Analysis Report

This report is structured as follows.

Contents

R Code Structure

1. Import and Data Preparation

Importing Libraries: Libraries like openxlsx are imported for reading Excel files, and tidyverse is loaded for data manipulation tasks.

Reading Data: The read.xlsx function is used to read the Excel file containing the clinical dataset.

Data Pivoting: The dataset is reshaped using pivot_longer() and pivot_wider() functions from the tidyverse package to organize the variables appropriately.

2. Data Inspection and Preprocessing

Declaring Dependent Variables: A vector dvs is created to list all the dependent variables.

Sanitizing Column Names: Column names are sanitized to make them syntactically valid, making them easier to use in later analysis.

Outlier Detection: A custom function find_outliers calculates Z-scores for each variable and identifies any outliers.

Boxplots: For each dependent variable, a boxplot is generated and saved as a PNG file.

3. Statistical Assumptions

Data Distribution: The calc_descriptive_stats_for_dvs function calculates skewness, kurtosis, and performs the Shapiro-Wilk test for normality.

Homogeneity of Variances: Levene's Test is applied to check for the equality of variances across groups using the leveneTest function from the car library.

4. Descriptive Statistics

Line Plots: Line plots for mean scores across each group and timepoint are generated.

Mean Value Dataframe: Mean scores are calculated for each dependent variable and stored in a dataframe (mean_values_df).

5. Linear Mixed Models

Model Fitting: The lme function from the nlme package is used to fit linear mixed-effects models.

ANOVA Table: For each model, an ANOVA table is generated to summarize the effects.

Log-transformed Data: The same analysis is performed on log-transformed data.

6. Age-Group Analysis

Age Summary: Mean and median ages are calculated for each group.

Boxplot: A boxplot of age distribution across groups is created.

Linear Mixed Models by Age: Data is filtered based on various age cutoffs and linear mixed models are fitted for each.

7. Visualization

Age-Specific Plots: For each unique combination of dependent variables and age cutoffs that showed a significant interaction, line plots are generated and saved.

Overall Plots: Similar line plots are generated for the overall data.

8. Export Results

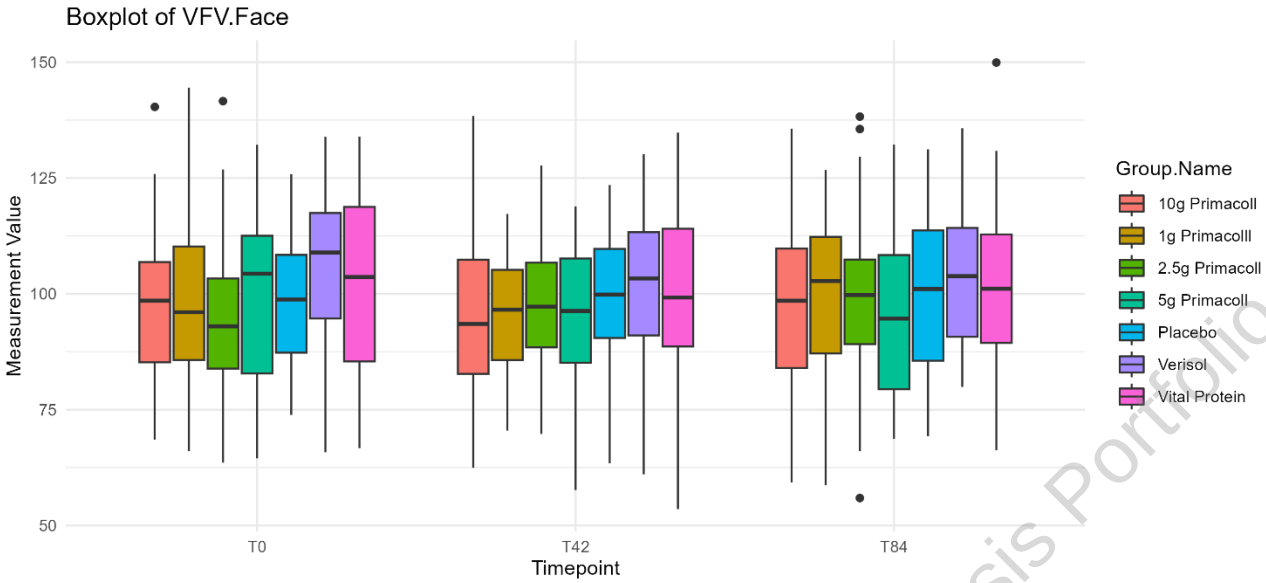
Excel Export: All the model summaries, significant interactions, and mean scores are exported to an Excel workbook with multiple sheets for easier interpretation.

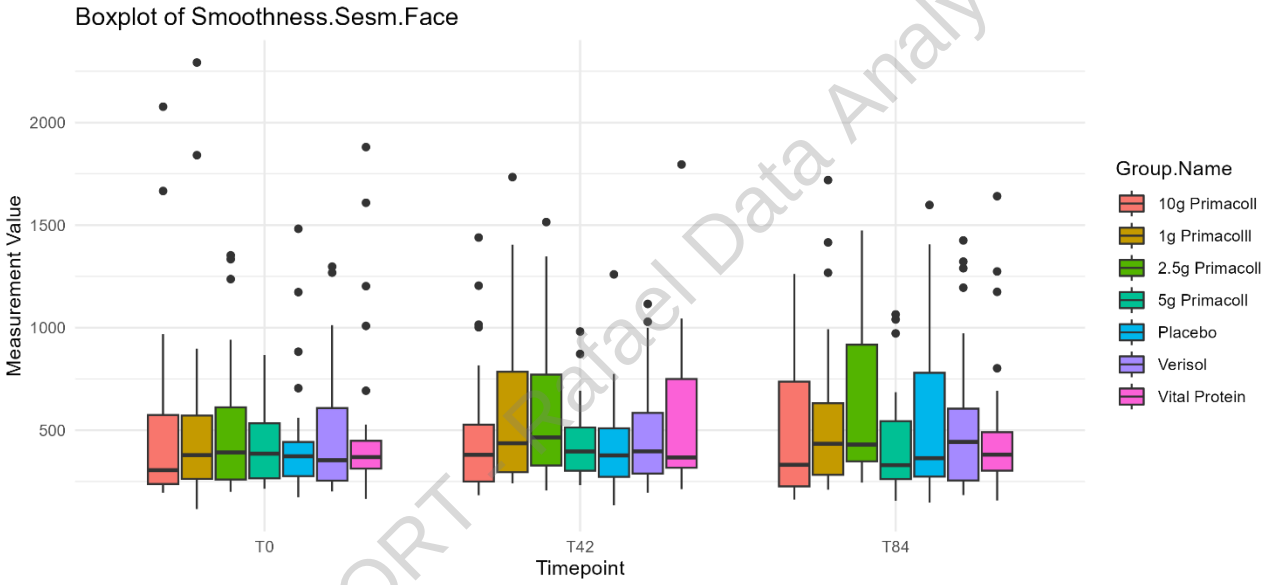
Outlier Analysis

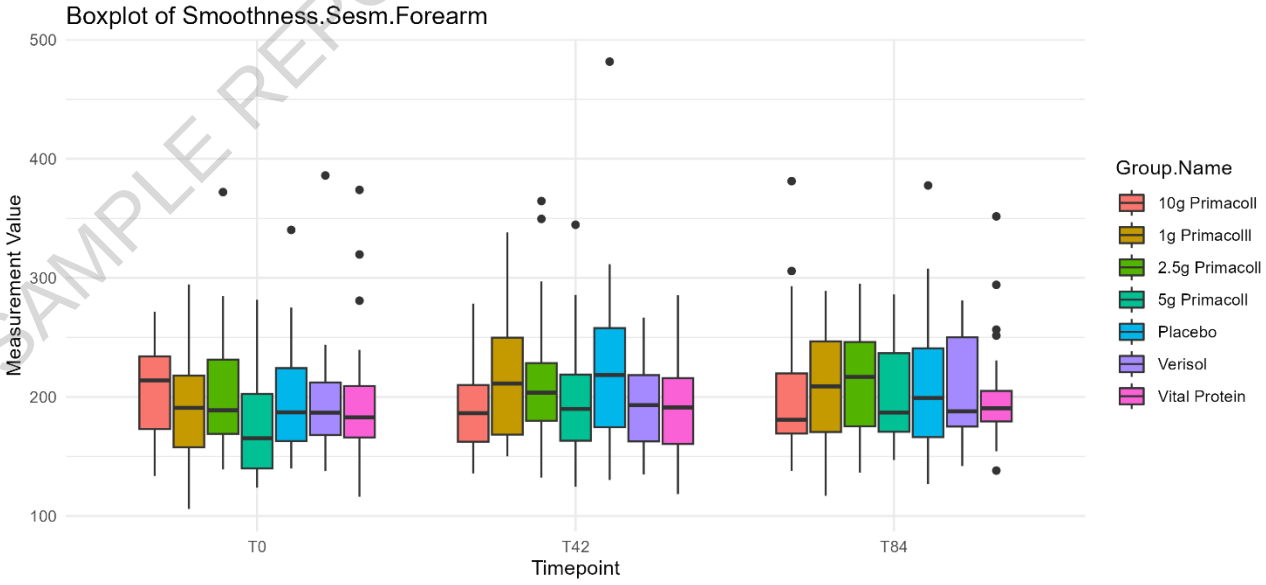
Outliers were inspected using Z-scores. Z-scores, also known as standard scores, are a measure of how many standard deviations an individual data point is from the mean of a distribution and is often used to detect outliers in datasets. Z-scores were generated for all clinical measurements and a total of 34 values surpassed the often-used threshold of ± 3 to detect mild outliers. That is about 1% of the total clinical measure over the 3 time periods (3,060 measurements). A closer inspection revealed that the highest Z-score was 5.58 which is not considered very extreme. Since there is no theoretical justification to consider this observation non-genuine, outliers were not excluded before further examining data distribution.

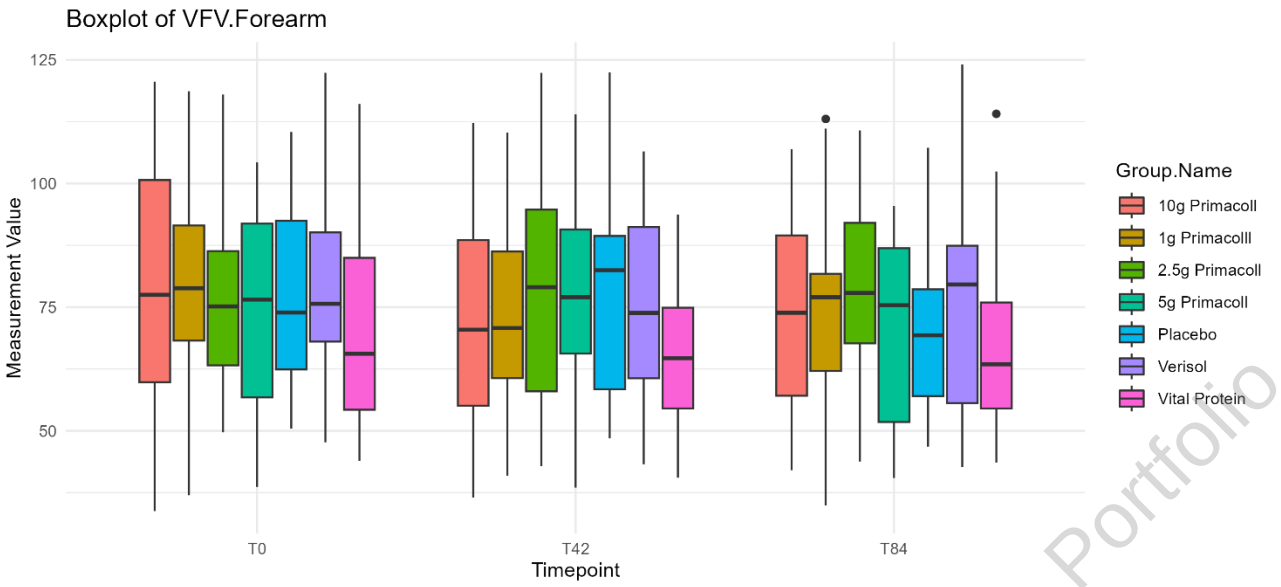
Nevertheless, in order to alleviate any potential impacts that these outliers might have on the analysis, log-transformed measures were calculated and the models were executed both on the original and log-transformed variables. The results were the same in both approaches, suggesting that outleirs are not particularly harming the original solution.

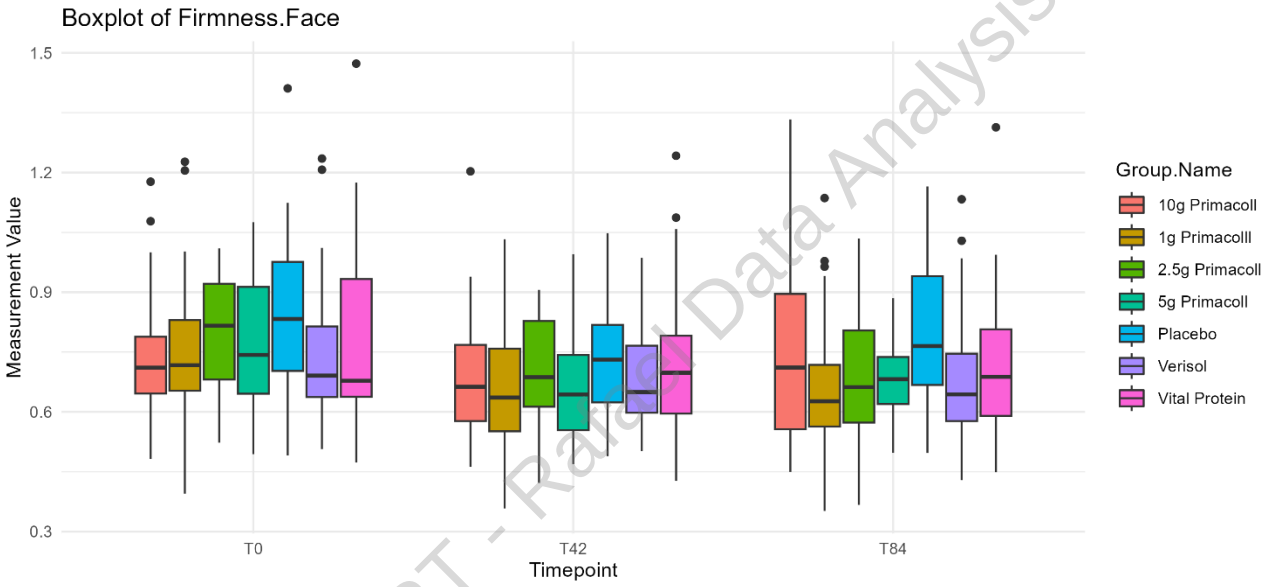
Boxplots

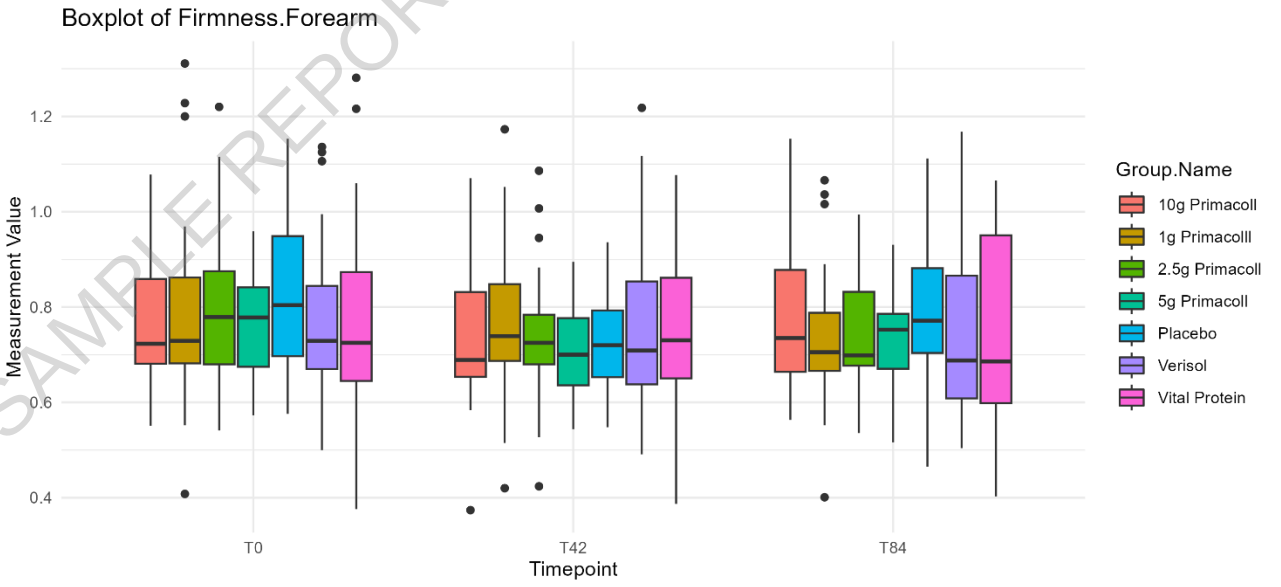




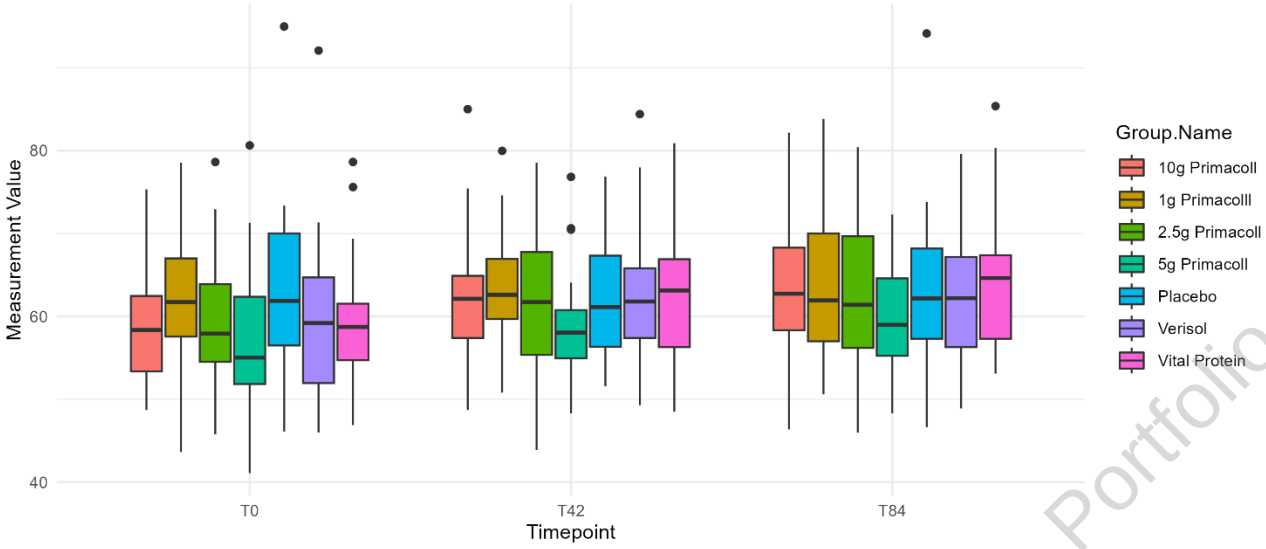




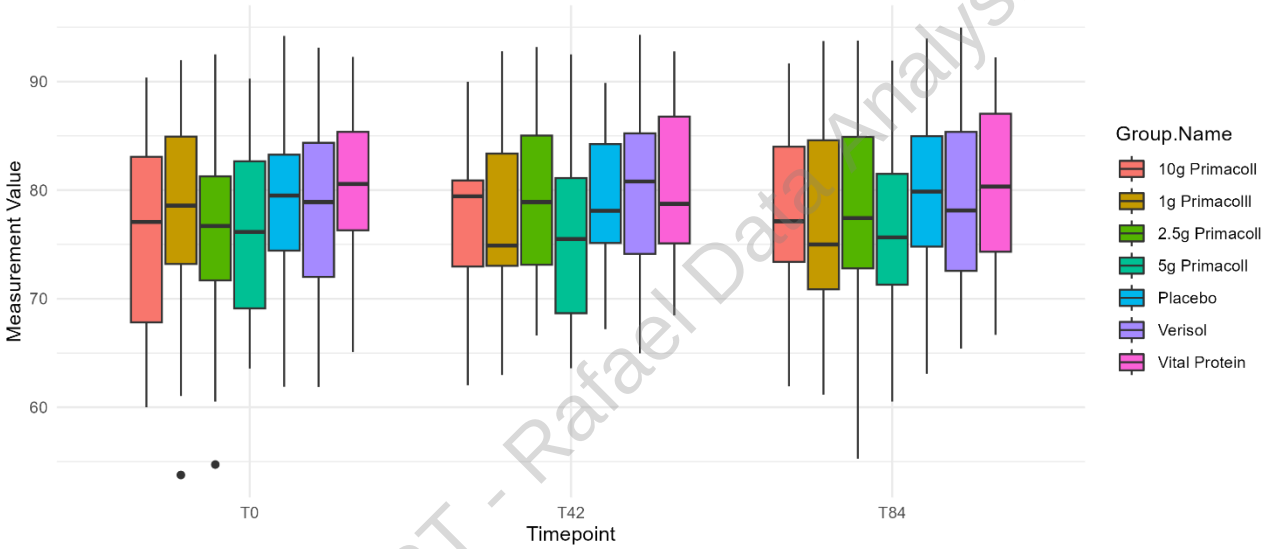




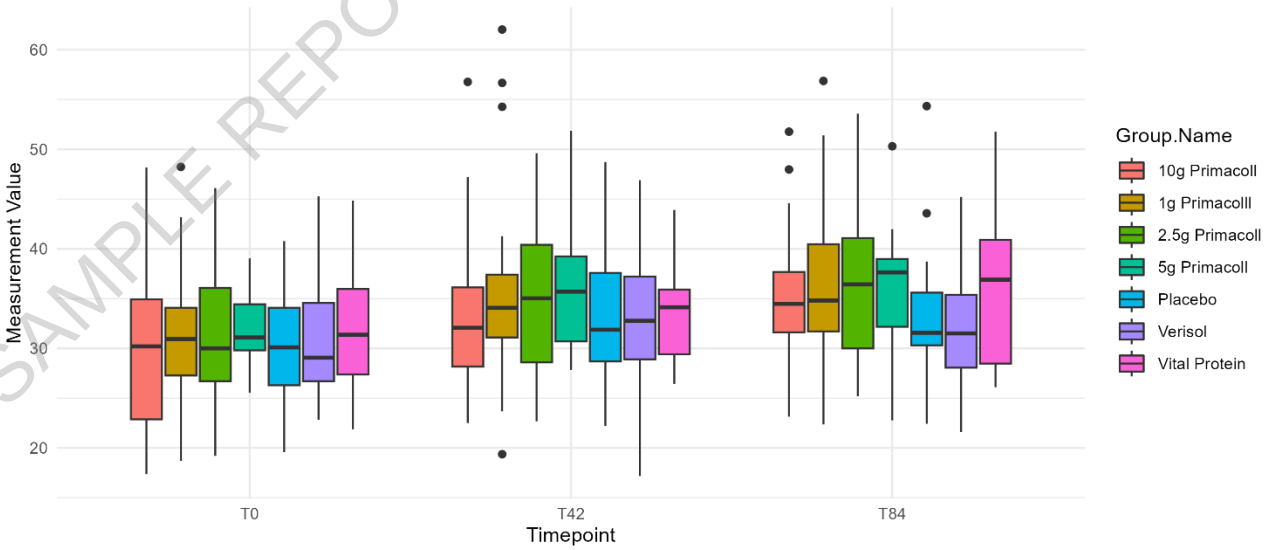
Boxplot of Elasticity.Face



Boxplot of Elasticity.Forearm



Boxplot of Corneometer.forearm



Mixed Models

A linear mixed-effects model analysis was conducted using the 'nlme' package in R. This package is commonly used for analyzing repeated measures or clustered data where both fixed and random effects are present.

The procedure begins by converting the Group.Name and Timepoint variables to factors, preparing them for inclusion in the model as categorical variables. An empty dataframe, model_summary_df, is then initialized to store the model summary statistics.

The analysis is conducted for each dependent variable (found in the vector dvs) and for each unique pair of clinical groups (specified in group_names). Within the nested loops, the dataset is filtered to only include observations from the current pair of groups being analyzed. This filtered dataset, df_pair, serves as the input for the linear mixed-effects model.

The formula for the model specifies an interaction term between Group.Name and Timepoint, while accounting for random effects at the subject level. The method "REML" (Restricted Maximum Likelihood) is used for estimating the model parameters.

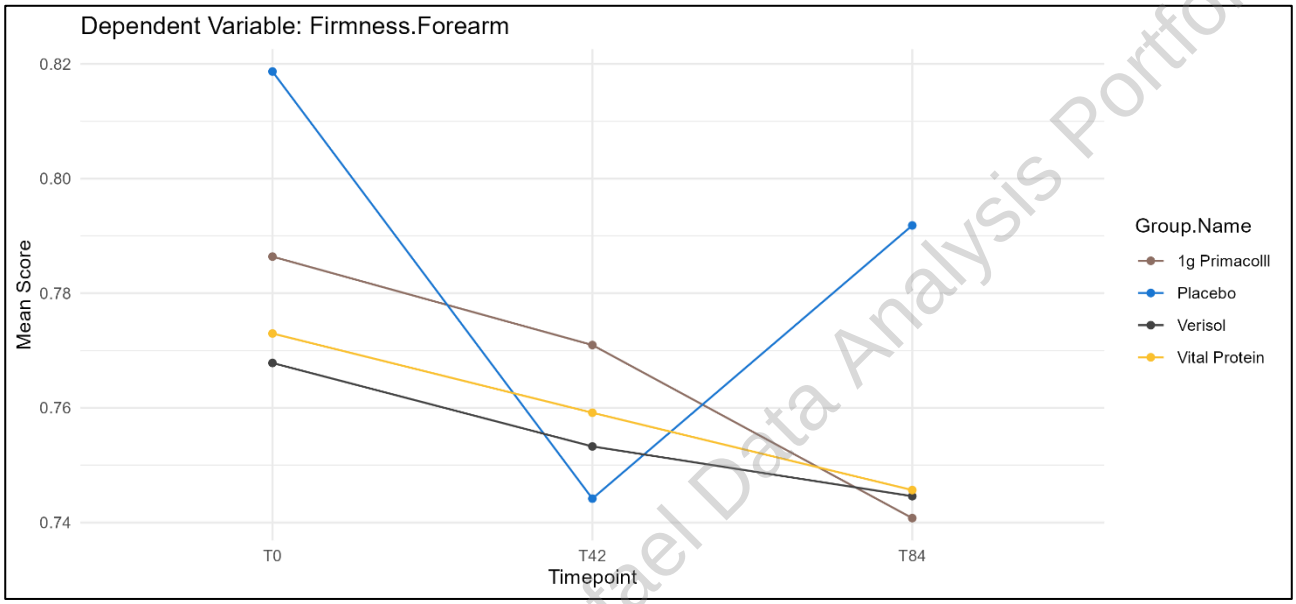
Upon fitting the model, an ANOVA table is generated to extract essential statistics such as the degrees of freedom (numDF and denDF), F-value, and p-value for each effect and interaction term.

The sections below show a summary of the significant effects (when $p < 0.1$) for each pair of products that is of interest.

Summary of Results - Overall

Firmness of the Forearm

In the comparison between Placebo and 1g Primacolll, a marginal interaction effect was observed (F-value not specified, p=0.069). Placebo demonstrated a 3.3% overall reduction in mean scores from T0 to T84, comprised of an initial 9.1% decrease and a subsequent 6.4% increase. In contrast, 1g Primacolll exhibited a 5.8% total reduction, marked by an initial 2.0% decrease followed by a 3.9% reduction.

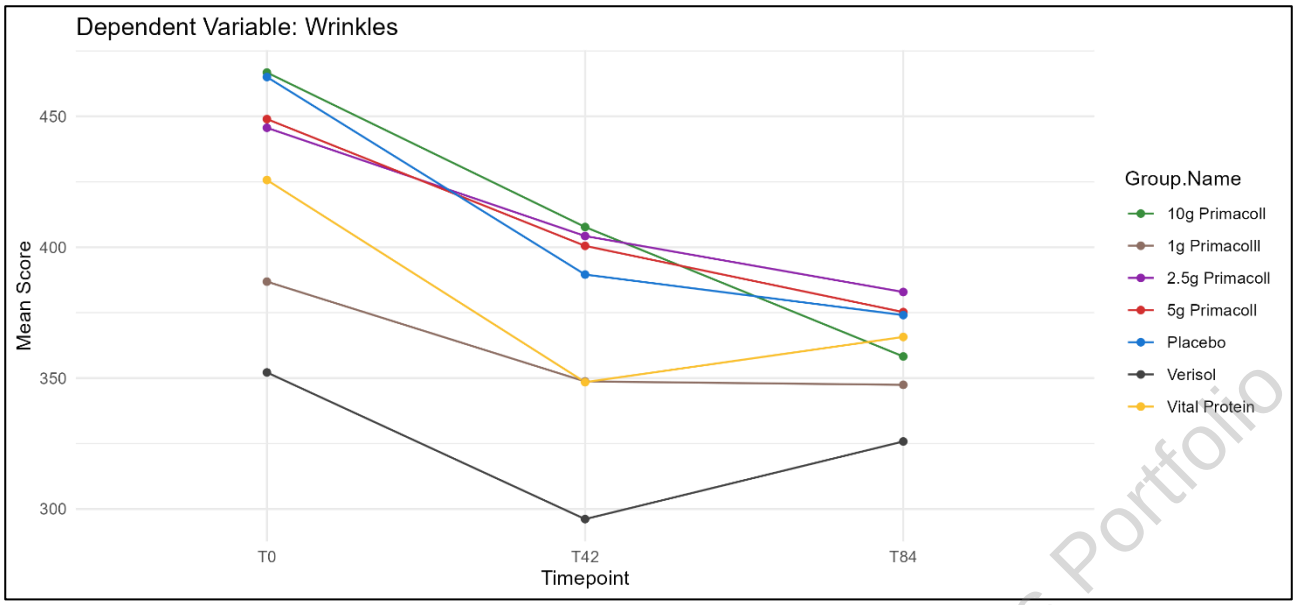


Wrinkles

For Placebo and 1g Primacolll, the interaction effect was marginally significant (F-value not specified, p=0.086). Placebo experienced a 19.6% overall reduction in mean scores from T0 to T84, while 1g Primacolll showed a 10.2% overall reduction.

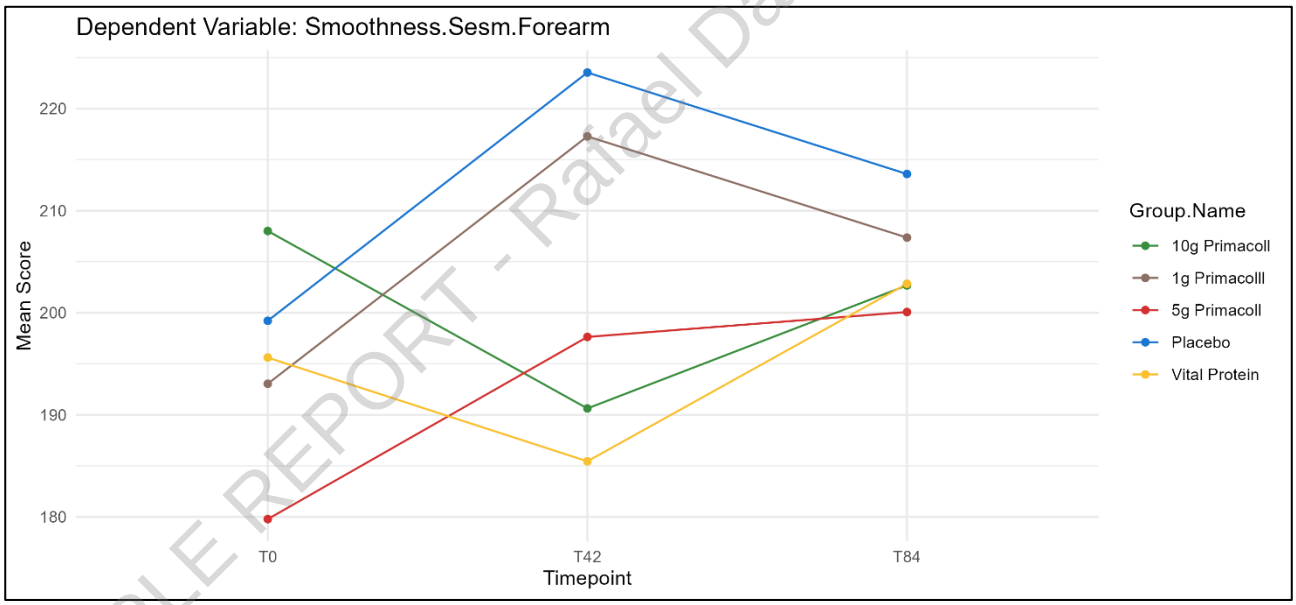
In the case of 10g Primacoll vs Vital Protein, a significant interaction effect was evident (F-value not specified, p=0.013). Specifically, 10g Primacoll registered a 23.2% reduction from T0 to T84, whereas Vital Protein indicated a 14.1% reduction.

When comparing 2.5g Primacoll and Verisol, a significant interaction effect was found (F-value not specified, p=0.048). 2.5g Primacoll displayed a 14.1% overall reduction from T0 to T84, as opposed to Verisol, which showed a 7.5% reduction.



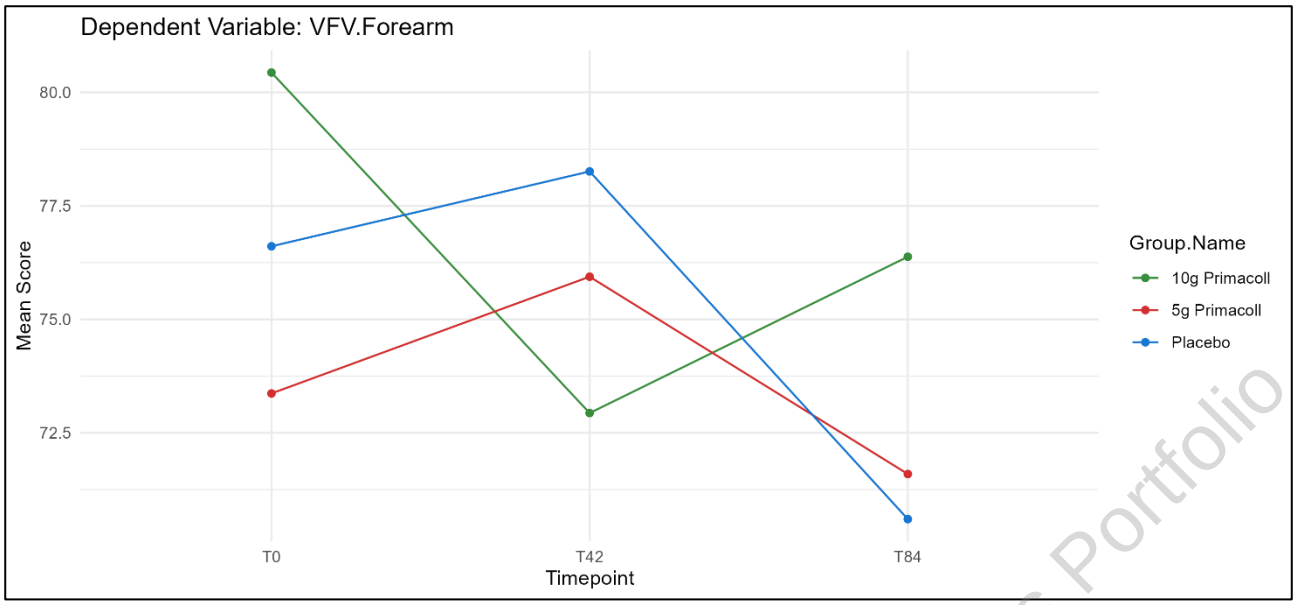
Smoothness of the Forearm

A significant interaction effect was noted between Placebo and 10g Primacoll (F-value not specified, p=0.032). Placebo recorded a 7.2% increase in mean scores from T0 to T84, while 10g Primacoll exhibited a 2.6% decrease.



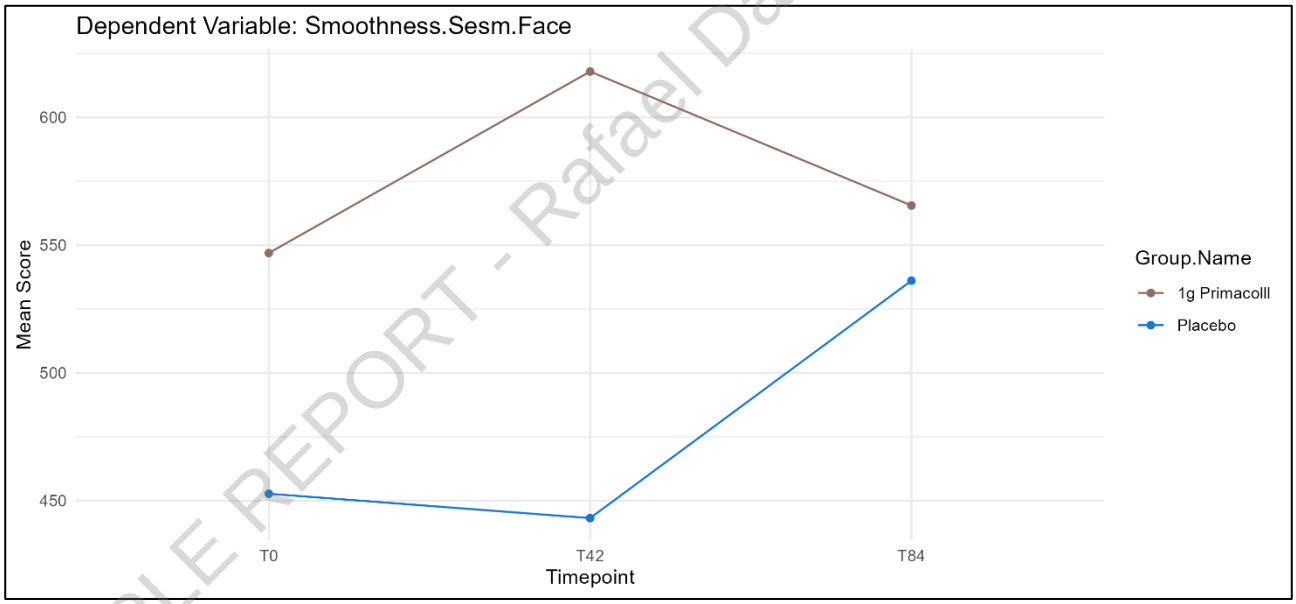
VFV of the Forearm

In comparing Placebo with 10g Primacoll, the interaction effect was significant (F-value not specified, p=0.021). Placebo showed a 7.8% overall reduction in mean scores from T0 to T84, whereas 10g Primacoll showed a 5.0% reduction.



Smoothness of the Face

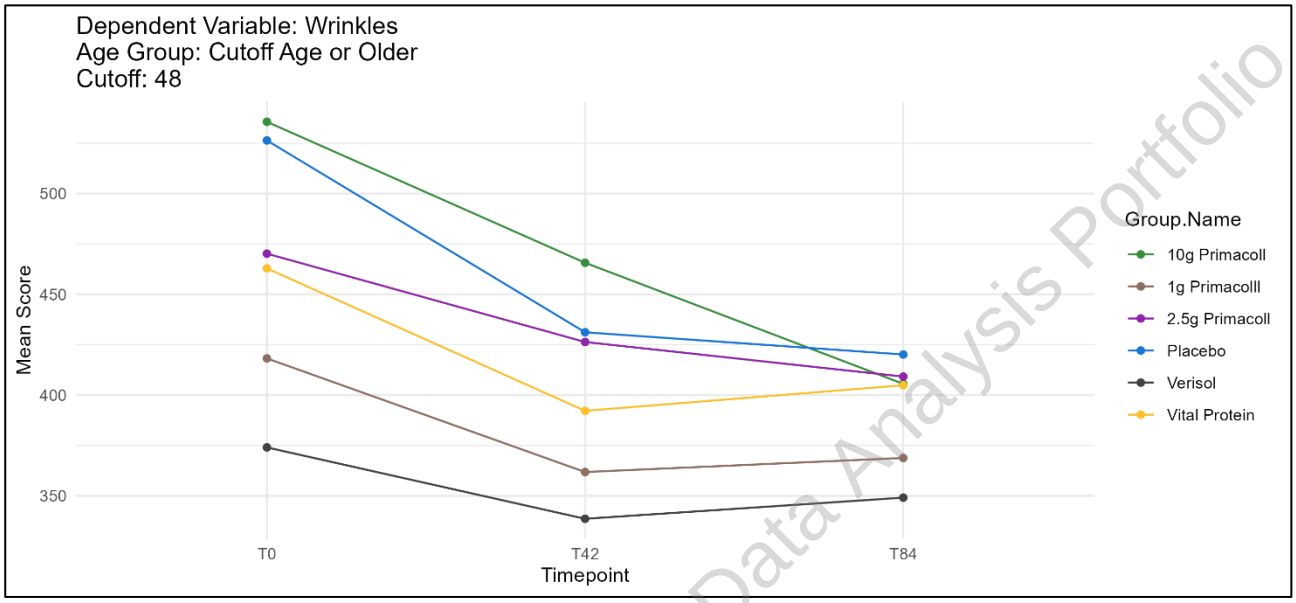
For Placebo and 1g Primacolll, the interaction effect was marginally significant (F-value not specified, p=0.059). Placebo recorded an 18.4% increase in mean scores from T0 to T84, compared to a 3.4% increase for 1g Primacolll.



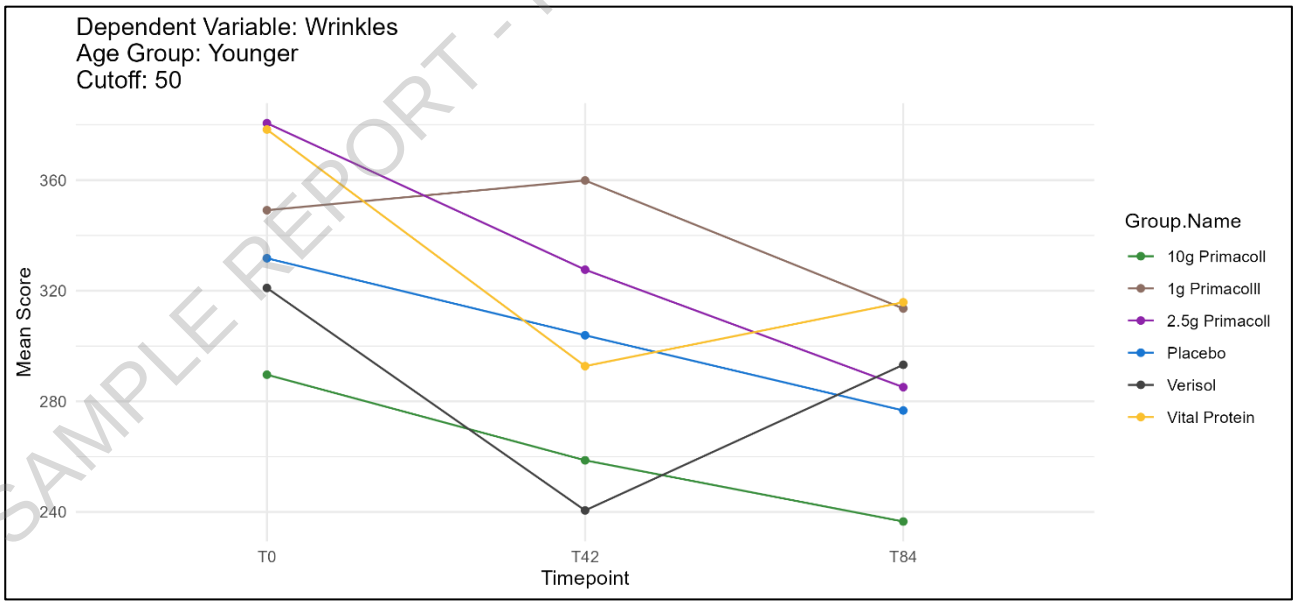
Summary of Results – Age Groups

Wrinkles

In individuals 48 years or older, a time-dependent variation in the effectiveness of 10g Primacoll and Vital Protein was observed (F=5.183, p=0.008). Mean scores for 10g Primacoll decreased by 24.3% from T0 to T84, whereas Vital Protein showed a 12.5% reduction.

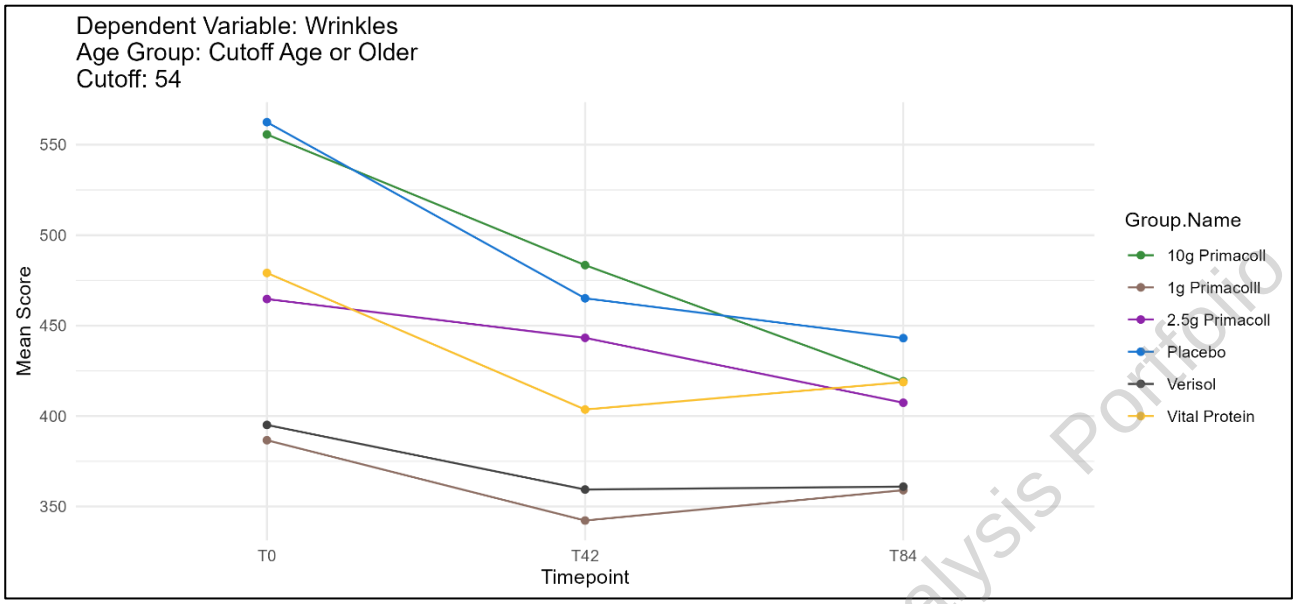


Among those younger than 50 years, 2.5g Primacoll and Verisol also demonstrated differential effectiveness across time (F=3.959, p=0.030). 2.5g Primacoll showed a 25.1% reduction in mean scores from T0 to T84, whereas Verisol reduced by 8.7%.

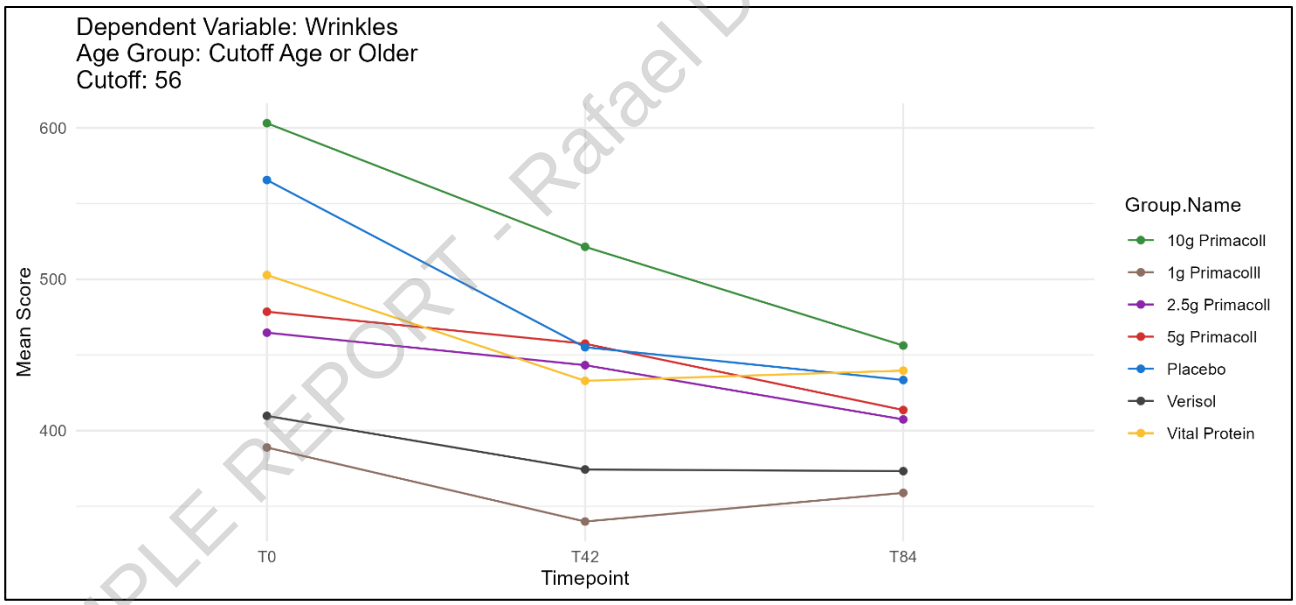


When the age cutoff was set at 54 years, both Placebo and 1g Primacoll demonstrated differential effectiveness across time (F=3.994, p=0.025) for individuals with that age or older. Placebo

experienced a 21.2% reduction in mean scores from T0 to T84, compared to a 7.1% reduction in 1g Primacolll.



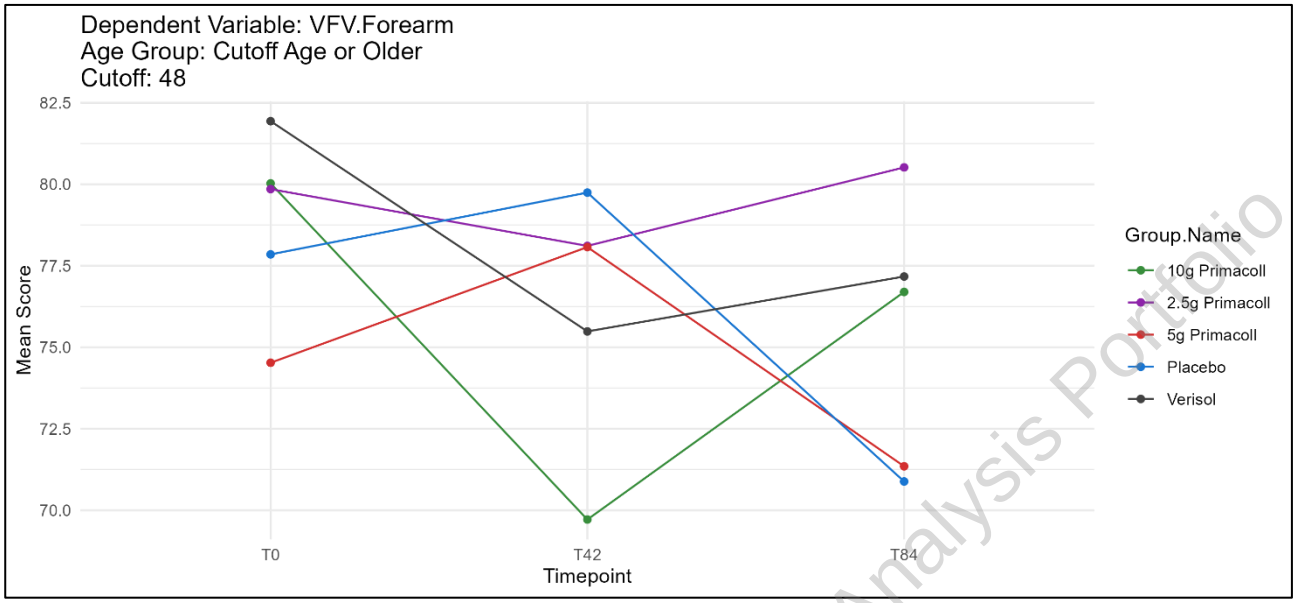
For those with 56 years or older, Placebo and 2.5g Primacoll exhibited differential effectiveness over time (F=3.735, p=0.031). Placebo showed a 23.4% reduction from T0 to T84, whereas 2.5g Primacoll reduced by 12.3%.



VFV.Forearm

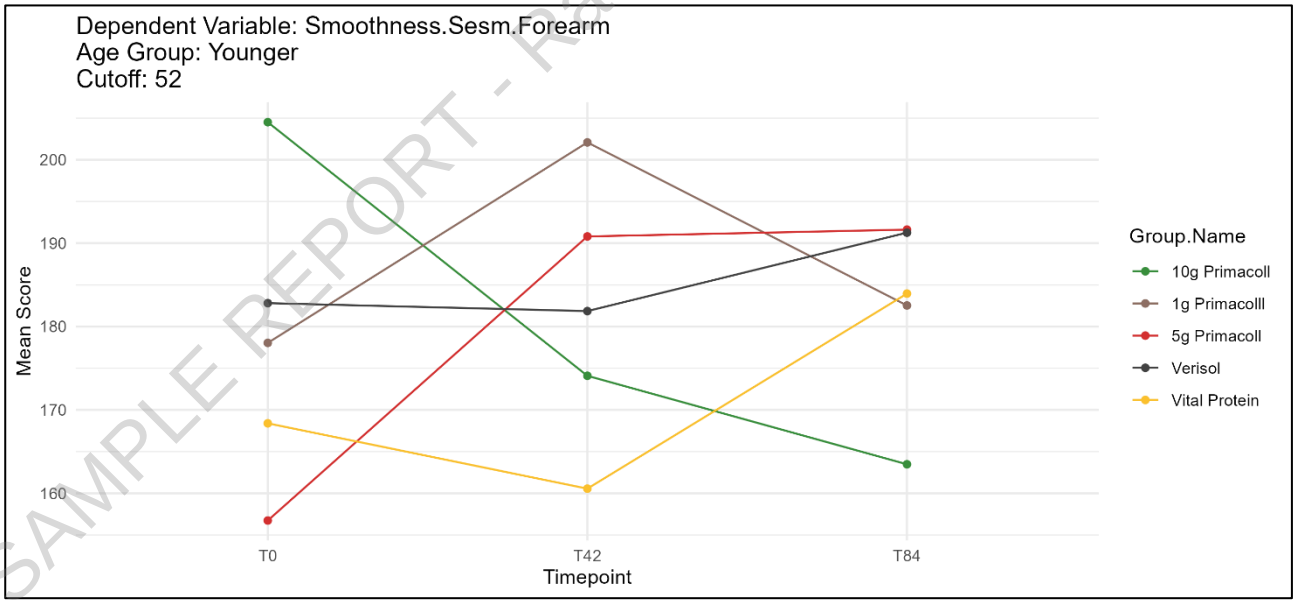
Among individuals 48 years or older, a differential time-dependent effectiveness between Placebo and 10g Primacoll was observed (F=5.003, p=0.009). Placebo exhibited a 8.9% reduction from T0 to T84, whereas 10g Primacoll reduced by 4.2%.

Observing individuals with the age of 54 or older, the effectiveness of Placebo and 2.5g Primacoll differed across time (F=2.594, p=0.084). Placebo reduced by 12.4% from T0 to T84, while 2.5g Primacoll increased by 4.0%.

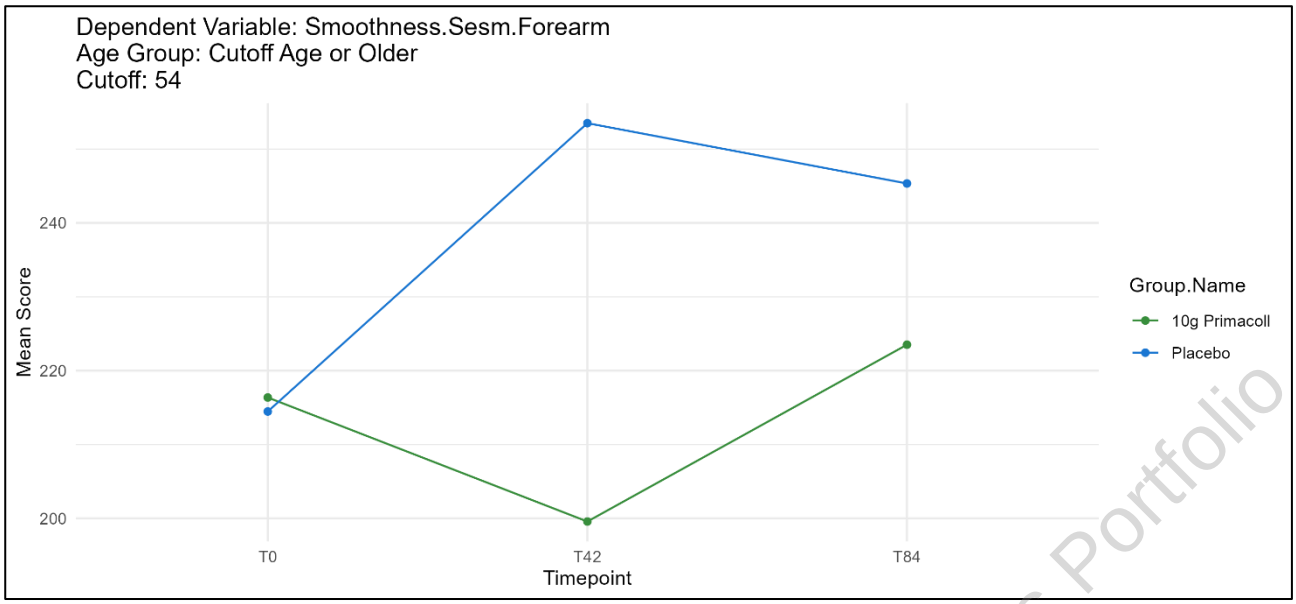


Smoothness.Sesm.Forearm

In the younger than 52 years group, 10g Primacoll and Vital Protein showed significant variation over time (F=4.218, p=0.023). 10g Primacoll reduced by 20.1% from T0 to T84, while Vital Protein increased by 9.2%.

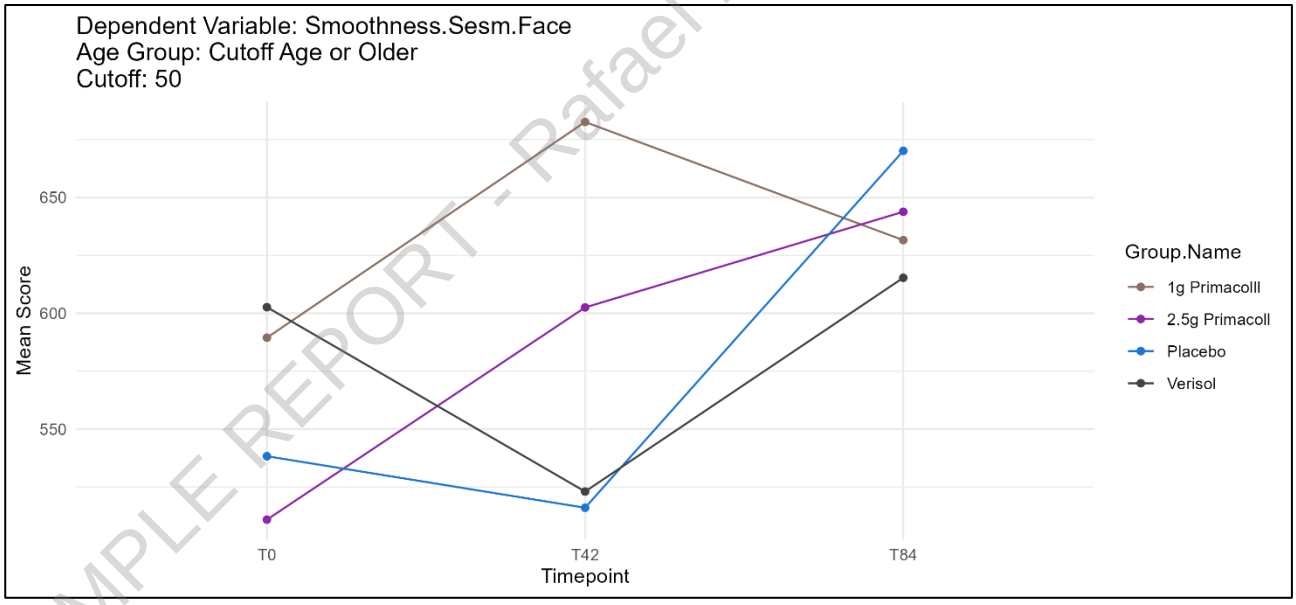


Among those 54 years or older, Placebo and 10g Primacoll demonstrated differential effectiveness across time (F=3.236, p=0.047). Placebo increased by 14.4% from T0 to T84, while 10g Primacoll increased by 3.3%.

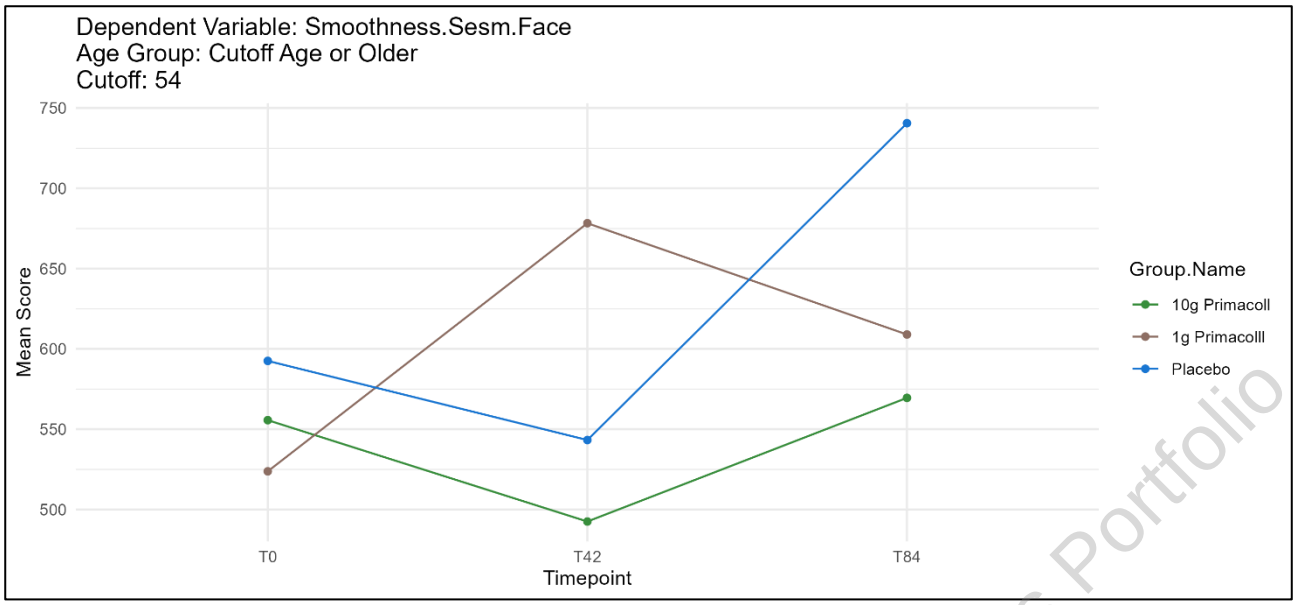


Smoothness.Sesm.Face

For those aged 50 or older, both 2.5g Primacoll and Verisol showed differential effectiveness across time (F=2.477, p=0.092). 2.5g Primacoll increased by 26.0% from T0 to T84, whereas Verisol increased by 2.1%.

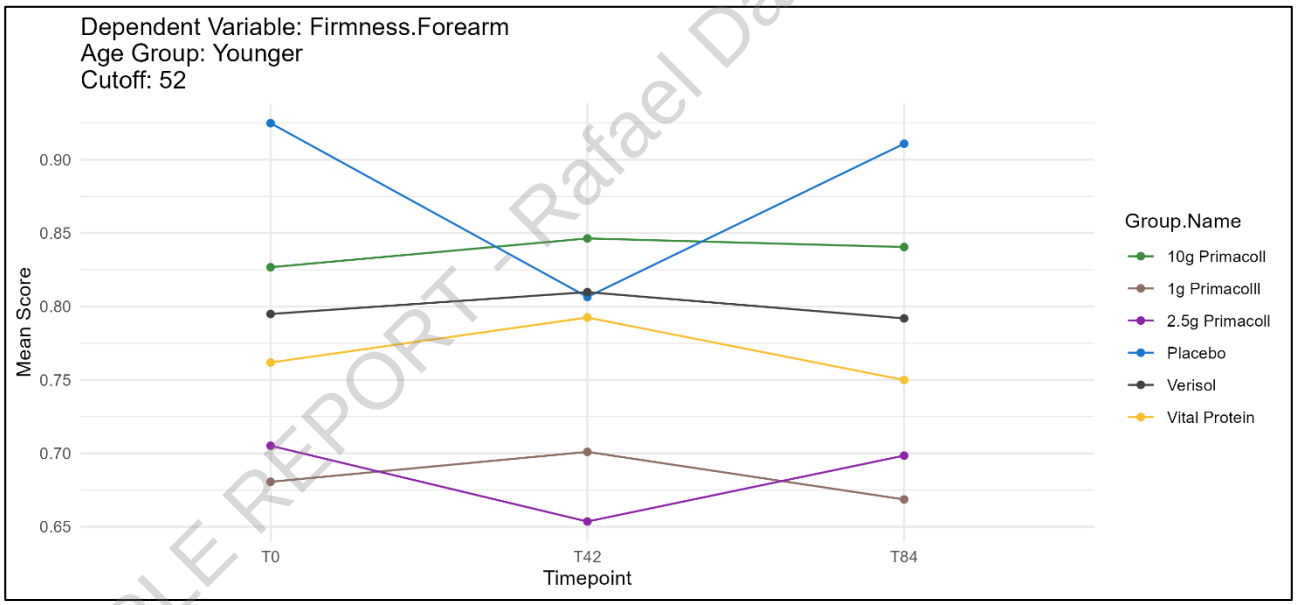


In the age group 54 or older, Placebo and 1g Primacolll showed differential effectiveness over time (F=4.177, p=0.021). Placebo increased by 25.0% from T0 to T84, while 1g Primacolll increased by 16.3%.



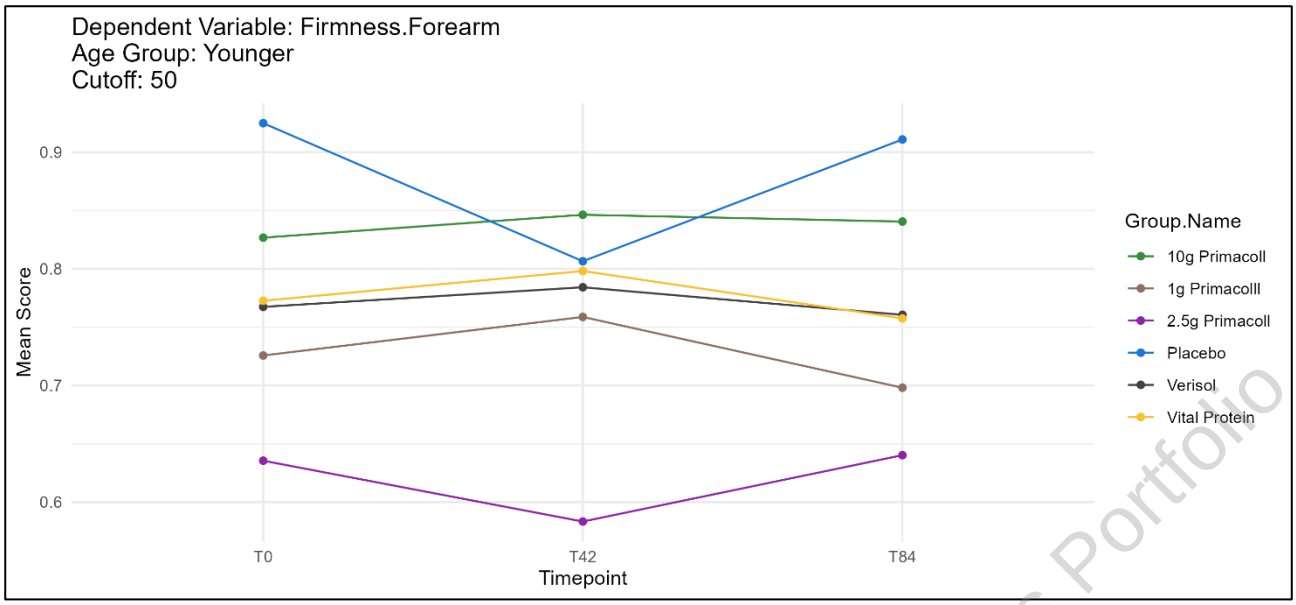
Firmness.Forearm

In the younger than 52 years group, the effectiveness of 2.5g Primacoll and Verisol varied over time (F=2.503, p=0.095). 2.5g Primacoll increased by 6.9% from T0 to T84, whereas Verisol reduced by 0.4%.



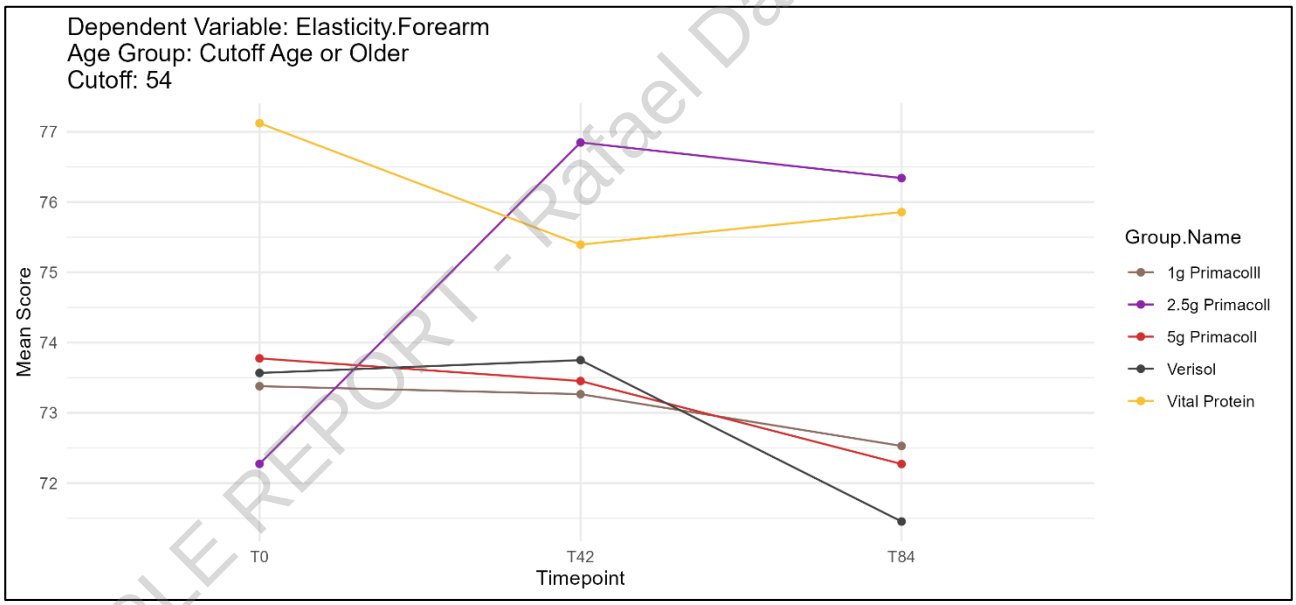
For those younger than 50 years, both Placebo and 1g Primacolll demonstrated differential effectiveness across time (F=6.538, p=0.004). Placebo showed a slight 1.5% reduction from T0 to T84, while 1g Primacolll reduced by 3.8%.

In that same group, Placebo and 10g Primacoll demonstrated differential effectiveness across time (F=3.842, p=0.034). Placebo reduced by 1.5% from T0 to T84, whereas 10g Primacoll increased by 1.7%.



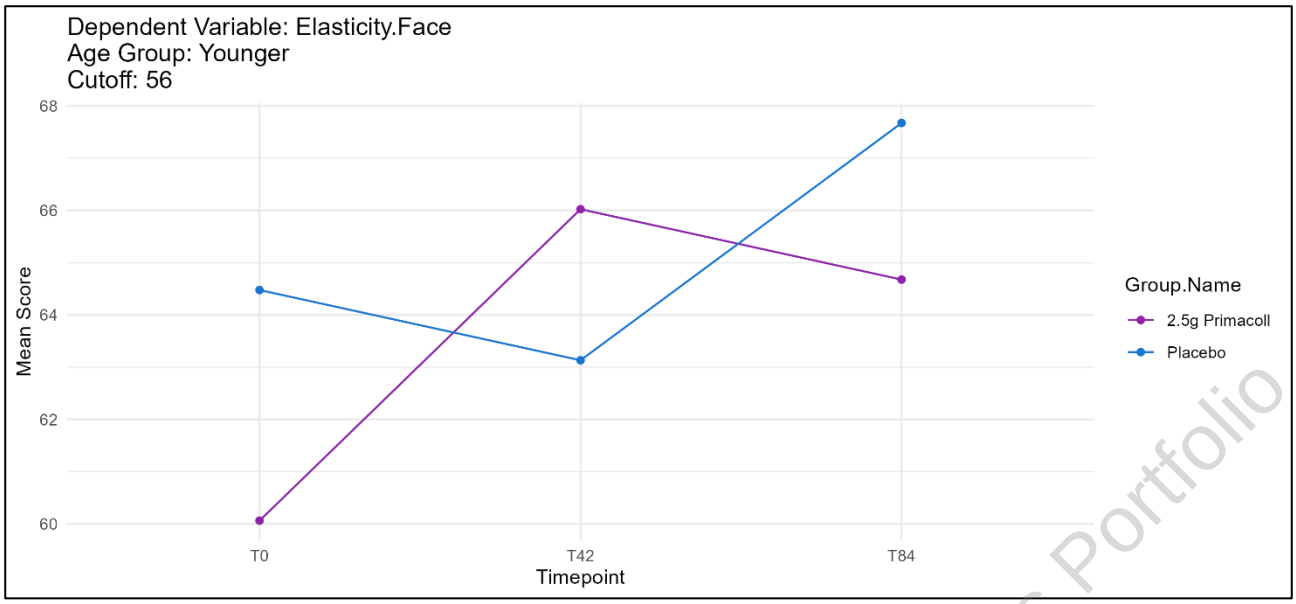
Elasticity.Forearm

In individuals 54 years or older, 2.5g Primacoll and Verisol exhibited differential effectiveness across time (F=2.649, p=0.081). 2.5g Primacoll increased by 5.6% from T0 to T84, whereas Verisol reduced by 2.9%.



Elasticity.Face

Among those younger than 56 years, Placebo and 2.5g Primacoll exhibited differential effectiveness over time (F=2.897, p=0.066). Placebo increased by 5.0% from T0 to T84, whereas 2.5g Primacoll increased by 7.7%.



Corneometer.Forearm

Among those younger than 48 years, the effectiveness of 2.5g Primacoll and Verisol differed across time (F=5.167, p=0.014). 2.5g Primacoll increased by 23.2% from T0 to T84, whereas Verisol reduced by 0.4%.

In the same group, Placebo and 2.5g Primacoll differed in effectiveness over time (F=2.932, p=0.076). Placebo increased by 8.9% from T0 to T84, whereas 2.5g Primacoll increased by 23.2%.