Salivary testosterone and cortisol in rugby players: correlation with psychological overtraining items

F Maso, G Lac, E Filaire, O Michaux, A Robert

**Background:** A psychocomportemental questionnaire has been devised by the consensus group of the Société Française de Médecine du Sport to characterise and quantify, using a list of functional and psychocomportemental signs, a state of “staleness”, for which no biological indicator is unanimously recognised.

**Objectives:** To determine the relation between this diagnostic method and two hormones (cortisol and testosterone) often used as indicators of a state of fitness or staleness.

**Methods:** The subjects were young rugby players. They were asked to complete the overtraining questionnaire and gave three saliva samples (at 8 am, 11 am, and 5 pm) during a rest day. Concentrations of cortisol and testosterone in the saliva were determined by radioimmunoassay.

**Results:** A preferential relation was found between the questionnaire score and testosterone concentration but not between the questionnaire score and cortisol concentration.

**Conclusions:** The questionnaire may be a useful tool for screening subjects at risk of overtraining. Testosterone concentration is influenced by tiredness, and is therefore a valid marker of tiredness.

**METHODS**

**Subjects**

Twenty five young international rugby players volunteered for the study. They were informed of the purpose and methods of the study before giving written consent to participate. None were taking any drugs. The study was performed during February, which is in the middle of the most intensive training and competition period for rugby players.

All measurements were made by the same investigator. The rugby players were weighed to the nearest 0.1 kg, and their height measured with a measuring rod to the nearest 0.1 cm. Percentage of body fat was estimated from four measurements of skinfold thickness as described by Durnin and Womersley. A Harpenden caliper was used to measure the thickness—that is, biceps, triceps, subscapular, and suprailliac—on the right side of the body with the subject in a standing position. The main biometric characteristics of the group of subjects were (mean (SE)): age, 17.6 (0.5) years; height, 177.6 (2.9) cm; weight, 73.8 (2.4) kg; percentage body fat, 15.6 (1.8) %.

**Training programme**

The subjects trained for 15 hours a week plus one match a week. They performed endurance training sessions (running at varying intensity below and above the anaerobic threshold), fartlek (interval training), strength training sessions (with loads at 80–90% of one maximal repetition), sprint training sessions, technical training sessions, and rugby specific fight training sessions each week. Matches consist of two halves, each of 40 minutes, separated by a 10 minute
recovery period, and are contested by two teams of 15 players (eight forwards and seven backs).

**Physical performance measurements**
To evaluate the performance of each subject, we chose tests to represent different aspects of physical fitness in rugby. These were performed three minutes after anthropometric assessment. The order of the tests was always aerobic capacity followed by vertical jump.

Maximal oxygen consumption (\(\text{VO}_{2\text{MAX}}\)) was estimated using a bicycle ergometer; the mean (SE) value for the group was 55.6 (0.8) ml/kg/min.

Sprinting speed was measured over 10 m and 40 m. These two distances are thought to indicate the initial acceleration and maximum sprinting capabilities respectively. After their usual warm up routine, the subjects performed two trials of maximum effort, sprinting over 40 m on their usual turf training surface. Light gates integrated to the timing system (DDHE, Bungendore, Australia) were placed at the 0, 10, and 40 m marks. Mean (SE) times were 1.8 (0.1) seconds for the 10 m run and 5.45 (0.3) seconds for the 40 m run.

Vertical jumping height was determined on a platform connected to a digital timer. The test battery consisted of vertical jumps performed from a standing position (a) without a preliminary counter movement jump (squat jump; SJ) and (b) with a preliminary counter movement jump (CMJ). Mean (SE) performances were: SJ, 40.5 (0.5) cm; CMJ, 42.1 (0.9) cm.

The mechanical power of the lower limb extensor musculature was measured in a jumping test. The subjects performed successive maximal jumps (CMJ) on the platform during a period of 30 seconds keeping their hand on their hips. The cumulative flight time and the number of jumps performed formed the basis for the calculations of mechanical power. Mean (SE) for 30 seconds of jumping was 28.2 (0.6) W/kg.

**Hormone assays**
Three saliva samples were taken from each subject during a rest day (24 hours without training). To avoid the effects of the circadian rhythm and variations in food intake on hormonal secretion, the three saliva samples were taken immediately after getting up (8 am), before breakfast (11 am), and in the evening (5 pm). These three points enabled us to determine a mean concentration over the day.

The saliva samples were stored in a freezer at \(-23\)0°C. Concentrations of salivary cortisol and testosterone were measured using a radioimmunological method routinely used and validated in our laboratory: sensitivity, 15 pg; accuracy, 10.5%; intra-assay reproducibility, 6.1%.

**Questionnaire**
A standardised questionnaire of early clinical symptoms of the overtraining syndrome was proposed. This psychological scale for overtraining was devised by the consensus group on overtraining of the French Society of Sports Medicine. This French questionnaire contains 54 psychocomportemental questions requiring answers of “yes” or “no”. The score is given by the sum of “yes” answers (fig 1). The questionnaire was administered on the day that the saliva samples were taken.

**Statistical analysis**
The data were analysed using the SPSS version 10.0 software. All values are expressed as mean (SE). Correlations between hormonal data and the score obtained in the overtraining questionnaire were determined using the Spearman correlation coefficient. \(p<0.05\) was considered significant.

**RESULTS**

**Psychological assessment**
The mean score obtained in the overtraining questionnaire was 9.5 (0.8) (maximum 25 and minimum 0). In an assessment on 2000 questionnaires (unpublished study), a mean of 8.9 was found, and the 10th centile corresponded to a score of 20.

**Hormones**
Table 1 gives salivary cortisol and testosterone concentrations as well as the testosterone/cortisol ratio. The different salivary concentrations of cortisol and testosterone at different times of day (8 am, 11 am and 5 pm) give a good demonstration of diurnal rhythm. Both cortisol and testosterone are more concentrated at the beginning of the day (8 am) and less concentrated at the end of the afternoon (5 pm).
overtraining score. Figure 2
cortisol ratio.

The correlation between questionnaire score and testosterone concentration at 8 am is
only, and the best correlations were obtained with the mean
data and the score from the overtraining test. The over-
time of cortisol and testosterone.

Table 2 shows the correlations found between the hormonal
data and the score from the overtraining test. The over-

tions of cortisol and testosterone.

DISCUSSION

From their anthropometric data, the subjects examined in
this study represent a homogeneous group of high level rugby
players.22 23 The study took place during February—that is,
after at least two months of hard training and competition.
This is the period when the players feel stale, and injuries and
infectious illness most often occur. The aim of the study was
to examine a possible relation between the score obtained
in the overtraining questionnaire and salivary concentra-
tions of cortisol and testosterone.

The two main findings are:

• The overtraining score correlates with testosterone con-
centration at 8 am \( (r = -0.53; p<0.01) \), mean testoster-
one concentration (8 am—11 am—5 pm) on the rest day
\( (r = -0.6; p<0.001) \), and the testosterone/cortisol ratio
at 8 am \( (r = -0.43; p<0.05) \).

• No correlations exist between cortisol concentration and
the overtraining score.

The standardised questionnaire on signs of overtraining was
developed by the French consensus group in order to
detect early disturbances in tolerance to intensive training. It
allows the calculation of a score suggestive of symptoms of
staleness or overtraining. We obtained a mean (SE) score of
9.5 (0.8) for our subjects. This corresponds to a value slightly
higher (non-significant) than the mean (8.9 (0.9)) obtained
from a more complete study \( (n = 1984) \) carried out on
athletes from various sports at various levels.24 25 This result
indicates tiredness in our subjects without necessarily
indicating overtraining.

To our knowledge, few studies have examined the presence
of a relation between overtraining and hormonal variations,
in particular cortisol and testosterone concentrations.26
However, there are many reports on the influence of training
on these hormones. High level sport is known to cause an
increase in cortisol. Testosterone concentration is also
affected and may show either an increase or decrease.27 The
testosterone/cortisol ratio, which reflects protein anabolism/
catabolism, often clearly delineates these variations.28 In a
study in our laboratory,27 it appeared that intensive physical
training over a long period induced an increase in testoster-
one and cortisol concentrations. Therefore the testosterone/
cortisol ratio showed little modification with time. Cumulative
tiredness, however, does produce a variation in the
concentration of these hormones. A fall in the testoster-
one/cortisol ratio is regarded as an indication of tiredness.28
However, this fall can have two different origins: cortisol
increase and/or testosterone fall. To determine more accu-
ragently the influence of tiredness on these hormonal varia-
tions, it was necessary to address these two variables. To
do this, we examined the existence of correlations between
the overtraining score and the hormonal assessment.

In our study, cortisol concentration was not found to be
related to the score obtained in the overtraining survey. In
contrast, testosterone concentration did show a relation to the
score. We noted a significant negative correlation between the
testosterone/cortisol ratio and the score. These
results show that it is more useful to follow variations in
testosterone (an anabolic hormone) than variations in
cortisol (a catabolic hormone) to determine the degree
of tiredness. To confirm these results, this survey needs to be
completed by a more heterogeneous population. In addition,
the individual variations in the score should be examined in
relation to changes in performance and biological markers
throughout the sporting season. The best way to use this tool
would be to carry out extensive follow up of an athlete during
a sporting season, in order to compare various states of
progressive tiredness with a baseline determined before the
start of the season.

<table>
<thead>
<tr>
<th>Hormone</th>
<th>r Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testosterone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 am</td>
<td>-0.53</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Mean</td>
<td>-0.6</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>T/C (8 am)</td>
<td>-0.43</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>T/C, Testosterone/cortisol ratio.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Correlation between hormonal concentration and overtraining questionnaire score

Figure 2 Correlation between testosterone concentration and overtraining score.
High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players: a study of radiographic and patient relevant outcomes

A von Porat, E M Roos, H Roos

Objective: To identify the consequences of an anterior cruciate ligament (ACL) tear in a cohort of male soccer players 14 years after the initial injury with respect to radiographic knee osteoarthritis and patient relevant outcomes.

Methods: Of 219 male soccer players with an ACL injury in 1986, 205 (94%) were available for follow up after 14 years; 75% of the cohort (154/205) answered mailed questionnaires (KOOS, SF-36, and Lysholm knee scoring scale) and 122 of these consented to weight bearing radiographs.

Results: Radiographic changes were found in 95 (78%) of the injured knees, while more advanced changes, comparable with Kellgren-Lawrence grade 2 or higher, were seen in 50 (41%). In the uninjured knees more advanced changes, comparable with Kellgren-Lawrence grade 2 or higher, were seen in five knees (4%). No differences were seen between surgically and conservatively treated players. The patient relevant outcome was affected and did not differ between subjects with and without radiographic changes. Eighty per cent reported reduced activity level.

Conclusions: A high prevalence of radiographic knee osteoarthritis was seen in male soccer players 14 years after an ACL disruption. The injury and the osteoarthritis, irrespective of the treatment provided to these patients, often result in knee related symptoms that severely affect the knee related quality of life by middle age.