THE COMPARISON OF AMONG DIFFERENT NUMERICAL INTEGRATION METHODS ON THE BIOMECHANICS OF SPORT COUNTERMOVEMENT JUMP

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The subject of this research is the countermovement jump. Support phase data has been calculated in accordance with criteria set out in Riemann's Sum. Numerical integration methods employed include the Trapezoidal Rule (TR), TR+Simpson Rule (SR), and 3/8R+SR to calculate the error of the surface countermovement value. The subject of this research was a male basketball player, aged 25 years, 180 cm in height, and 80 kg. in weight. Swing-arm countermovement jumps of various force levels were performed a total of ten times. System sampling rate was set at 240Hz with data first passing through a Butterworth low-pass filter set at a cut-off frequency of 50Hz prior to calculating raw time and force values. Data was entered into an editing program written in turbo pascal as well as an Excel database to calculate end values. In terms of countermovement jump values, using the 3/8R+SR formula resulted in the smallest variance among result values, while TR resulted in the largest.

KEY WORDS: Riemann’s sum, support phase, countermovement jump, numerical integration methods

INTRODUCTION: Regardless of whether quantitative or qualitative research is applied, it is exceptionally difficult to remove error from research work. Nonetheless, it is a researcher's responsibility to reduce such error to the smallest practical level. With the formal reporting of error scope and level, readers can better assess the importance of reliability and efficiency in research. Changes in force by the subject on the force platform are picked up and recorded by system equipment. Typically the board curve tested cannot be directly calculated by numerical integration. In most cases, data is produced in an analog-to-digital method. To calculate the margin of error in such calculations, the researcher may employ software-based calculation methods (Kibele, 1999). In theory, in accordance with the Newton’s laws of motion, to obtain the highest jump speed and central stretch height, the surface horizontal impulse must be added. In the event that this value contains an error, all generated athletic reference values will similarly be in error. Therefore, in calculating the horizontal rate imparted to a subject by the ground, the accuracy of variable data clearly is essential to end value accuracy. Numerical analysis is employed to calculate a wide variety of number-based equations and to solve a broad array of mathematical problems. In recent years, numerical analysis has been used in the field of physical education sciences to process data. Such data include that gathered from EMG and Force Plate instruments. However, in terms of validity there remains some margin of error (Kibele, 1999). Therefore, today's force test plates incorporate numerous new methods to assess performance and employ Newton’s laws of motion to obtain variables. Typically, the force plate was used to provide a fixed measure in the test in order to get standardized test results. In other words, the force plate provided some measure of reliability. If further values are to be produced, one needs to calculate them using numerical analysis. In general, there are two types of numerical analysis. The first is the selection of the desired categories and their distances or selection of the variable easiest to calculate. The results are then obtained using these already-known values and their representations. The second method involves selection of uncontrolled variables for entry into the formula. This is followed by selection of the desired level of accuracy and differential needed to obtain the ideal result. As the second calculation method employs the precepts of Riemann's Sum, even though more complicated, it is still the more accurate of the two. Calculative methods used in the first category primarily include the Trapezoidal Rule (TR) of the Newton-Cotes integration formula, Simpson‘s 3/8 Rule (3/8R), TR+SR, and 3/8R+SR. In theory, these calculation methods all have their defined limitations and, regardless of the methodology used, qualitatively different movements will produce different levels of data error. Thus, this research employs the theories of Riemann's Sum as its base to obtain evaluative criteria for countermovement jump.

METHOD: The subject in this study is a male basketball player in a top-tier basketball team. At the time of this study, the subject was 180 cm, weighed 80kg., and 28 years of age. Research instrumentation used include a force plate (Kistler 9287) and Kistler response bridge amplifier. Prior to the test, system settings were set to 240 Hz and test time ran for a total 3 seconds. Prior to formal testing, the subject was given a full briefing by the research regarding the test and points of particular note. After warm up, the subject performed three countermovement jumps. To obtain results at different force functions, during formal testing, the subject was requested to perform countermovement jumps at different levels of force for a total of ten times each. The scope of raw data is defined as the data resulting from subject countermovement jumps during the support phase. The support phase lasted from the period when the subject stepped onto the force plate through movements until he left the force platform. Prior to analysis, this raw data was fed through FTT to select the load frequency and implement residual analysis in order to determine which frequency reduced noise to the lowest level while retaining the maximum amount of useable data. After passing through the butterworth low-pass filter, the cutoff frequency was defined at 50Hz (Kibele, 1999) and provided relevant timing and force data.

Analysis methods.

1. Theoretical Base for Riemann's Sum

$\mathcal{A}$ Then□we have the following□

$\forall \varepsilon > 0$ □ $\exists P\varepsilon \in P([ab]\ s.t.,\ \delta < \varepsilon$ □

$\forall P \geq P\varepsilon\ \forall tk \in [Xk - 1$ □Xk]□K=1□……..□n

S(P □ f)= $\sum_{k=1}^{n} f(tk)(Xk, Xk - 1)$ □ $tk \in [xk - 1, xk]$ is arbitrary □

$mk(f) \approx irf\{f(x) \approx |x \in [xk - 1, xk]\}$ □ $\left|S(P, f) - \int_a^b f(t)dt\right| < \varepsilon$

RESULTS: The results of this research, after data was run through software calculation and analysis follows:

Table 1 The Relative Error Margins Obtained Using Different Numerical Analysis Methods

Num.Analysis Value and relative error	Riemann's Sum (n=10)	Trapezoidal Rule (n=10)	Trapezoidal Rule &Simpson Rule (n=10)	Simpson 3/8 Rule & Simpson Rule (n=10)
Value (kg-sec)	74.46±2.84	75.54±2.80	75.22±2.86	74.59±2.84
EstimatedStandard Error (kg-sec)		1.04	0.76	0.16
Relative Error (%)		1.3 **%**	1.1%	0.2%

(p.s. SEE est.= $\frac{\sum (X - X')}{N}$)

DISCUSSION: As the sampling rate obtained by the force platform will be affected by variances in system settings, the resulting scope of results will differ as well. Typically, when employing different types of numerical analyses to calculate scope values, the raw data values are used. However, it was identified in the course of this research that SR and 3/8R were not appropriate. This is because SR requires the use of imaginary numbers and 3/8R in calculations must be taken to a multiple of three before use. Therefore, this research uses TR, TR+SR, and 3/8R+SR to calculate force and estimate error margins. In accordance with the Oxford athletic cycle, speed is determined by force. Therefore, to jump effectively higher in a vertical jump and achieve the highest jump speed and central raised height, one must increase the reactive force on the ground, time, and force - in other words the time line slope. This research compares the results of different calculative methods to estimate the error margin in testing. In the creation of a true solution, this research employs the principles of Riemann's sum in combination with software to achieve values. In general, when using numerical methods to achieve a solution, the key is to consider the accuracy of results. There are many calculative methods, some of which are incapable of producing accurate results. Typically, numerical analysis methods are more accurate than those relying upon calculus. There are many pitfalls to using calculus and numerical analysis results are more stable. In theory, the trigonometric formula in TR provides for highly accurate calculations. However, for the vertical jump, this research uses multiple test categories in 6 dimensions (R Square = 0.97). Thus, the line may be in multiples of two or more. It is this that threatens to create most of the error problems. SR, however, employs estimation calculations on a static line for a total of three times or less. Data must be extrapolated, thereby making use of this analysis inconvenient. The combinations TR+SR and 3/8R+SR are an attempt to account for SR and 3/8R's respective weaknesses. The values obtained in this research that are returned by these analytical processes are exceptionally high. The Standard Error Exponential (SEE) shown in chart one is 1.04 kg-sec for TR, 0.76 kg-sec for TR+SR, and 0.16 kg-sec for R+SR. The relative error resulting from use of TR is 1.3%, 1.1% from using TR+SR, and 0.2% from using R+SR. Therefore, again, 3/8R+SR is the most accurate method of calculating values for the countermovement jump.

CONCLUSION: This research uses test instruments to obtain raw data on time and force. Using the principles of Reimann's sum, the different margins of error were explored and returned by various analytical methods performed on countermovement jump data. After processing through software, the results of this research have determined that in terms of the countermovement jump, use of the 3/8R+SR method of numerical analysis, results in the smallest margin of error. The TR method results in the largest margin of error.

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