

Re-Visiting “How do you know he tried his best” ...
The Coefficient of Variation
As a Determinant of Consistent Effort

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Introduction

Several years ago, the paper “How Do You Know He Tried His Best?” (Matheson, 1988) provided guidelines for the use of the coefficient of variation statistic as a means to determine the consistency of performance in tests of physical ability. The coefficient of variation statistic is a measure of the statistical consistency of a set of data; in this case the data are scores on multiple repetition performance trials. As reported in the original paper, the coefficient of variation statistic should not be the sole means for determining test reliability. The author cautioned that the use of this statistic requires confirmation and an interpretation of the factors that may have caused higher-than-expected variability.

Unfortunately, the developers of some functional capacity evaluation systems have touted the coefficient of variation statistic as a simple and effective method to determine if an evaluatee is “faking” his or her effort. Even worse, the coefficient of variation has been incorrectly used out of context as a means to determine eligibility for benefits or allowances that are associated with disability programs. Although it has utility in identifying less than full effort (Matheson, Bohr, & Hart, 1998), its use as an independent measure is quite limited (Lechner, Bradbury, & Bradley, 1998). Functional capacity evaluators who persist in relying on this measure risk being successfully challenged in forensic proceedings. This article is intended to improve the professional community’s understanding of the coefficient of variation statistic and its use in this application.

Background

The coefficient of variation statistic is a index of variability that can be used to describe data that are measured on a ratio scale (Zar, 1984). It is operationally defined as the ratio of the standard deviation of a set of scores to its mean, expressed as a percentage (Portney & Watkins, 1993). It is useful in applications that compare persons in terms of the individual’s consistency in repeated trials because it is a measure of relative variation, not affected by the magnitude of the values on which it is based. Thus, aside from spurious error variance in the measurement tool, it can be used to compare the variability of persons who differ substantially on the variable. For example, it allows fair comparisons of the variability of weak evaluatees to strong evaluatees or of fast evaluatees to

slow evaluatees. Given a standard error of measurement, neither the high-scoring individual nor the low-scoring individual is at a disadvantage.

It is important to understand the factors that make appropriate the application of the coefficient of variation statistic to functional testing. In the original article, several guidelines were provided for the appropriate use of the coefficient of variation statistic in occupational rehabilitation. Those factors were:

1. Not require cardiovascular effort that exceeds 65% of predicted maximum heart rate.
2. Not directly involve an impaired component of the biomechanical system.
3. Be controlled by the evaluatee.
4. Have low error variance.
5. Have high inherent stability relative to the range of recorded values.
6. Allow short-term (brief rest) replication.
7. Give the evaluatee minimal visual or proprioceptive feedback regarding the results of his or her effort.

As reported in the original paper, the likelihood of an increased coefficient of variation is substantial when an impaired component is tested. The performance of the individual with impairment can be significantly impacted by the nature of the test if the test directly affects the impaired component. Therefore, using the statistic as a measure of less than full effort for the impaired component is likely to produce spuriously high results, and should be avoided.

The author also encouraged functional capacity evaluators to address the occurrence of high coefficient of variation within an appropriate context. An elevated coefficient of variation may be explained by factors such as joint or segment instability, pain, fatigue, fear of the test, or additional causes other than purposeful less than full effort performance. Through observations of the evaluatee and an appropriate analysis of other performance data, alternative causes for elevated coefficient of variation scores can be

identified. Unfortunately, instead of interpreting the coefficient of variation in such a manner, some evaluators have used the coefficient of variation as the sole factor in determining reliability of the evaluatee's efforts. This is inappropriate. Similarly, in an attempt to represent a competitive technological advantage, some manufacturers of functional capacity testing systems have falsely reported that their systems could determine when an evaluatee was "faking" his or her effort.

At the time of the original article, many of the technologies associated with the recording and calculation of performance tests were quite limited. Most of the measures of strength were based on peak values that were recorded by mechanical or hydraulic dynamometers. Isometric testing with computers provided data as unitary peak values or in simple force curves recorded at 5-10 data points per second. As a consequence, the calculation of the coefficient of variation was usually limited to the comparison of peak scores during each test repetition, even with "computerized" systems. Isokinetic strength was recorded with more sophisticated devices, but proved to have high inherent error variance when the usual methods of testing were employed (Matheson et al., 1992). After a brief period of success, most isokinetic testing has been abandoned or relegated to the laboratory.

The Coefficient of Variation Today

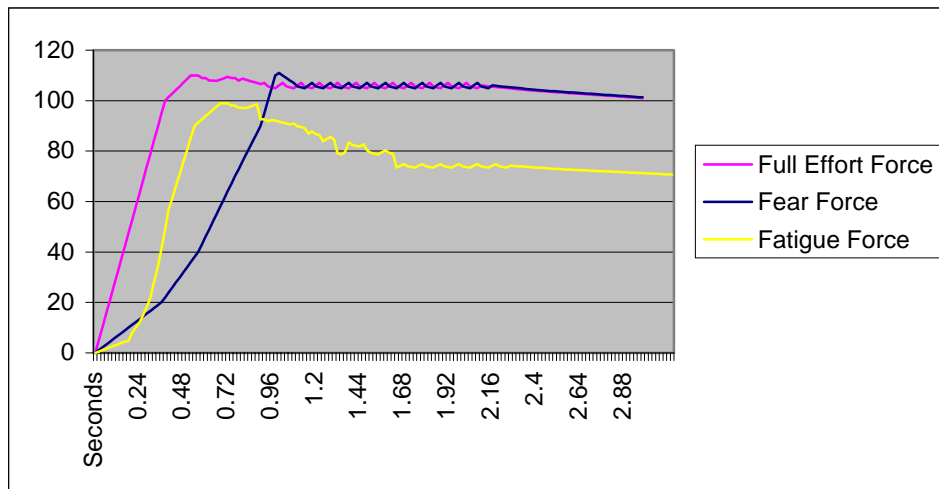
The misapplication of the coefficient of variation statistic has led some evaluators to reject its value in the determination of effort in functional testing. This is unfortunate because the coefficient of variation statistic is a valuable indicator of consistency, one measure of performance that is generally regarded to be important in functional capacity evaluation. In fact, it may be more useful than the absolute value of the performance, because it reflects on the reliability of the measure, notwithstanding the cause of any aberrations. Simply stated, there is no other statistic that is as fair. The problem comes with its appropriate interpretation.

One approach that may facilitate appropriate interpretation is the application of the coefficient of variation statistic in a "reliability profile" such as has been used in test protocols such as the Maximum Voluntary Effort (Matheson et al., 1998) and in a few of

the commercially available functional capacity evaluation systems. The pattern of coefficients of variation over several similar test protocols, especially when considered in the context of absolute performance values and means of performance values appears to be a more dependable approach. Though this requires much more time to administer, it is to be recommended.

Technology in this area continues to evolve. The computer's value in the functional testing process has been accepted. Its ability to guide the standardization of administration and provide the recording and calculation of performance on a real-time basis provides is valuable. Supplemental real-time graphing of performance has surmounted the earlier limitations imposed by reliance on peak values. Graphing of performance may be a much more useful indicator of reproducibility (and therefore consistency) of effort. Perhaps more importantly, a high coefficient of variation, explained in conjunction with a real-time graph, increases the likelihood that the evaluator can avoid potential misinterpretation of a non-deliberate sub-maximal effort. The real-time graph can help the evaluator identify certain performance characteristics that may have affected the evaluatee's performance and thereby avoid incorrect classification. An example of a real-time graph appears in Figure 1.

Figure 1. Characteristic force values for various types of performance.



The computer's ability to structure standardized test administration, rapidly record and analyze performance data, and facilitate comparison of results is helpful. It allows evaluators to avoid use of the coefficient of variation statistic outside of the explanatory context that each evaluatee's performance presents. Given this new technology, the coefficient of variation statistic need no longer be a "stand-alone" measure. It can always be considered within the evaluatee's performance context.

To which factors should we pay attention? The wide variety of data that are available has improved the potential utility of these methods. A new set of factors can be considered, including:

1. The component of the performance variable that is measured
 - a. Peak value;
 - b. Average value;
 - c. Time to peak value or slope;
 - d. Stability over time after peak.

2. The structure of the performance test

- a. Complexity of the task;
 - b. Complexity of the cognitive load imposed by test instructions;
 - c. Number of full effort repetitions;
 - d. Duration of required hold at peak;
 - e. Rest prior to repetition;
 - f. Rate of repetition.
3. How the performance data are collected and analyzed
 - a. Computer collected and analyzed;
 - b. Computer collected, human analyzed;
 - c. Human collected and analyzed.

With computer-interfaced dynamometry, the ability to collect real-time values is possible. This is attractive, but the value of the strategies that are available with this new technology should not be assumed and needs to be explored. Problems are likely to exist about which we are unaware. For example, real-time recording may result in a higher inherent coefficient of variation than a test employing only peak force, because there may be more inherent variability in performance over time on an intra-test basis. Scientific studies are needed to resolve such issues.

Recommended Guidelines: Use of the Coefficient of Variation in Functional Testing

A skilled functional capacity evaluator must adhere to appropriate standards of practice, not only in the administration of functional tests, but also in the analysis and interpretation of the evaluatee's performance. The coefficient of variation is a critical component in the evaluation of the evaluatee's performance. The following guidelines are proposed for the use of the coefficient of variation in functional testing:

1. The coefficient of variation should be described as a measure of the consistency of an evaluatee's efforts.

2. The coefficient of variation should not be used on a standalone basis for the determination of the sincerity of effort of an evaluatee. The evaluator should include an analysis of all factors potentially affecting the evaluatee's efforts.
3. Whenever possible, real-time performance recording should be included with the coefficient of variation in order to facilitate the appropriate analysis of the evaluatee's efforts.
4. The test protocol must identify whether or not peak or average forces are being used in the calculation of the coefficient of variation.
5. Test protocols employing coefficients of variation should be explained fully, including such factors as the nature of the test, length of time for each repetition, the number of repetitions and the rest period between repetitions.
6. The coefficient of variation, when employed in conjunction with the evaluation of an impaired component of the biomechanical system should be appropriately noted.
7. The coefficient of variation should only be employed in test situations where absolute reproducibility of the standardization of administration is possible. Even minute variations in the administration of the test protocol can significantly affect the resulting coefficient of variation.
8. In functional evaluations employing several tests with a coefficient of variation calculation, the evaluator should consider the entire evaluation effort as opposed to using a limited number of elevated coefficients of variation to determine sincerity of effort.

The coefficient of variation can be an invaluable tool for the functional capacity evaluator. By adhering to appropriate guidelines for the application and interpretation of

the coefficient of variation, it will remain as one of the most reliable means to help the professional evaluator determine the consistency of a evaluatee's performance.

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