

Meta Analysis And Systematic Review for Electric (Powered) Versus Manual Toothbrushes Among Pediatric And Adult Orthodontic Patients

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Introduction

Pediatric oral hygiene has been a topic of great concern due to the continuing prevalence of oral diseases, such as dental caries. Additional challenges such as orthodontic brackets among pediatric patients have further complicated these efforts to improve oral hygiene and reduce caries lesions. Many methods of improving dental hygiene, including mouth washing, flossing and tooth brushing have been evaluated through the use of systematic reviews and meta analyses. However, some of these methods, such as the use of powered or electric toothbrushes have been less well studied among pediatric patients with orthodontic brackets. Methods: ATo address this deficiency, the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) protocol was utilized to screen peer-reviewed articles from the National Library of Medicine (NLM) using the PubMed database. Results: From the independent, blind reviewers n = 660 peer-reviewed articles were identified from these searches. Applying detailed exclusion and inclusion criteria, a total of n = 19/660 or 2.9% were included in the systematic review and meta analysis. These studies published between 1996 and 2023 encompassed a total of n=965 patients, which revealed an average relative effect (RE) in plaque reduction of 18.7% comparing powered or electric toothbrushing with manual toothbrushing controls. Conclusions: These data show a clear clinical benefit for using powered or electric toothbrushes among pediatric and adolescent orthodontic patients undergoing orthodontic therapy with fixed appliances.

Materials and Methods

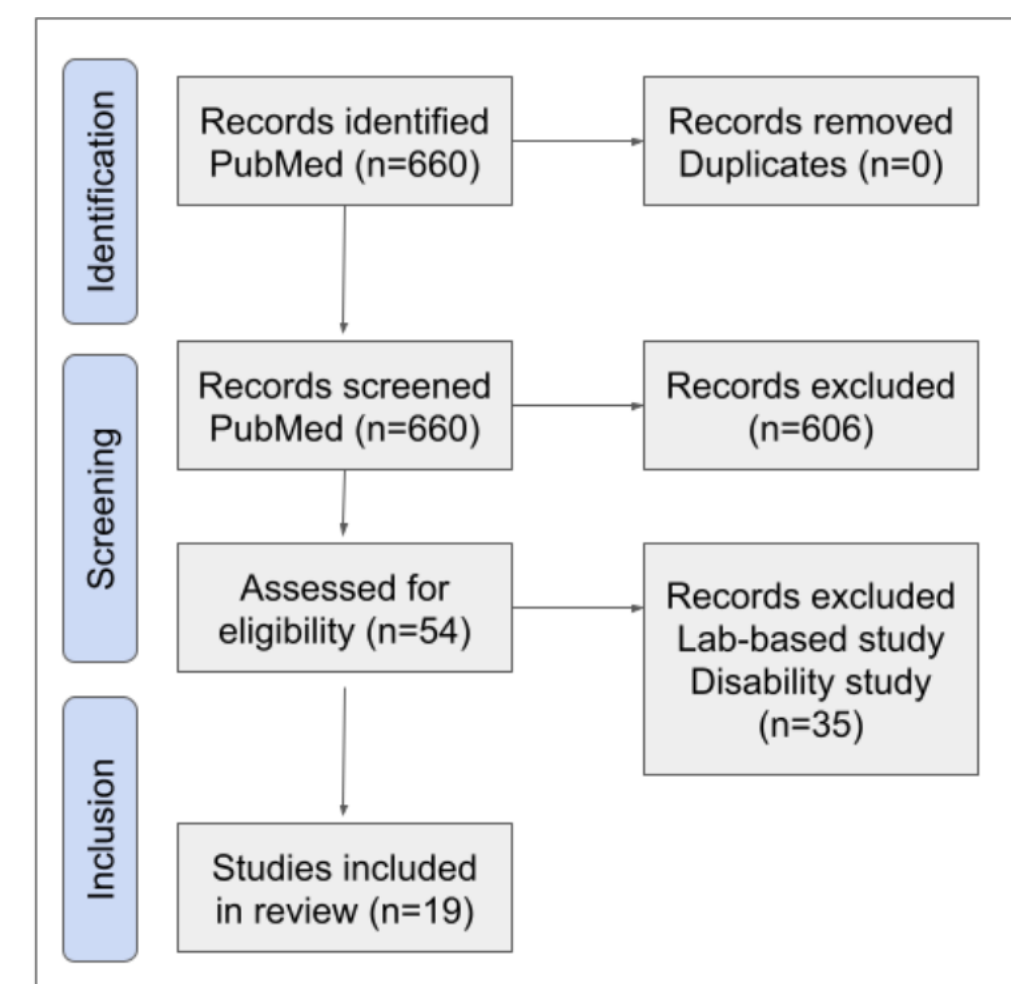


Figure 1: Flow Diagram of PRISMA Protocol

This study was reviewed and approved by the Office for the Protection of Research Subjects (OPRS) and the Institutional Review Board (IRB) at the University of Nevada Las Vegas (UNLV) as Research Exempt

All articles were then screened using the inclusion and exclusion criteria. The inclusion criteria required each article to be published within the last thirty years (1996-2025), involve subjects that were 18 years of age or younger, had at least one group with fixed orthodontic appliances, and also at least one group that used electric or powered toothbrushes compared with another group that used traditional or manual toothbrushes. Exclusion criteria were applied to remove articles that dealt exclusively with adults (over 18 years of age), were ex vivo or in vitro (laboratory based) in nature, involved physically or cognitively impaired individuals that were not brushing their own teeth, or studies that did not utilize an objective or standardized measure of plaque, such as the Turesky Quigley Hein plaque index (TQH-PI), Rustogi et al. Modified Navy Plaque Index (RMNPI), the Silness-Loe plaque index (SLPI), or a similar standardized Visual Analog Scale (VAS).

Each of the study authors performed the search independently using the combinations of search terms and operators described above with all identified articles imported into the online system (Rayyan.ai) for comparison and analysis by study authors. Any articles identified by only one reviewer were marked for discussion, but were included in the total number of articles identified. Each author applied the exclusion criteria independently and articles that were marked for exclusion by all three reviewers were removed from the final analysis. Articles marked for exclusion by only one or two reviewers were marked for discussion and further review. All authors concurred with the final articles selected for review.

The freely available data from each previously published study was gathered and input into Microsoft Excel (Redmond, Washington, USA) for further analysis and graphical display. Almost all studies included data regarding the age of study participants (range and overall average, if available), overall length of the study observation time period, the number of study participants, as well as the baseline and endpoint plaque index scores. Comparisons between the baseline measurements with the changes observed between the control (manual) and experimental (powered or electric toothbrushing) groups were used to determine the relative effect (RE). Meta analysis of associations between the potential confounding variables, including the age of study participants, length of study, size of the clinical trial (number of participants), and type of plaque index scale used were performed using R2 or the coefficient of determination, as previously described [23,24].

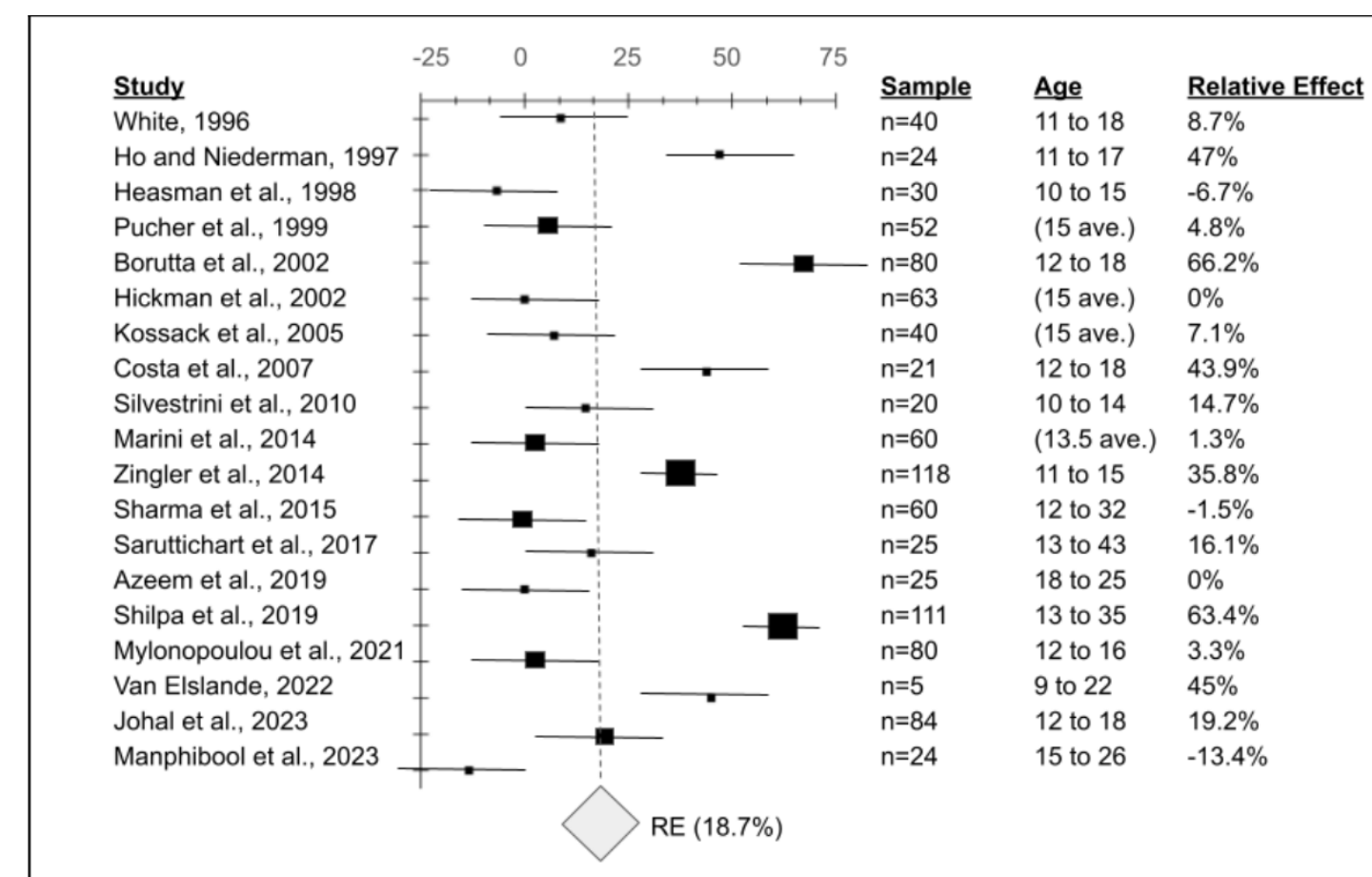


Figure 2: Forest Plot

Forest plot of pediatric orthodontic studies comparing changes in plaque index with electric versus conventional toothbrushing. Study samples ranged between n=5 to n=118 (average n=54) with subject ages ranging between 10 and 43 (average 15.3 years). The percent change in plaque index ranged between 13.4% and 66.2%, yielding a positive relative effect (RE) of 18.7% with the majority of studies (n=16/19 or 84.2%) demonstrating positive or equivalent relative effects.

Results, Discussion, and Conclusion

To determine if any differences among study outcomes were associated with the age of the study participants, average or mean age for each study sample if provided (n=15/19 or 78.9%) was plotted against the reduction in plaque index (Figure 3). This analysis revealed that the age of study participants was not significantly correlated with the primary measurement outcomes (plaque index reduction), with an overall coefficient of determination determined to be R2= 0.011. Although the majority of studies with age-specific information involved participants with an average age of less than 18 years (n=11/15 or 73.3%), some of these studies did include participants up to 22 years of age. Moreover, three of the four studies with an average age of more than 18 years also included pediatric patients as young as 12 years of age.

More detailed analysis was performed to determine if the length of study was associated with the study outcomes (Figure 4). This revealed that the majority of studies had published and well-defined timelines (n=16/19 or 84.2%), which ranged from two weeks (14 days) to a full year (365 days). In addition, this analysis revealed that no statistically significant associations were found between the length of the study and the observed reduction in plaque index scores among the participants, R2 = 0.011. Finally, this analysis also revealed that most of the studies included in this analysis (n=11/16 or 68.8%) were between one month and three months in length. The remaining studies that provided the length of the observation period ranged between four months and one full year.

Comparison of the study outcomes (reduction in plaque index) with the study size (number of participants) was also analyzed (Figure 5). These data revealed a weak positive correlation between the number of study participants and the percent reduction in plaque index score observed, R=0.268. Although the coefficient of determination was not statistically significant (R2 =0.072), these data may suggest that study size may have played a confounding role in the study outcomes. For example, two of the three studies that showed no reduction in plaque index scores with electric toothbrushes had relatively smaller sample sizes (n<30), whereas all of the larger studies (n>80) found significant differences.

Comparisons were made to determine if there was any association between the type of plaque index score used and the study outcomes (Figure 6). This analysis demonstrated that the type of plaque index scoring system utilized (Turesky Quigley Hein plaque index (TQH-PI), the Silness-Loe plaque index (SLPI), or the Visual Analog Scale (VAS) was not significantly associated with the study outcomes R2=0.008. In fact, studies using each of these scales had both high and low relative effect scores. For example, studies that used the Turesky Quigley Hein plaque index (TQH-PI), had relative effects that ranged between +1.3% to +66.2%, while those using the Silness-Loe plaque index (SLPI) observed relative effects ranging from -13.4% to +63.4%. The remaining studies that used the visual analog scale (VAS) reported relative effects that ranged between -6.7% to +45%.

This systematic review combined multiple clinical trials involving teenage and adolescent patients undergoing orthodontic therapy to evaluate electric versus manual toothbrushing in order to determine the overall relative effects and potential clinical benefits in plaque reduction. This analysis greatly increased both the number of studies and the number of overall patients evaluated, which clearly demonstrates electric or powered toothbrushing is associated with a robust reduction in plaque index scores among this patient population. Moreover, these effects can be seen immediately and are often sustained over the long-term, suggesting that patient and parental education regarding these potential benefits may be an important component of the oral health discussions leading up to and during orthodontic treatment and care involving fixed orthodontic appliances.

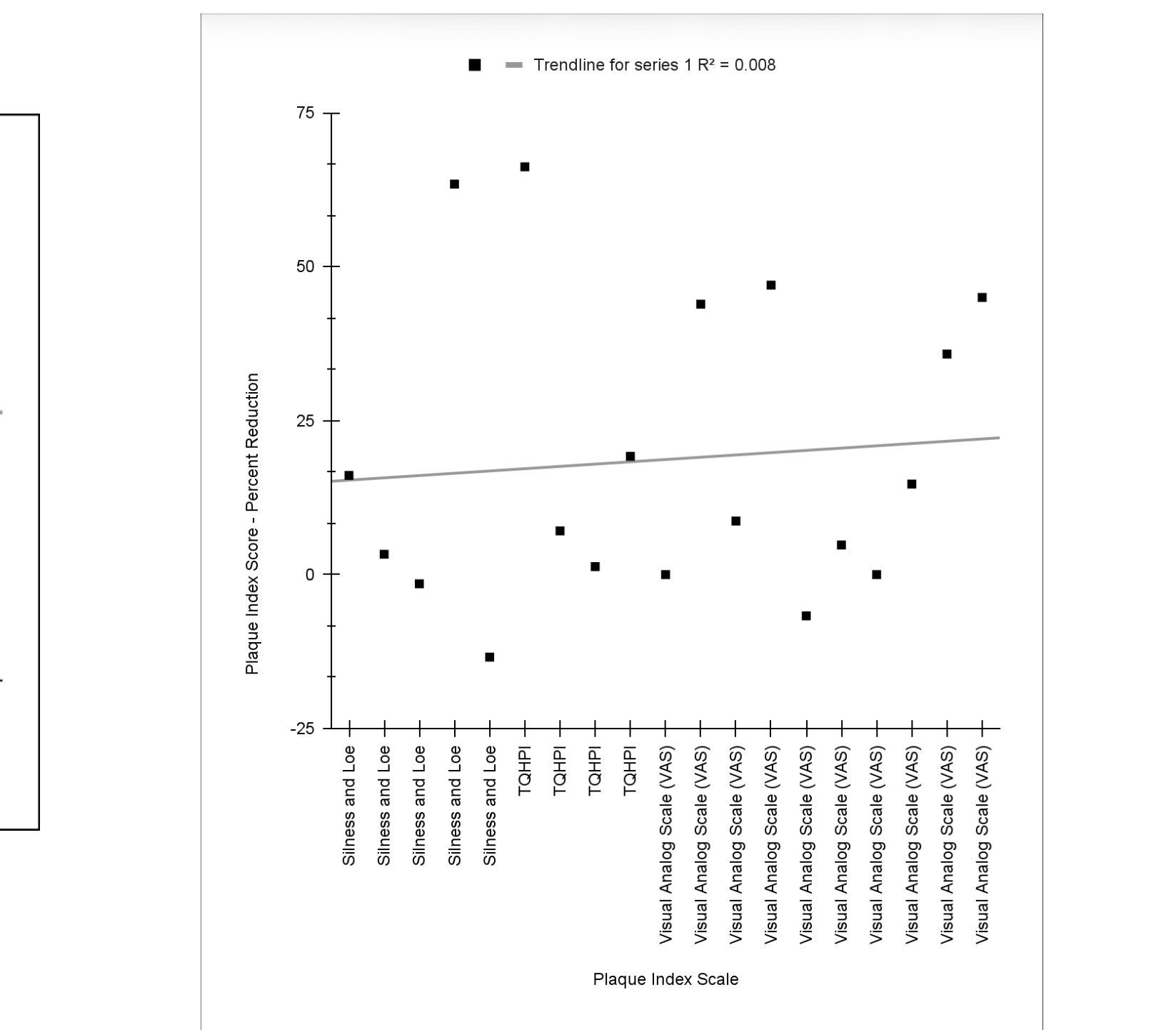
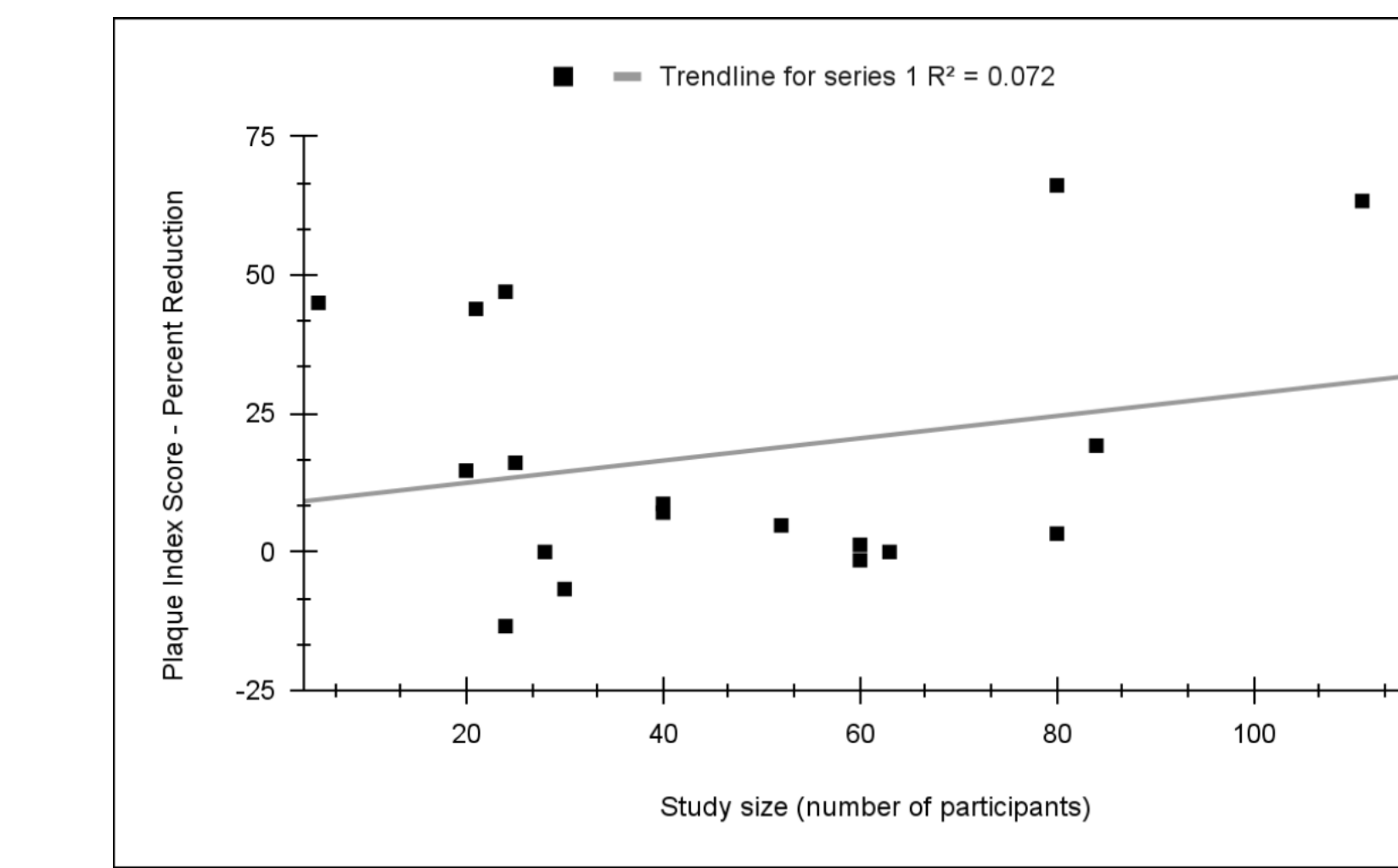
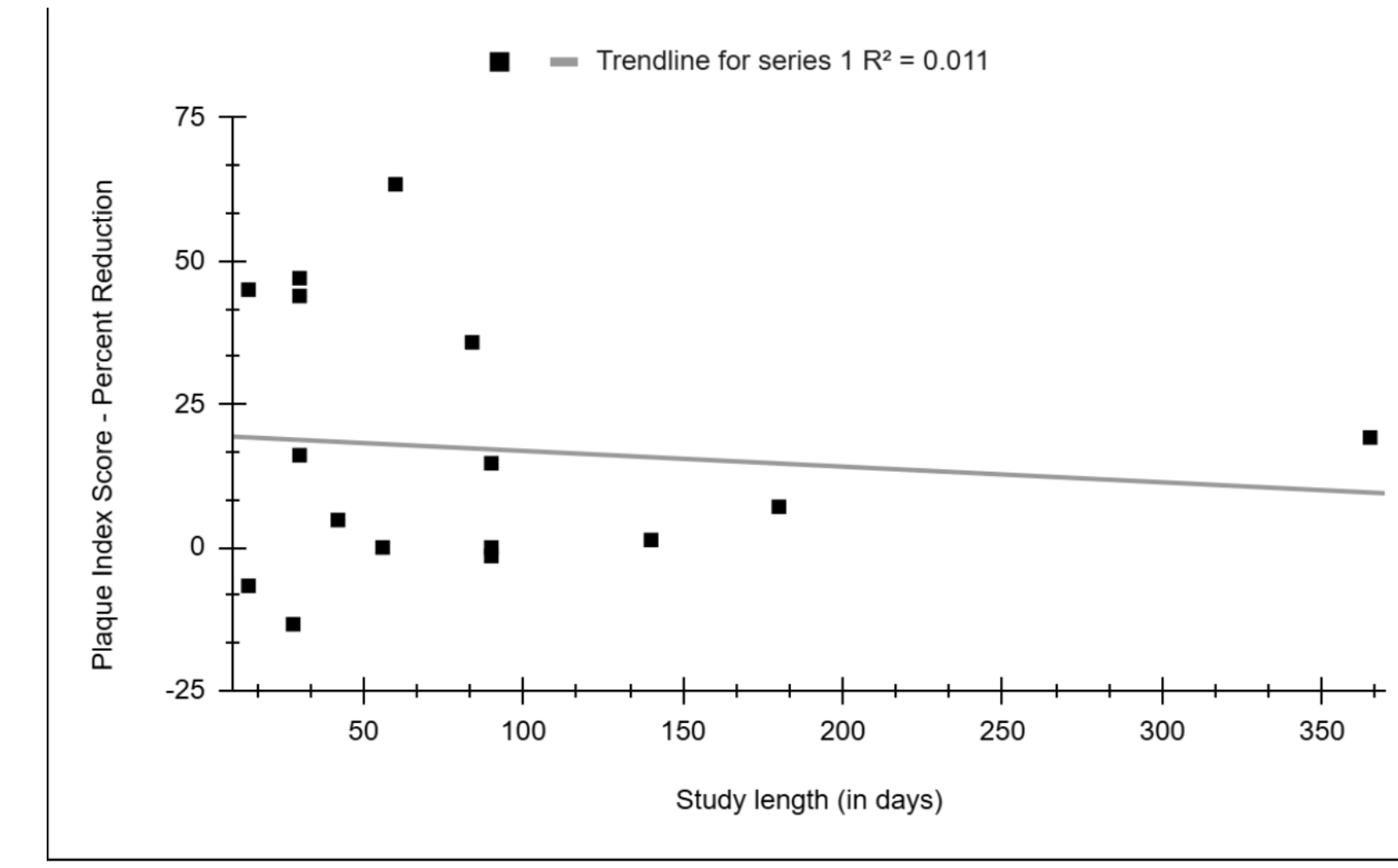
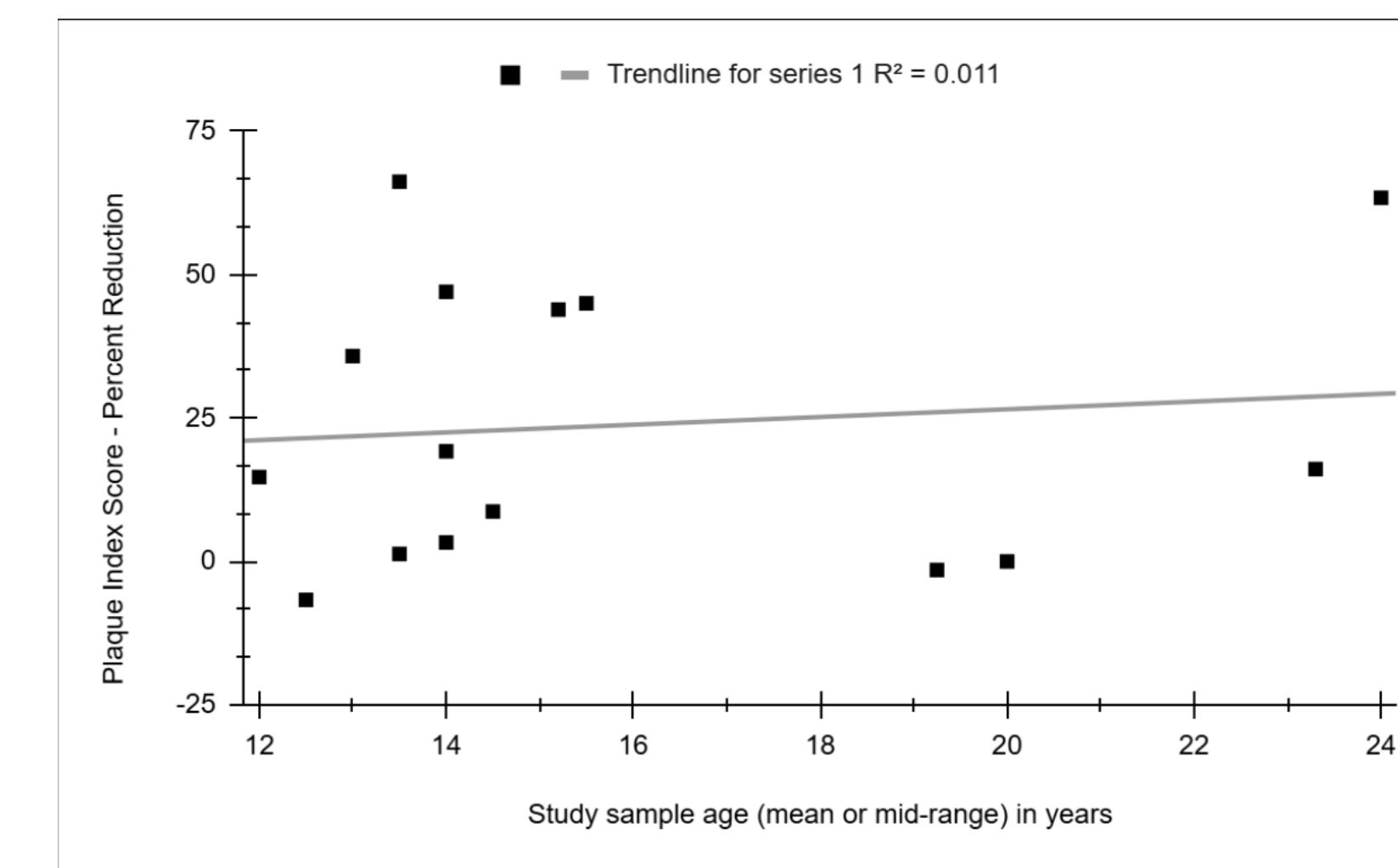


Figure 3,4,5,6: Meta-Analysis Age, Length, Number of Participants, Plaque Index
Top left chart meta-analysis of age, top right meta-analysis of length, bottom left meta-analysis of number of participants, and bottom right meta-analysis of plaque index used .

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