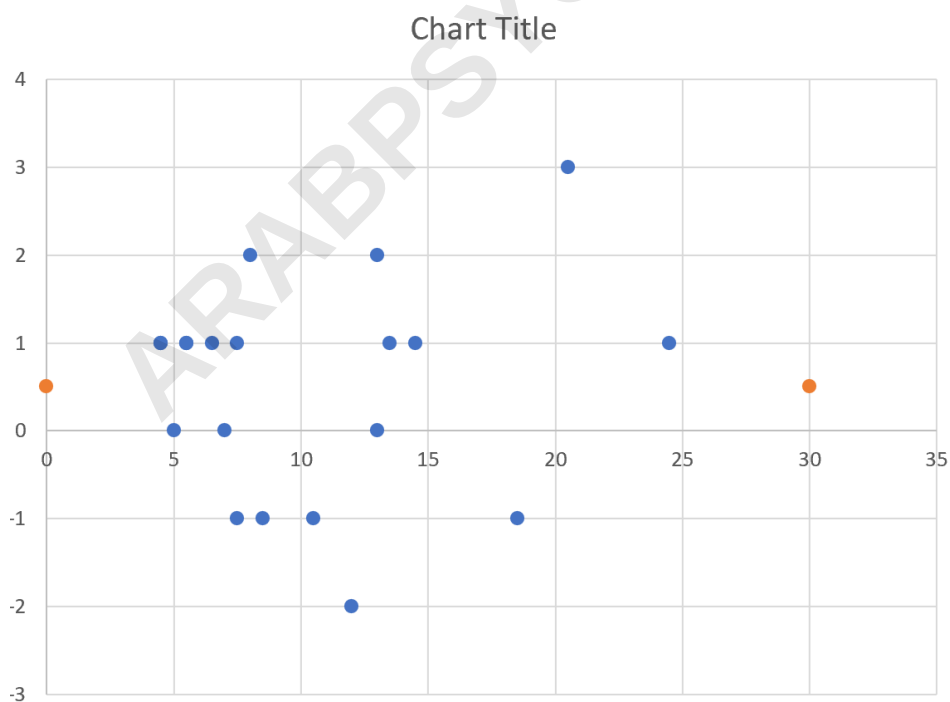
Series X values: Select the two cells corresponding to the X-axis values (Min X and Max X, e.g., 0 and 30).

Series Y values: Select the two cells corresponding to the Mean Difference Y-value (e.g., 0.5 and 0.5).

The completed dialogue box should reference the correct ranges from your spreadsheet:



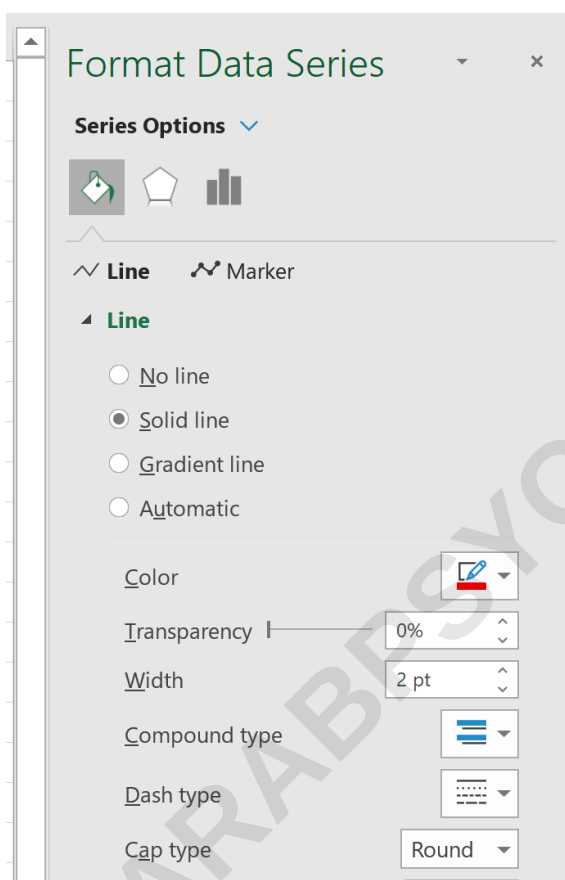
Once you click **OK**, two small markers (typically orange dots, indicating the second data series) will appear on the chart at the calculated height of the mean difference:



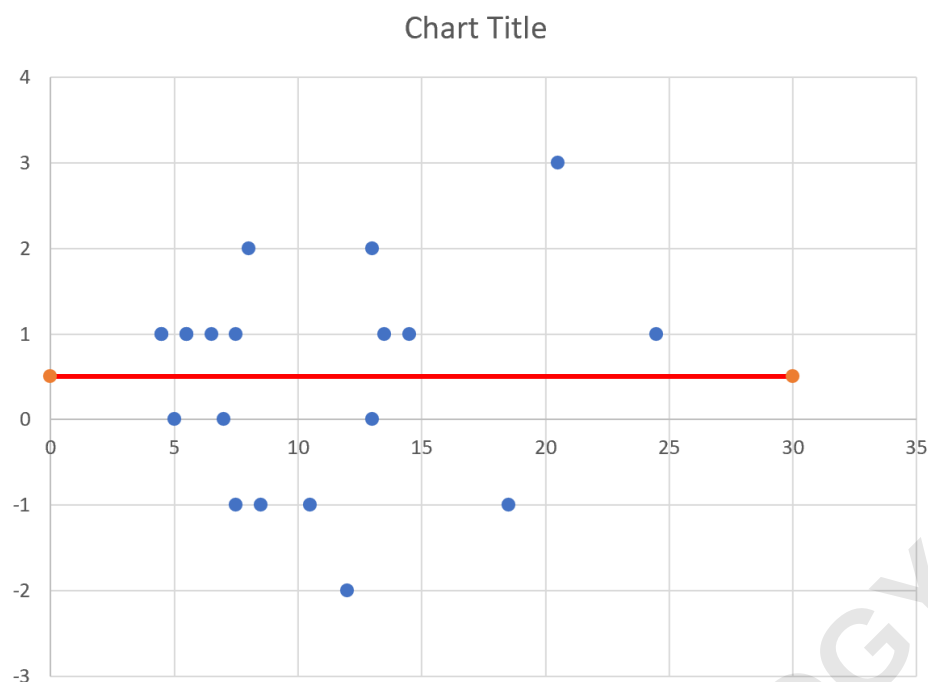
Step 7: Formatting the Reference Lines

The two markers added in the previous step must be connected and formatted into a clear, continuous line to represent the systematic bias effectively. Right-click on one of the newly added markers (the orange dots) and select **Format Data Series...** from the menu.

In the formatting pane that appears on the right side of the Excel window, navigate to the "Fill & Line" options (the paint bucket icon). Under the "Line" section, select **Solid Line**. You may also wish to adjust the color (often black or red) and the thickness of the line for better visual prominence.



Applying the solid line formatting will transform the two discrete points into a continuous horizontal line that spans the chart, representing the average difference between the two instruments:



Crucially, you must repeat the entire process (Steps 6 and 7) for both the Upper Limit of Agreement (ULoA) and the Lower Limit of Agreement (LLoA). Add these two limits as separate series using their respective calculated Y-values (2.921 and -1.921, in this case) and format them as solid or dashed lines. These outer limits define the critical boundary for the 95% confidence interval of agreement.

Step 8: Finalizing Aesthetics and Interpretation

Once all three critical horizontal lines (Mean Difference, ULoA, LLoA) are added and formatted, the Bland-Altman Plot is structurally complete. The final step involves enhancing the chart's aesthetics and ensuring proper labeling to facilitate accurate interpretation. Modify the line styles (e.g., dashed lines for LoA, solid line for Mean), adjust axis labels (e.g., "Average Weight (g)" for X-axis and "Difference (A - B) (g)" for Y-axis), and assign a clear, descriptive title.

Interpreting the final plot is straightforward:

Mean Difference Line: If this line is close to zero, there is minimal systematic bias. If it is far from zero, one instrument consistently measures higher or lower than the other.

Limits of Agreement: These lines define the acceptable range of variability. If the width between ULoA and LLoA is narrow, the methods agree well. If the range is too broad, the instruments are not interchangeable.

Data Point Distribution: All points should ideally scatter randomly around the Mean Difference line. If there is a pattern (e.g., points fanning out as the average measurement increases), it

indicates proportional bias, suggesting the agreement changes depending on the magnitude of the measurement.

By following these steps, you produce a professional and statistically robust Bland-Altman Plot in Excel, ready for rigorous statistical reporting and decision-making:

