

# Cytokine production by monocytes, neutrophils, and dendritic cells is hampered by long-term intensive training in elite swimmers

José Mário Morgado · Luís Rama · Isabel Silva · Maria de Jesus Inácio · Ana Henriques · Paula Laranjeira · Susana Pedreiro · Fátima Rosado · Francisco Alves · Michael Gleeson · Maria Luísa Pais · Artur Paiva · Ana Maria Teixeira

Received: 19 January 2011 / Accepted: 8 April 2011  
© Springer-Verlag 2011

**Abstract** Elite level athletes seem to be prone to illness especially during heavy training phases. The aim of this study was to investigate the influence of long term intensive training on the functional features of innate immune cells from high competitive level swimmers, particularly the production of inflammatory mediators and the possible relationship with upper respiratory symptoms (URS) occurrence. A group of 18 swimmers and 11 healthy non athletes was studied. Peripheral blood samples were collected from athletes after 36 h of resting recovery from exercise at four times during the training season and at three times from non athletes. Samples were incubated in the presence or absence

of LPS and IFN- $\gamma$  and the frequency of cytokine-producing cells and the amount produced per cell were evaluated by flow cytometry. In addition, plasma cortisol levels were measured and URS recorded through daily logs. The athletes, but not the controls, showed a decrease in the number of monocytes, neutrophils, and dendritic cell (DC) subsets and in the amount of IL-1 $\beta$ , IL-6, IL-12, TNF- $\alpha$ , and MIP-1 $\beta$  produced after stimulation, over the training season. Differences were most noticeable between the first and second blood collections (initial increase in training volume). Athlete's cortisol plasma levels partially correlated with training intensity and could help explain the reduced in vitro cell response to stimulation. Our results support the idea that long-term intensive training may affect the function of innate immune cells, reducing their capacity to respond to acute challenges, possibly contributing to an elevated risk of infection.

---

Communicated by William J. Kraemer.

---

José Mário Morgado and Luís Rama contributed equally to this work.

---

J. M. Morgado · I. Silva · M. de Jesus Inácio · A. Henriques · P. Laranjeira · S. Pedreiro · M. L. Pais · A. Paiva  
Histocompatibility Center, Coimbra, Portugal

L. Rama · F. Rosado · A. M. Teixeira  
Faculty of Sport Sciences and Physical Education,  
Research Center for Sport and Physical Activity,  
University of Coimbra, Coimbra, Portugal

F. Alves  
Faculty of Human Kinetics,  
Technical University of Lisbon, Lisbon, Portugal

M. Gleeson  
School of Sport, Exercise and Health Sciences,  
Loughborough University, Loughborough, UK

A. Paiva (✉)  
Centro de Histocompatibilidade do Centro, Edifício São Jerónimo,  
4º Piso, Praceta Mota Pinto, 3001-301 Coimbra, Portugal  
e-mail: apaiva@histocentro.min-saude.pt

**Keywords** Innate immunity · Dendritic cells · Cytokines · Swimming training

## Introduction

Moderate activity may exert a positive effect on the immune system reducing the incidence of illness (Gleeson 2007; Matthews et al. 2002; Nieman 2003; Nieman et al. 1999). However, excessive amounts of prolonged and high-intensity exercise may lead to the opposite effect (Spence et al. 2007). Upper respiratory tract infection (URTI) is the most common medical condition affecting athletes (Fricker et al. 2005; Gleeson et al. 1999; Nieman 2000; Reeser et al. 2003). The incidence of URTI episodes may be low-to-normal during periods of regular training and high during periods of hard training and competition (Nieman 2000), suggesting a transitory reduced