The effects of measurement error and testing frequency in applying the Fitness Fatigue Model to resistance training: a simulation study.

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The effects of measurement error and testing frequency in applying the Fitness Fatigue Model to resistance training: A simulation study

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Introduction

- The four parameter, two component, Fitness Fatigue Model (FFM) posits that training causes two antagonistic after-effects, a long-lasting positive fitness effect and a shorter-lasting negative fatigue effect. [1]
- Whilst the model is frequently used as a conceptual framework, it can be applied using mathematical functions and fitted to individuals using recorded training and performance data. [2]
- Performance as a function of time, is denoted by the discretized form of the model (where w(s) is training load on day s and k_1, k_2, T_1, T_2 are the fitted individual parameters). [2]

$$p(t) = p(0) + k_1 \sum_{s=0}^{t} e^{-\frac{t-s}{\tau_1}} \cdot w(s) - k_2 \sum_{s=0}^{t} e^{-\frac{t-s}{\tau_2}} \cdot w(s)$$

- The use of mathematical models in training science may offer an approach to describe the effects of training, and improve coaching decisions.
- The emergence of affordably priced field devices for measuring variables commonly associated with athletic performance, opens up new possibilities for individualised, practitioner lead implementation of mathematical models of this type.
- However, not much is known about the precision of existing models such as the FFM, when operated using data collected from these devices.

1 Quantify arbitrary training load (TRIMPS) for each individual athlete via suitable method (i.e. exponential weighting of intensity). Make reasoned guesses at initial model starting parameters.

2 Collect regular training derived criterion measure (i.e. vertical jump), or competitive performance (i.e. 50m swim sprint under simulated competitive conditions).

3 Fit model predicted values for performance to collected training derived measures using suitable method, i.e. minimising residual sum of squares (RSS)

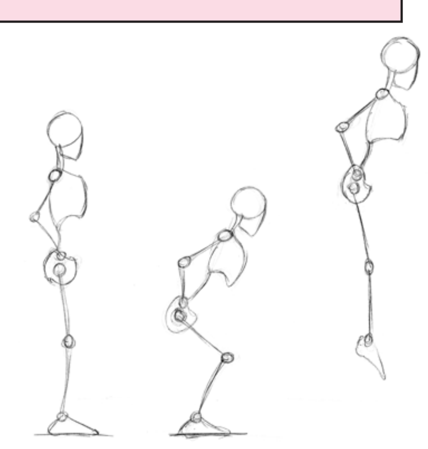
4 Follow athlete through many training cycles. Model becomes more predictive, as better precision achieved in model fit (through manipulation of initial parameters and TL quantification).

Figure 1. A simplified method for applying the FFM in practice

Research Aim & Approach

To assess the effects of measurement error (typical error) and testing frequency on the ability of the FFM to accurately model resistance training data. A simulation approach assuming correct model specification was used to identify upper bounds for precision based on realistic measurement error and testing frequencies.

Method



- Representative training data and vertical jump power values were generated for an 80kg athlete over 24 weeks using the FFM and selected parameter values.
- Measurement error was added to the data to correspond with power values collected from a force platform (typical error: 100 W) or a linear position transducer (typical error: 175 W).[3]
- The FFM was fitted with least squares regression using data from the first 12 weeks and assuming performance measurement on a weekly or daily basis.
- Simulations of N = 50,000 were completed for each scenario comparing variability in predicted performance with values generated by the true parameters over the final 12 weeks.

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The simulation platform was custom built for this project using R.

Results

Greater variability in predicted performance was obtained when reducing measurement frequency (weekly vs. daily measurement) compared with increasing measurement error (linear position transducer (LPT) vs. force platform). This is shown in table 1.

Measurement Tool	Measurement Frequency	2.5% CI	97.5% CI
Force Platform	Once Per Day (OPD)	- 44 Watts	+ 81 Watts
Linear Position Transducer	Once Per Day (OPD)	- 83 Watts	+ 138 Watts
Force Platform	Once Per Week (OPW)	- 222 Watts	+ 647 Watts
Linear Position Transducer	Once Per Week (OPW)	- 501 Watts	+ 1148 Watts

Table 1. Ninety five percent confidence intervals calculated for the difference between the true performance measure and simulated FFM predictions with fitted parameters at the end of the 24 weeks.

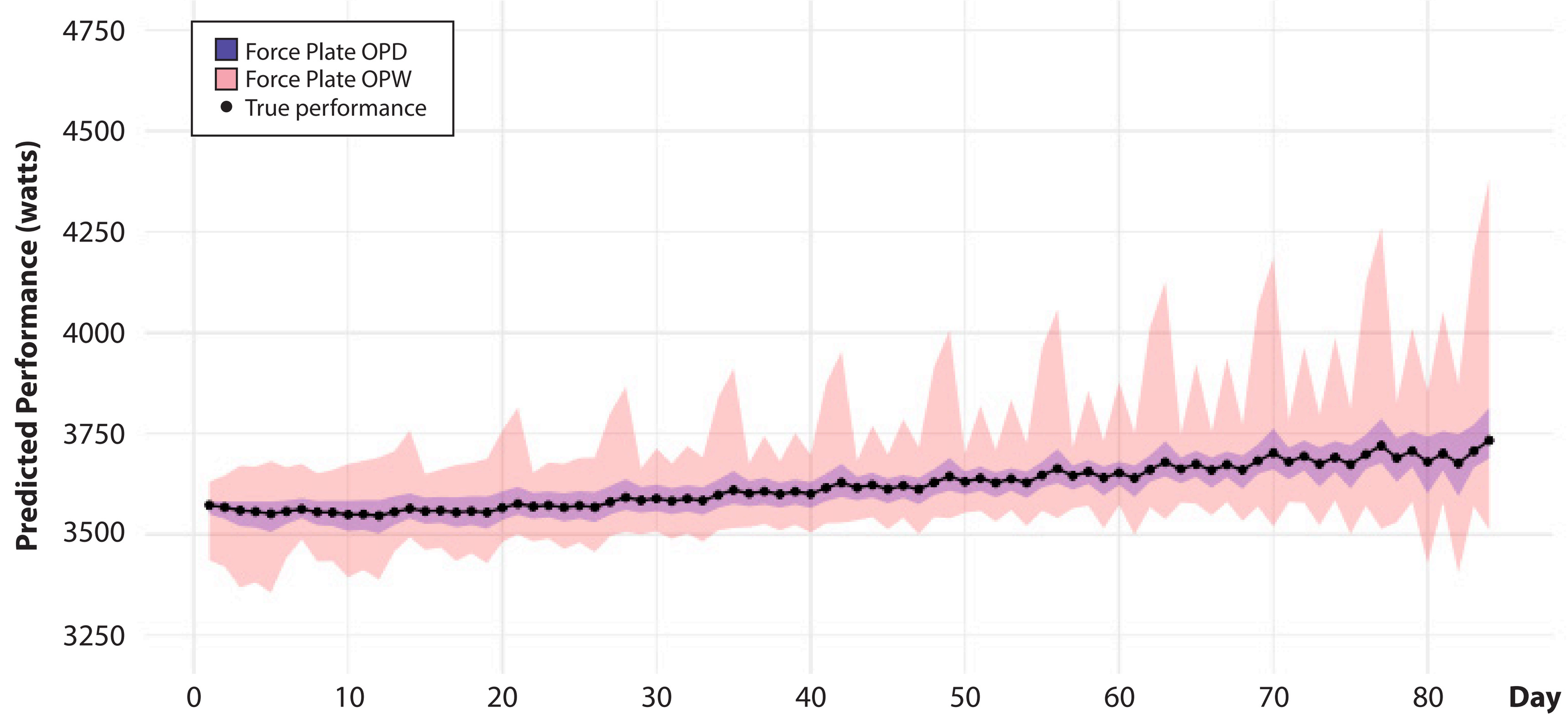

Figure 2. Variability in simulated predicted performance (VJ Peak Power Output), measured with a force plate once per week (pink) and once per day (purple), compared to values generated by true parameters (dots/line), over the final 12 weeks.

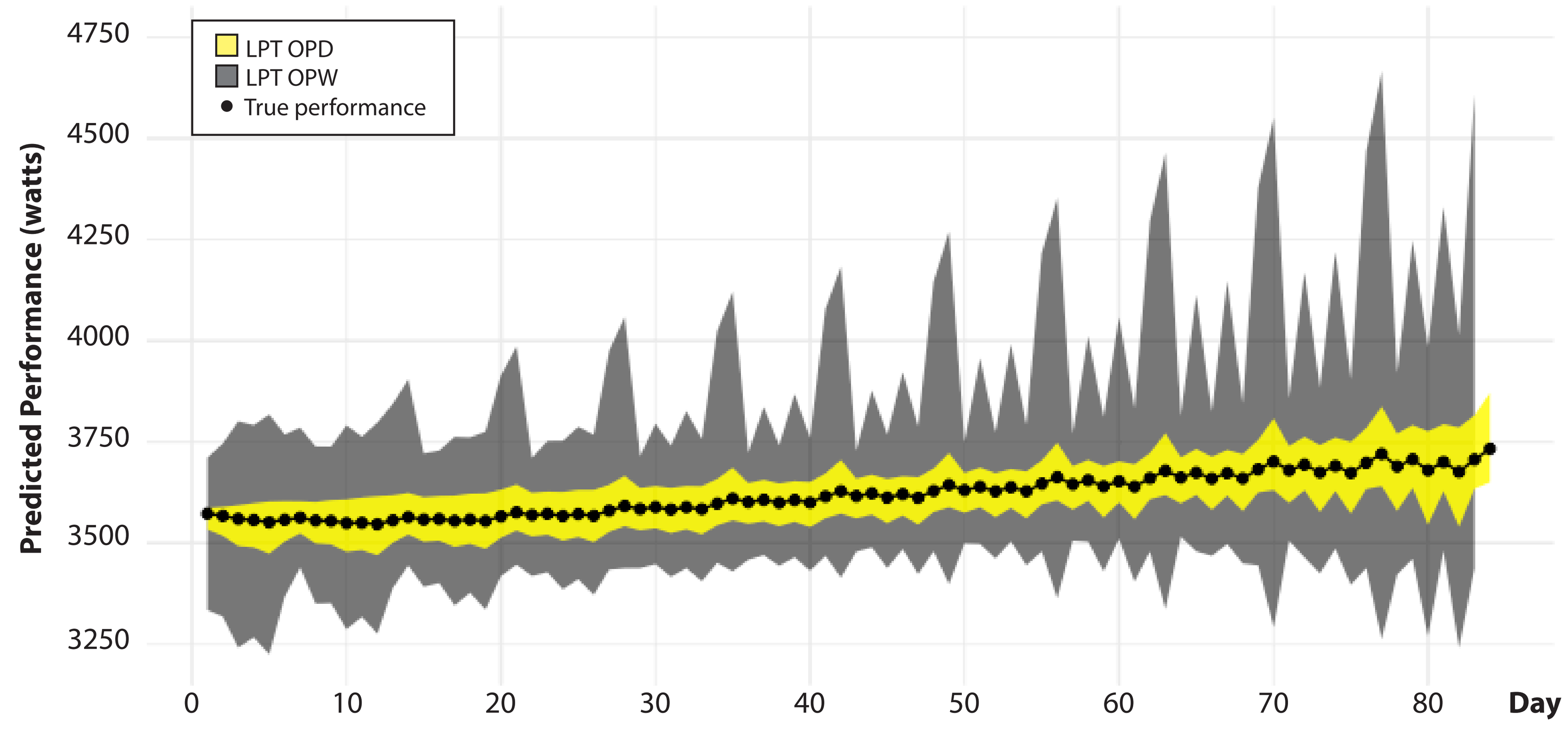

Figure 3. Variability in simulated predicted performance (VJ Peak Power Output), measured with a LPT once per week (grey) and once per day (yellow), compared to values generated by true parameters (dots/line), over the final 12 weeks.

Conclusions & Practical Relevance

- The Fitness Fatigue Model requires frequent measurements in order to consistently model the response to resistance training.
- Reliable measurement technology is preferred; however, frequent measurements may compensate to some degree for the use of less expensive and subsequently less reliable technology.
- Further simulations incorporating a greater range of training programs and response profiles are required to better understand the potential for applying the FFM in modelling and programming resistance training.

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1. Busso, T. Häkkinen, K. Pakarinen, A. Carasso, C. Lacour, J.R. Komi, P.V. Kauhanen, H. (1990) A systems model of training responses and its relationship to hormonal responses in elite weight-lifters *European Journal of Applied Physiology and Occupational Physiology*. 61, pp.48-54.
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