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Analysis of Covariance in Dental Caries Clinical Trials: Discussion of Dr. Grainger's Presentation

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In their first paragraph, the authors note: "There are three theoretical reasons for interest in analysis of covariance in clinical trials of a caries inhibiting agent. . . . In spite of these potential advantages, analysis of covariance has not been exploited in caries clinical trials."

I agree. However, in caries clinical trials where increments have been calculated for the analysis (*i.e.*, final DMFS - initial DMFS), a "quick and dirty" form of analysis of covariance (ANOCOV) has been utilized - quick, in that increment analysis is easier to conceptualize than ANOCOV, and dirty, in that increment analysis is usually less precise than ANOCOV. In other words, if we analyzed our caries data using final DMFS as the criterion and initial DMFS as the covariate, instead of using the usual increment analysis, we would increase the precision of the study with no cost other than that of a slightly more complex conceptual model.

This is not a new idea or radical suggestion. Several authors have previously noted that ANOCOV will generally be more precise than increment analysis.^{1,3,4} One states¹ that both ". . . are directed toward the same inferential problem, but analysis of covariance is in general more powerful and should routinely be used." Another concludes⁴ that the use of increment analysis in this type of study ". . . seems questionable. . . ." Indeed, two of our respected colleagues³ once wrote: "While the increment approach is direct and simple arithmetically and may often suffice, the analysis of covariance is likely both to be more efficient and to produce unbiased results". Granted that our colleagues were then writing on the "Use of analysis of covariance in periodontal clinical trials", but the same conclusion applies for caries clinical trials. Incidentally, our two colleagues who recommended ANOCOV over increment analysis almost ten years ago were the first two authors on the paper I am discussing today. Clearly, they are familiar with everything I am saying today, but apparently tradition may overcome technical knowledge in the case of caries studies.

Now you might say that increment analysis is to be preferred because the assumptions of analysis of covariance are more difficult to meet. Not so. Porter⁴ has pointed out that not only does increment analysis test the same null hypothesis as ANOCOV, but that the ". . . assumptions are identical for the two analyses". Indeed, various authors have pointed out that increment analysis is essentially a special case of ANOCOV, where the regression of post-measure on pre-measure is assumed to equal unity.^{2,3,5}

The paper being discussed today has considered increment ANOCOV - *i.e.*, the increment as criterion and the initial DMFS as covariate. As has been noted in a previous paper⁵, increment ANOCOV is equivalent to ANOCOV. Hence, any improvement in precision with the use of increment ANOCOV over and above the traditional increment analysis is due to the inability of the increment analysis to utilize all the information in the initial DMFS.

Furthermore, if it seems desirable to look for additional covariates, multiple correlation (regression) analysis might proceed along the same lines suggested in the paper being discussed, with the exception that final DMFS would be the criterion, and initial DMFS would be the first selected covariate. Since the sole criterion for a covariate(s) is the proportion of variance predictable in the criterion, other covariates which added significant (practical as well as statistical) predictable variance could be added to the model. Of course, the data base presented in the paper being discussed could be used for this purpose.

In summary, I offer the abstract of a recent paper⁶ comparing increment analysis and covariance analysis in caries studies:

Consider a caries study where experimental units are (a) randomly assigned to groups, (b) pre-measured on DMFS, (c) administered a specified treatment depending on group membership, and (d) post-measured on DMFS. Traditional analysis of these data consists of analysis of variance of the increment scores (increment ANOVA). In place of increment ANOVA, others have suggested analysis of covariance with the post-measure as criterion and the pre-measure as covariate (ANOCOV). The present paper examines and documents the following: (1) Increment ANOVA and ANOCOV test the same null hypothesis. (2) Increment ANOVA and ANOCOV have exactly the same assumptions. (3) Increment ANOVA is usually less precise than ANOCOV. (4) The same concern for violations of assumptions must be expressed with increment ANOVA as with ANOCOV (see No. 2 above). (5) ANOCOV should replace increment ANOVA in caries studies (see points 1-4).

Finally, it appears to me that the only thing going for increment analysis is tradition. I have nothing against tradition if its effects are positive, or at least non-negative. Increment analysis, unfortunately, has negative effects. It is costing us precision in caries studies. I believe it is a tradition that should be laid to rest.

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