Effect of a Habitual Late-Evening Physical Task on Sleep Quality in Neither-Type Soccer Players

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Purpose: The aim of this study was to investigate objective and subjective sleep quality, daytime tiredness and sleepiness in response to a late-evening high intensity interval training (HIIT) session in neither-type soccer players that habitually trained late in the day. This is the first study that considered both athletes’ chronotype and habitual training time as crucial factors when assessing sleep quality in relation to an evening physical task.

Methods: In this longitudinal, prospective, observational study, 14 Italian soccer players were recruited (mean age: 26.1 ± 4.5 years; height: 1.81 ± 0.06 m; weight: 78.9 ± 6.1 kg) and performed an extra-routine 4 × 4-min HIIT session at 09:00 p.m. Players used to train always between 09:00 and 11:00 p.m during the competitive season. All subjects wore an actigraph to evaluate their objective sleep parameters and a sleep diary was used to record subjective values of sleep quality, daytime tiredness, and daytime sleepiness. All data were analyzed as: the mean of the two nights before (PRE), the night after (POST 1), and the mean of the two nights after (POST 2) the extra-routine HIIT session. The subjects’ chronotype was assessed by the morningness-eveningness questionnaire (MEQ).

Results: All players were classified as N-types (mean MEQ score: 49.4 ± 3.7). None of the actigraph parameters nor the subjective values of sleep quality, tiredness, and sleepiness showed significant changes in PRE, POST 1, and POST 2.

Conclusion: The results of our study added more information regarding sleep quality outcomes in response to a late-evening HIIT session. Athletic trainers and medical staff should always control for chronotype and habitual training time when assessing variations to sleep quality in athletes.

Keywords: sleep, soccer, chronotype, habitual training time, actigraphy, orthopedics
METHODS

Study Design and Subjects
This was a longitudinal, prospective, observational study. Soccer players were recruited from a non-professional Italian male team of the seventh league of Federazione Italiana Giuoco Calcio. Players’ chronotype was assessed by the morningness-eveningness questionnaire (MEQ; Horne and Ostberg, 1976). According to the MEQ-score, participants were categorized as M-types (scoring ≥ 59), E-types (scoring ≤ 41), or neither-type (N-types, scoring 42–58). Inclusion criteria were age ≥ 18 years, and soccer practice of three times a week for ≥ 2 h in the evening. Exclusion criteria were being a goalkeeper, being a morning- or evening-type, tobacco use, and medical conditions contraindicating physical exercise. Before entering the study, all participants provided written informed consent to the experimental procedure, which was previously approved by the Ethical Committee of Università degli Studi di Milano in compliance with current laws and regulations governing the use of human subjects (Declaration of Helsinki II).

Late-Evening High Intensity Interval Training Protocol
Soccer players, during the competitive season, used to train at the same time of the day, between 09:00 and 11:00 p.m., three times per week, on Tuesday, Wednesday, and Friday. All players, in April 2018, performed an extra-routine HIIT session at 09:00 p.m., on Thursday. During the test, heart rate was recorded using a heart rate monitor (Polar RS800, Polar, Kempele, Finland). The HIIT protocol was the 4 × 4-min interval training (Helgerud et al., 2001) and it consisted of running 4 times at 90–95% of HRmax with 3 min of active recovery at 70% of HRmax between each interval.

Actigraphy and Subjective Evaluations
All players wore an actigraph (Actiwatch 2, Philips Respironics, OR, United States) to record their sleep parameters. The

| Objective and subjective sleep parameters | Parameters description |
|------------------------------------------|------------------------|
| Time in Bed (TB, minutes)                | The amount of time spent in bed attempting to sleep between bedtime and get up time. |
| Sleep Latency (SL, minutes)              | The period of time between bedtime and sleep onset time. |
| Sleep Efficiency (SE, %)                 | The percentage of time in bed that was spent asleep. |
| Wake After Sleep Onset (WASO, min)      | The amount of time spent awake after sleep has been initiated. |
| Immobility Time (IT, %)                  | The total time, expressed in percentage, spent without recording any movement during time in bed. |

| Fragmentation Index (FI, %)              | Sum of mobility and immobility accesses in 1 min, divided by the number of immobility accesses. |
| Subjective Sleep Quality (1-to-10 point scale) | Subjective value of sleep quality in a scale from 0 = very poor sleep quality, to 10 = optimal sleep quality. |
| Subjective Daytime Tiredness (1-to-10 point scale) | Subjective value of daytime tiredness in a scale from 0 = not at all tired, to 10 = extremely tired. |
| Subjective Daytime Sleepiness (1-to-10 point scale) | Subjective value of daytime sleepiness in a scale from 0 = not at all sleepy, to 10 = extremely sleepy. |
actigraph monitoring lasted from Monday to Friday. A high actigraphic sensitivity threshold was used (80 counts) since it provides the best combination of sensitivity and specificity when studying sleep in athletes (Sargent et al., 2016). A sleep diary was used to record bed time, wake up time, hours napping, and subjective values of sleep quality, daytime tiredness, and daytime sleepiness. Data derived from actigraphs and sleep diaries were used to determine the amount and quality of sleep participants obtained. The description of both actigraphy-based and subjective parameters is reported in Table 1.

Objective and subjective sleep quality data and subjective parameters of tiredness and sleepiness were analyzed as: the mean of the two nights before (PRE), the night after (POST 1), and the mean of the two nights after (POST 2) the extra-routine HIIT session.

### Statistical Analysis

Data are presented as mean ± standard deviation (SD). Each objective and subjective sleep parameter were checked with the Shapiro–Wilk test at PRE, POST 1, and POST 2. Repeated-measures analysis of variance (RM-ANOVA) followed...
by the Bonferroni post-hoc test, or Friedman test with Dunn’s comparison for non-normal distributed variables, was performed to test the differences in sleep among PRE, POST 1, and POST 2. A $p$-value $\leq 0.05$ was considered statistically significant.

**RESULTS**

Twenty-one soccer players were screened and seven were excluded because E-types ($N = 2$), injured ($N = 3$), or goalkeepers ($N = 2$). Therefore, 14 soccer players were finally recruited (age: 26.1 $\pm$ 4.5 years; height: 1.81 $\pm$ 0.06 m; body mass: 78.9 $\pm$ 6.1 kg, MEQ score: 49.4 $\pm$ 3.7). The intensity of HIIT session was 175 $\pm$ 5 bpm, corresponding to 92 $\pm$ 3% of HR$_{max}$. All soccer players were classified as N-types. None of the actigraph parameters nor the subjective values of sleep quality, tiredness, and sleepiness showed significant changes in PRE, POST 1, and POST 2. Figure 1 shows the Whiskers plot of the six actigraphy-based parameters while Figure 2 reports the raw data, with connecting lines, of subjective values of sleep quality, tiredness, and sleepiness.

**DISCUSSION**

The study highlighted no differences in objective and subjective sleep quality in response to an extra-routine late-evening HIIT session in N-type soccer players accustomed to train late in the day. In addition, neither subjective values of daytime tiredness nor subjective daytime sleepiness showed significant variations. Our initial hypothesis was confirmed.

The strength of this study is that we controlled for two important confounding factors, both able to influence athlete's sleep in response to a physical task: the chronotype and the habitual training time. The athletes' chronotype was determined by the MEQ and all included players were N-types; M- and E-types were excluded from this trial since these two chronotype categories showed large differences in their sleep behavior: M-types usually registered higher sleep quality and quantity in normal conditions but they suffered more the influence of an evening training session while, conversely, E-types can more easily adapt to delayed training times without showing worsening of their sleep quality (Vitale and Weydahl, 2017; Vitale et al., 2017). Having a homogenous study sample, with subjects belonging to the same intermediate category of chronotype, have favored a clearer interpretation of sleep data. In addition, the “habitual training time” variable was controlled too since all soccer players were accustomed to train late in the evening (09:00–11:00 p.m.). It has been recently showed that diurnal variations in the psychophysiological responses to a performance are also related to the players' habitual training time: athletes who habitually trained in the evening had lower ratings of perceived exertion and better performances in the evening compared to a morning session and, similarly, athletes who habitually trained in the morning had lower fatigue and higher vigor scores prior to a morning physical performance (Rae et al., 2015). It is therefore possible that, in the present study, the habitual (evening) training time was able to mitigate the potential negative effects on sleep dictated by a high-intensity evening physical task. However, further studies to be conducted with a cross-over design, including both M-, N-, and E-type athletes, are needed to confirm these preliminary data.

The present findings could help coaches to better interpret the discrepancies that have been previously observed in sleep behavior with reference to evening physical tasks; the chronotype and the habitual training time should be always considered by athletic trainers and medical staff when assessing variations to sleep quality in athletes. Avoiding sleep problems represents a key strategy of primary prevention for muscle and bone injuries.

**AUTHOR CONTRIBUTIONS**

JV and MB participated in the data collection and analysis. JV conducted the manuscript writing process. All authors were involved during study set-up and done final revision.

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**Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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