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Published in:
Journal of Fitness Research

Published: 01/01/2016

Document Version
Publisher's PDF, also known as Version of record

[Link to publication](#)

Citation for published version (APA):
Rowlands, D. D., Wada, T., Lee, J., & James, D. (2016). Quantifying Consistency of Technique in Swimming. *Journal of Fitness Research*, 5(Special Issue), 19-21.

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CONFERENCE PAPER

Quantifying Consistency of Technique in Swimming

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ABSTRACT

Swimming consists of a repetitive action which can be visualised using overlay and phase portrait techniques to determine the consistency of the swimming action. However, this does not lead to a quantifiable value for the consistency. This paper uses curve fitting techniques on the body roll data measured by inertial sensor gyroscopes to quantify the consistency of action of two swimmers. It was found visually that the consistency between the two swimmers were different and the curve fitting technique also showed a difference indicating that the technique can be useful in quantifying the consistency of the action.

Keywords: visualisation, swimming, inertial sensors

INTRODUCTION

Inertial sensors have been applied with success to many sports [1-3]. These sensors typically generate large datasets especially for long periods of capture time. Visualisation is a useful tool in extracting information from these long duration or large datasets [4]. Many sporting activities contain repetitive motion which can benefit from the use of visualisation techniques [5]. Particular visualisation techniques such as the overlay method [5], and phase space portrait methods [5] (both delay and derivative types) are very useful to see changes in the repetitive activity over multiple repetitions. These visualisations are graphical in nature and thereby allow changes to be readily identified by inspection but do not quantify these changes. What would be useful is a method to use the

visualisations to quantify the consistency of a repetitive action. This paper uses curve fitting techniques on the body roll data measured by inertial sensor gyroscopes to quantify the consistency of action of two swimmers.

METHODOLOGY AND RESULTS

The body roll was determined from the gyroscopic data of an inertial sensor unit placed at the 7th Cervical Vertebra (C7) of the spine. Body roll data was collected from two swimmers according to the method outlined in [5]. (ENG/02/13/HREC). Swimmer 1 is a former Olympian and Swimmer 2 competed at state and national age championships. The data collected consisted of 7 swimming strokes with individual

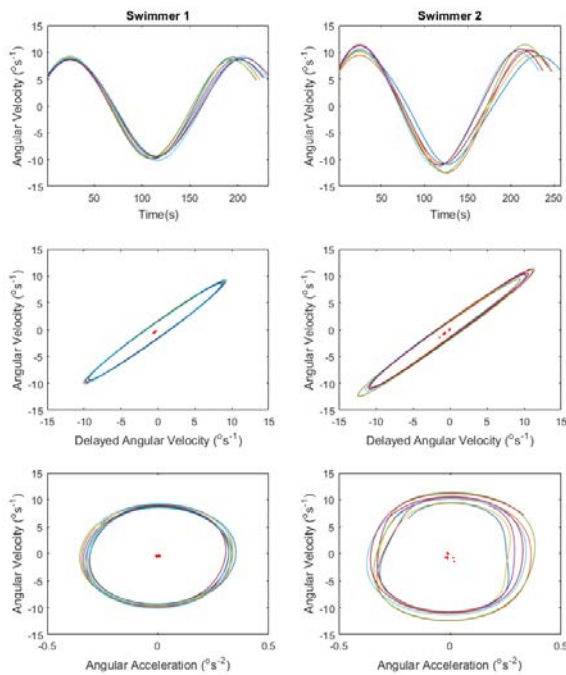


Figure 1 Visualisation of body roll for 2 swimmers from a sensor placed on the body at the 7th Cervical Vertebra (C7). The red dots show the centre as determined by an ellipse fit.

strokes being separated before being visualised. The visualisation of this data is shown in figure 1. The top graphs use the overlay method, the middle graphs use the phase portrait delay method, and the bottom graphs use the phase portrait derivative method. Curve fitting was used as the method to quantify each graph. The type of curve fitting used depended upon the shape of the graph and was

applied to each individual stroke. A sinusoidal fit of the form $A\sin(Bx+C)$ was used for the Overlay graphs and an elliptical fit was used for the Phase portraits. The extracted fitting parameters from the ellipse consisted of the ratio of the major axis to minor axis and the distance from the centre of the ellipse to the origin.

The fitting parameters were extracted from each individual stroke in a given graph. The variability of these parameters were determined by calculating the mean, standard deviation, and a percentage value representing the spread of the parameter. This was repeated for every graph in Figure 1 with the results given in Table 1.

DISCUSSION AND CONCLUSIONS

It can be seen from Figure 1 that the consistency of Swimmer 1 is better than the consistency of Swimmer 2. Swimmer 2's graphs are more spread compared to Swimmer 1 and the centre locations from the ellipse fit (red dots) are also more spread. The ratio of the standard deviation to the mean expressed as a percentage indicates the relative spread of each parameter and will be referred to as the relative spread.

Table 1 Extracted Fitting parameters for all strokes

| Visualisation Technique | Swimmer1 | | | Swimmer 2 | | |
|-------------------------|----------|--------|---------------|-----------|--------|---------------|
| | mean | stdev | (stdev/mean)% | mean | stdev | (stdev/mean)% |
| Overlay | | | | | | |
| A | 9.064 | 0.147 | 1.624 | 10.495 | 0.432 | 4.1193 |
| B | 0.035 | 0.001 | 2.906 | 0.032 | 0.001 | 3.9378 |
| C | 0.684 | 0.051 | 7.476 | 0.765 | 0.055 | 7.3039 |
| Delay | | | | | | |
| Major/Minor | 11.3328 | 0.3562 | 3.1435 | 13.6731 | 1.0876 | 7.9541 |
| Distance | 0.6158 | 0.1407 | 22.8523 | 0.9063 | 0.6860 | 75.6930 |
| Derivative | | | | | | |
| Major/Minor | 28.4472 | 0.8894 | 3.1263 | 34.3493 | 2.7417 | 7.9819 |
| Distance | 0.4356 | 0.1010 | 23.1815 | 0.6422 | 0.4868 | 75.7995 |

The relative spread of parameters A and B in the Overlay graph is larger for Swimmer 2 than Swimmer 1 indicating that Swimmer 1 has the more consistent technique. This matches what is shown in Figure 1. It should be noted that parameter C is about the same for Swimmer 1 and 2.

The relative spread of the major/minor axis in the delay phase portrait is 2.5 times larger for Swimmer 2 compared to Swimmer 1 and the relative spread of the distance of the centre from the origin is 3.3 times larger for Swimmer 2 compared to Swimmer 1. This indicates that Swimmer 1 has a more consistent technique which matches the graphs from figure 1.

The relative spread of the major/minor axis in the derivative phase portrait is 2.5 times larger for Swimmer 2 compared to Swimmer 1 and the relative spread of the distance of the centre from the origin is 3.3 times larger for Swimmer 2 compared to Swimmer 1. This indicates that Swimmer 1 has a more consistent technique which matches the graphs from figure 1. It should be noted that the y axis on the derivative phase portrait graphs is approximately 30 times greater in magnitude than the x axis hence the major/minor ratio is around 30 as seen in Table 1.

All the fitting parameters in table 1 are derived from the graphs in figure 1 and show larger or close to equal values in the relative spread for Swimmer 2 compared to Swimmer 1 which indicates that Swimmer 1 is more consistent than Swimmer 2. This matches the graphs which show Swimmer 2 has a larger spread than Swimmer 1. Overall the technique of fitting curves to the visualisation graphs looks like a promising method to quantify the consistency in the swimming action.

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