Standard Melatonin Intake and Circadian Rhythms of Elite Athletes after a Transmeridian Flight

R Manfredini¹, F Manfredini² and F Conconi²

¹First Internal Medicine Section, Department of Clinical and Experimental Medicine, and ²Centre for Biomedical Studies for Sports, University of Ferrara, Italy

Many transmeridian travellers, including top athletes, regularly take melatonin to reduce negative jet lag symptoms. Standard (rather than individually tailored) doses are often used. We examined the effects of a standard dose of melatonin on the body temperature rhythms of 12 elite biathletes (eight men and four women) after an eastward transmeridian flight to an international competition. The different effects on body temperature rhythms in men versus women underscore the need for personalized dosing schedules to avoid potential undesirable consequences.

KEY WORDS: Melatonin; Desynchronization; Jet lag; Circadian rhythm; Chronobiology; Athletic performance

INTRODUCTION

Compared with only a few years ago when worldwide athletics competitions were limited to the Olympic Games, World Championships and a few other top events, today’s competitive athletes may take part in a growing series of sponsored international competitions. As a direct consequence, however, athletes frequently need to travel long distances by air to attend such international competitions, and their periods of travelling may extend over several months. It is known that rapid air travel across several time zones exposes the traveller to a shift in the internal biological clock and to a transient desynchronization of their rhythms, jet lag, which lasts until rhythms adjust to the new environmental conditions.¹ The usual symptoms of jet lag...
include: sleep disorders; difficulties with concentrating; disorientation; depression; irritability; distorted estimation of time, space and distance; lightheadedness; loss of appetite; and gastrointestinal disturbances.\(^2\)

In transmeridian travellers, exogenous melatonin seems to have some beneficial effects on the symptoms of jet lag, although the optimal dose and timing of ingestion have yet to be determined.\(^3\) Many frequent transmeridian travellers, including athletes, take melatonin in an attempt to avoid the symptoms of jet lag.

The aim of this study was to evaluate whether taking standard doses of melatonin is likely to be effective in reaching rhythm resynchronization following transmeridian travel. Body temperature was chosen as an indicator of endogenous biological clock function; it is often used as a marker of circadian rhythms because of its ease of measurement and because it is largely endogenously controlled.\(^4\)

**SUBJECTS AND METHODS**

We studied the effect of a standard melatonin dose on body temperature rhythm in 12 elite athletes of the Italian National Biathlon Team (eight men, mean age 25.9 years; four women, mean age 22.5 years), who agreed to participate and gave their written consent to the study protocol.

The oral body temperatures of biathletes were measured with a digital thermometer eight times daily (at 07.00, 09.00, 12.00, 14.00, 16.00, 18.00, 20.00, 22.00), both during the last full training day before departure (A) and after an 8-h eastward transmeridian flight to Japan (across eight time zones) for an international competition (B – C). The flight schedule was: departure from Milan, Italy at 14.05 local time, arrival in Tokyo, Japan at 08.50 local time; the scheduled duration of air travel was 11.45 h.

On arrival, the athletes started an oral regime of melatonin once daily, at 22.00 local time. The dosage was 5 mg for men (0.070 ± 0.008 mg/kg) and 3 mg (0.056 ± 0.003 mg/kg) for women.

Body temperature was measured on the first (B) and last (sixth, C) full day in Japan, both of which were free of competitions. Athletes were asked to fill in a daily questionnaire reporting subjective impressions of quality of sleep (scored from 1 = poor to 5 = excellent) and the presence or absence of undesired effects.

Chronobiological analysis to determine circadian rhythms was done by single cosinor and partial Fourier series, using the Chronolab software on an Apple Macintosh computer.\(^5\) The program calculates the mean of the best fit sine function (Midline Estimating Statistic of Rhythm or MESOR, the rhythm-adjusted mean over the time-period analysed), the amplitude (half the distance between the absolute maximum and minimum of the sine function), and the acrophase of each single harmonic (time of peak of sine function).\(^6\)

**RESULTS**

The main results are summarized in Table 1. The men who had a delayed body temperature acrophase in Italy (peak time A: 22.14 local time) did not show a significant change after the flight (peak time B: 22.41 local time), and melatonin apparently advanced the time of the peak body temperature to the afternoon (peak time C: 17.22 local time). On the other hand, women, who had their peak in the afternoon in Italy (peak time A: 13.39 local time), showed an 8-h shift of body temperature after the flight (peak time B: 21.29 local time), and melatonin had no resynchronizing effect (peak time C: 21.37 local time).
No significant variations were present for MESOR and amplitude.

No undesired side-effects or sleep disturbances were reported, whereas the self-evaluated quality of sleep ranked from normal to excellent.

**DISCUSSION**

The main finding of this study is that a standardized melatonin administration had different effects on the computed body temperature rhythms of athletes. The extreme paucity of studies in the literature probably derives from the difficulty in obtaining data from elite athletes engaged in their usual activity, and their willingness to comply or to participate as ‘controls’, and the difficulties of devising chronobiological protocols with a reasonably limited number of daily measurements. It is known that body temperature, in humans, shows a well defined circadian pattern characterized by an afternoon peak. In the male athletes studied, who had their own delayed body temperature acrophase, melatonin apparently induced an advance-phase effect towards the physiological afternoon peak. The female athletes did not show such a delayed effect, and the melatonin dosage used apparently was not effective in resynchronizing the 8-h shift following the transcontinental flight.

Although considerations such as environmental influences, temperature, meteorological conditions and scheduled time of events make generalization difficult, most components of sports performance exhibit a circadian rhythm with a peak in the late afternoon/early evening, rendering athletic performance most efficient at this time of...
day. Taking circadian rhythms into consideration can be beneficial in tasks involving endurance, mental function, physical strength and others. Selecting the best circadian time can result in as much as a 10% increase in athletic performance. A 10% decrease in peak performance is roughly equivalent to the change in performance after less than 3 h of sleep, after drinking the Italian legal limit of alcohol (80 mg/dl), or after taking barbiturates.

Jet lag may cause a shift in the optimal circadian peak window for performance, although the question of the relationship between athletic performance and rapid transmeridian air travel is controversial and still debated. Some previous studies have concluded that athletic performance is impaired by transmeridian air travel but a recent review by Youngstedt and O’Connor concluded that the scientific evidence supporting such an assumption is neither consistent nor compelling, and further rigorous research is needed. Anecdotal reports, however, indicate that many elite athletes and other transmeridian travellers usually consume melatonin preparations. In consideration of this, a recent position statement for members of the British Olympic Association suggested caution in the use of melatonin because of potential debilitating effects in athletes.

The present results show that the generic intake of melatonin at standardized times and dosages, although in the presence of a good sleep and in the absence of undesired side-effects, may have widely differing effects on biological rhythms, and the resynchronizing effect is not always fully obtained. It should be considered, however, that inter-individual and intra-group variations may also result from the use of different drug dosages in relation to body weight, and possibly different endocrinological patterns, and these factors deserve further research. At this time we can only recommend a degree of caution in selecting melatonin doses for self administration. The determination of individual circadian rhythms and correspondingly tailored melatonin administration, scheduled by specialists, could avoid potential disappointing consequences and have beneficial effects for competing athletes and other international travellers.

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References


Address for correspondence

Dr R MANFREDINI

First Internal Medicine Section, Department of Clinical and Experimental Medicine, University of Ferrara, via Savonarola 9, I-44100 Italy.

E-mail: r.manfredini@unife.it