INTRODUCTION

Physical strain during a soccer game or training is high [3,6] and effective recovery strategies, beside others (e.g., adequate training per se), are important factors to maintain the best performance capacity. Reports based on prior experiences suggest that the combination of a classical regeneration method (i.e., massage) with exposure to hypoxia may enhance regeneration in soccer. The aim of this study was to evaluate whether this specific combination could affect blood parameters related to muscle damage and physical strain after a soccer game. Approximately 15 hours after two separate championship games, 10 professional male outfield players of the first Austrian division were exposed to normobaric hypoxia (F1O2 13.5% ~ 4000m) or normoxia for 1 hour (30 minutes rest followed by 30 min massage) (cross-over design). Creatine kinase (CK), urea and uric acid (UA) were measured 4 days before the first game, and 15 and 63 hours after the two games. Match play increased CK values independently of the intervention. No effect of the massage in combination with hypoxia was seen. A trend was found between \( \Delta \) UA (UA 48 hours after exposure minus [UA] before exposure) in response to hypoxia and SaO2 measured in hypoxia (\( r=0.612, p=0.06 \)). Results show that massage under hypoxic conditions had no additional positive effect on the measured parameters compared to massage alone. Solely the trend of a relationship for \( \Delta \) UA and SaO2 might indicate that redox alterations are a potential consequence of hypoxic exposure.

KEY WORDS: recovery, high altitude, football
10 players). The study was carried out in conformity with the ethical standards outlined within the 1975 Declaration of Helsinki and was approved by the Review Board of the Department of Sport Science of the University of Innsbruck (Austria). During the study period, players performed two championship games, played one week apart from each other. Mean playing time of the players during the games was 84 ± 10 and 87 ± 8 min (p>0.05). Approximately 15 hours after each game players rested for 1 hour (30 minutes passive exposure followed by 30 minutes of massage) either at a simulated altitude of 4000 m (FiO₂ of 13.5%) or under placebo conditions (approximately 700 m, Innsbruck) in a normobaric hypoxic chamber (Low Oxygen Systems, Germany). After the first game 5 players were exposed to 4000 m and 5 players to 700 m; after the second game the order was reversed (cross-over design). Creatine kinase (CK), a marker of muscle damage (1], urea, a marker of amino acid breakdown [1] and uric acid (UA), a marker of enhanced nucleotide cycle turnover and an indirect marker of oxidative stress [1,2], were measured in capillary blood taken from the fingertip by the Reflotron Sprint (Roche Diagnostics, Austria). Measurements were taken 4 days before the first game (baseline) and approximately 15 hours (i.e. before hypoxic exposure) and 63 hours after the games (i.e. approximately 48 hours after the hypoxic or normoxic exposure). This time schedule was selected because muscle damage and physical strain indices were shown to be elevated up to 72 hours after a soccer game [2]. Oxygen saturation (SaO₂) was measured by finger pulse oximetry (Onyx, Nonin Medical, USA) after 30 minutes of hypoxia. After both games players had their usual post-game diet and performed their usual post-game training programme. After testing for normal distribution (K-S-test) paired Student t tests were used to identify changes over time and differences between interventions (Δ values, calculated as values measured 48 hours after the exposure minus values before the exposure). A Pearson correlation analysis was performed for oxygen saturation values and Δ values. Results are presented as means ± SD. Significance level was set at p≤0.05.

RESULTS

Table 1 shows values for CK, urea and UA in the course of the study. CK values were increased after both games but returned to baseline 63 hours after the games. Urea was increased before the placebo exposure. No statistically significant differences between hypoxic and normoxic conditions were detected, except for SaO₂ values (84 ± 6% vs. 96 ± 2%, p<0.001). A trend was found between Δ UA in response to the hypoxic exposure and SaO₂ after 30 minutes of hypoxia (r=0.612, p=0.06), indicating that lower SaO₂ values were associated with larger decreases in UA.

DISCUSSION

The results indicate no beneficial effects of massage under hypoxic conditions on the measured parameters compared to massage alone. Only a trend of a relationship for Δ UA and SaO₂ may indicate a potential favourable effect of hypoxic exposure on the redox state.

Some critical points have to be outlined. Data show that urea and UA values were within the reference range and were not affected by the match play. Additionally, CK values already returned to baseline within 63 hours after the games (Table 1). These indicate complete recovery, at least for the measured parameters, and contradict Ascenso et al. showing that UA and CK were elevated for 72 hours after a game [2].

The procedures used in the present investigation correspond to the standard practice done by the soccer team (i.e. massage the day after the game). By doing so, the dose of hypoxia (i.e. 1 hour) may have been too low. The question arises whether more and regularly implemented sessions would have had additional effects. Furthermore, only a limited set of parameters was tested. Therefore effects on other parameters (e.g., oxidative stress) cannot be excluded.

TABLE 1. VALUES FOR CREATINE KINASE (CK), UREA AND URIC ACID (UA) IN THE COURSE OF THE STUDY

| Reference range | before exposure | 48 h after exposure | before exposure | 48 h after exposure |
|-----------------|-----------------|---------------------|-----------------|---------------------|
|                 | (FiO₂ 13.5% ~ 4000m) | (FiO₂ 13.5% ~ 4000m) | (normoxia) | (normoxia) |
| CK (U•l⁻¹)      | n=10            | 215.9 ± 94.5*       | 84.7 ± 31.5*   | 210.6 ± 83.4*       | 92.0 ± 47.0*       |
| UREA (mg • dl⁻¹) | n=10            | 44.2 ± 12.8        | 42.6 ± 10.7    | 47.3 ± 5.8          | 41.9 ± 5.5*        |
| UA (mg • dl⁻¹)  | n=10            | 6.0 ± 0.9          | 5.9 ± 1.1      | 5.7 ± 0.8           | 5.6 ± 0.9          |
| ΔCK (U•l⁻¹)     | -131.2 ± 80.0  |                     | -118.6 ± 55.8  |                     |
| ΔUREA (mg • dl⁻¹)| -1.6 ± 6.1    |                     | -5.3 ± 5.5     |                     |
| ΔUA (mg • dl⁻¹) | -0.1 ± 0.6     |                     | -0.1 ± 0.3     |                     |

Note: * significantly different from before, # significantly different from baseline, Δ calculated as values measured 48 hours after exposure minus values before exposure.
CONCLUSIONS

In conclusion, this study demonstrated that the combination of massage and hypoxia does not show an additional benefit with respect to regeneration compared to massage alone.

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