Optimising Pre-Season Training Loads in Australian Football

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Background

- Pre-season training is considered crucial in Australian football
- It can influence player injury risk and competitive performance
- Training load prescription in team sport athletes is a balance between performance improvement and injury risk reduction

Training load – injury relationship

- Relationships have been found between injury rates in Australian football and:
  - High cumulative running loads (3-4 weeks) (Colby 2014)
  - High and low relative training loads (Gabbett 2016, Carey 2016)
    - Commonly quantified using the *acute:chronic workload ratio.*
    - Ratio of short term (acute) to long term (chronic) loads

Aim

- To investigate whether an optimisation approach could generate pre-season training plans based on injury risk and performance objectives

Optimisation approach

Decision Variables

$$w_i = training\ load\ on\ day\ i; i \in \{1, 2, \dots, 125\}$$

We considered total training distance and sprint running distance.

Constraints

1. Daily maximum and minimum: $0 \leq w_i \leq 50{,}000$
2. Bounded acute:chronic workload ratio (relative load progression):

$$r_i = \sum_{j=i-6}^{i-1} \frac{w_j}{6} \Big/ \sum_{j=i-24}^{i-1} \frac{w_j}{24}$$

$$0.6 < r_i < 1.3 \text{ (Gabbett 2016, Carey 2016)}$$

3. Maximum cumulative workload (rolling 21 days):

$$C_i = \sum_{j=i-21}^{i-1} w_j$$

$$C_i < 73{,}721 \text{ (Colby 2014)}$$

Objective

A: Maximise total 'safe' training volume

- Simple objective
- Desirable for coaches (want as much time as possible to coach)

$$f_A(\boldsymbol{w}) = \sum_{i=1}^{125} w_i$$

B: Maximise projected performance level

- Banister impulse-response model (Banister 1975)
- Reach peak projected performance levels on day of first match

$$p_i = p_0 + k_1 \sum_{j=1}^{i-1} w_j e^{\frac{-(i-j)}{t_1}} - k_2 \sum_{j=1}^{i-1} w_j e^{\frac{-(i-j)}{t_2}}$$

$$k_1 = 1, k_2 = 2, t_1 = 45, t_2 = 11 \text{ (Morton 1990)}$$

$$f_B(\boldsymbol{w}) = p_{125}$$

Methods

- Training plans were initialised by random sampling from a normal distribution:

$$(\mu, \sigma)_{distance} = (3\ \text{km}, 1\ \text{km})$$
$$(\mu, \sigma)_{sprint} = (30\ \text{m}, 10\ \text{m})$$

- Optimisation was performed using the MATLAB software package:
  - Constrained nonlinear solver (fmincon)
  - Sequential quadratic programming algorithm (SQP)
  - Default step and function convergence tolerances (10^{-6})

Results

- Able to generate training plans that satisfied relative and absolute workload constraints (Fig. 1-2)
  - Comparable to those previously reported in professional AFL teams:

$$\mu_{total\ distance} = 314 - 411\ \text{km} \quad \& \quad \mu_{sprint\ distance} = 2.7 - 8.9\ \text{km}$$

- Increasing the off-season chronic training loads (Fig 1):
  - ↑ amounts of 'safe' training
  - ↑ projected performance levels

- *Objective A*:
  - Prescribed frequent, moderate intensity training (Fig 2a,c)
- *Objective B*:
  - Plans included a taper prior to competition
  - Favoured more variation in daily training loads (Fig 2b,d)
  - Gives consideration to fatigue accumulation

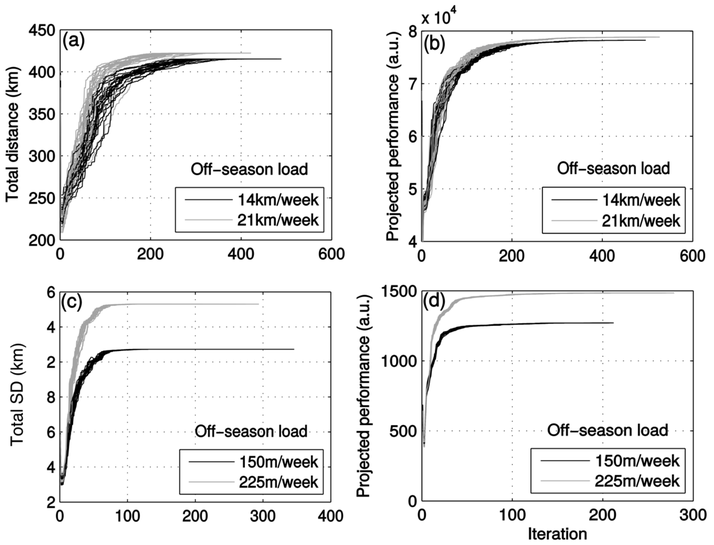

Figure 1: Convergence of 20 simulated pre-season training plans for: (a) distance under objective A, (b) distance under objective B, (c) SD under objective A and (d) SD under objective B.

Practical Applications

- Provides an adaptable framework for physical preparation staff to quickly create training plans that:
  - Satisfy injury risk constraints
  - Optimise training goals
  - Are not exposed to subjective biases

- Individualised training plan design
  - Parameters could be modified for:
    - New recruits
    - Players returning from injury
    - Different athletic profiles

- Ability to adapt to changing training objectives
  - E.g. peaking for multiple important games

- Theoretical framework for testing training strategies and assumptions:
  - Can match fitness levels be reached if off-season loads are reduced?
  - How much more training can we do if accept higher injury risk?

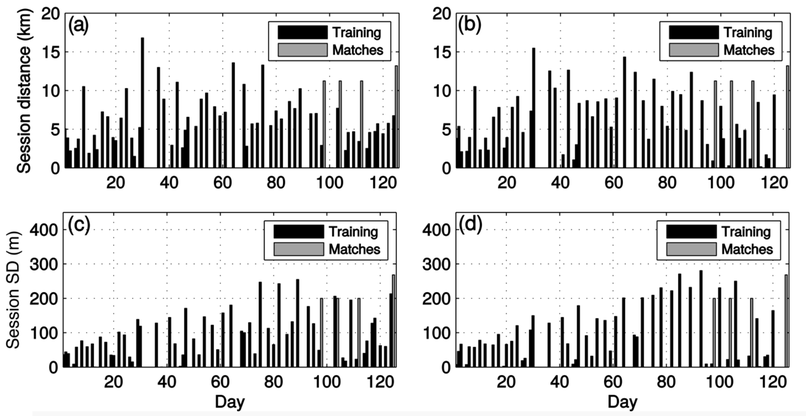

Figure 2: Computer generated optimal pre-season training plans for: (a) distance under objective A, (b) distance under objective B, (c) SD under objective A and (d) SD under objective B.(off-season chronic loads: 14km/week distance and 150m/week SD).

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