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. (Gabbe et al. 2013)
- 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

\[ w_i = \text{training load on day } i; i \in \{1, 2, \ldots, 125\} \]

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):
   \[ r_j = \frac{w_j}{w_{j-1}} \quad \frac{1}{2} < r_j < 1.3 \] (Gabbe et al. 2016, Carey 2016)
3. Maximum cumulative workload (rolling 21 days):
   \[ C_i = \sum_{j=21}^{i} w_j \]
   \[ C_i < 73,721 \] (Colby 2014)

### Objective

**A:** Maximise total ‘safe’ training volume
- Simple objective
- Desirable for coaches (want as much time as possible to coach)

\[ f_A(w) = \frac{125}{w_1} \sum_{i=1}^{125} w_i \]

**B:** Maximise projected performance level
- Banister impulse-response model (Banister 1975)
- Reach peak projected performance levels on day of first match

\[ f_B(w) = p_i + k_i \sum_{j=2}^{15} \frac{(t_j - t_1)}{t_j - t_1} - k_2 \sum_{j=15}^{24} \frac{(t_j - t_1)}{t_j - t_1} \]

\[ k_1 = 1, k_2 = 2, t_1 = 45, t_2 = 11 \] (Morton 1990)

Methods

- Training plans were initialised by random sampling from a normal distribution:
  \[ (\mu, \sigma)_{\text{distance}} = (1 \text{ km}, 1 \text{ km}) \]
  \[ (\mu, \sigma)_{\text{speed}} = (30 \text{ m}, 10 \text{ m}) \]
- 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):
  - 1 amounts of ‘safe’ training
  - 1 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

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 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 (off-season chronic loads: 14km/week distance and 150min/week SD).

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 150min/week SD).

References