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Actigraphy-Based Sleep Parameters in Wheelchair Basketball Athletes: Influence of Training and Competition Load

Marcos López-Flores[1] David Suárez-Iglesias[2] José Antonio Rodríguez-Marroyo[2]

[1] European Network for Innovation and Knowledge, Health & Dual Careers, Amersfoort, Utrecht, Netherlands
[2] University of León, VALFIS Research Group, Institute of Biomedicine (IBIOMED), León, Spain

Address for correspondence David Suárez-Iglesias (e-mail: dsuai@unileon.es; devots88@hotmail.com).

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Abstract

Objective This study aimed to analyze the actigraphy-based sleep parameters in wheelchair basketball (WB) athletes during the 3 weeks leading up to the playoffs, the week of playoffs, and the week after playoffs. Secondarily, the relationship between training load, sleep, and recovery was evaluated.
Methods During 5 consecutive weeks, 10 male elite WB athletes wore a triaxial accelerometer. The session rating of perceived exertion (sRPE) and athletes' quality of recovery were also measured.
Results There were no significant differences ($p > 0.05$) in any of the studied parameters between the 3 weeks leading up to the playoffs, the week of playoffs, and the week after playoffs. No significant relationship between training load, sleep parameters, and recovery values was detected.
Discussion The WB competition does not affect sleep quantity and quality.

Keywords
- Exercise actigraphy
- Spinal cord injuries
- Para-athletes
- Sports for persons with disabilities

Introduction

Sleep is of particular concern for wheelchair basketball athletes (WB). During high-risk periods for sleep disruption, such as a major competition, WB athletes may face a lack of sleep.[1] Indeed, Paralympic athletes often experience sleep disruptions associated with their condition, which compromises their sleep more than those without impairments.[2] This way, impairment-specific reasons (i.e. muscle spasms, phantom pain, and neuropathic pain) have been identified in wheelchair court athletes (basketball/rugby/tennis) reporting difficulty sleeping.[3]

Under these circumstances, the prevalence of subjective poor sleep quality is apparent among WB athletes. In the Japanese national team, athletes of both genders had poorer sleep quality than their peers without disabilities in Japan's population.[4,5] Similarly, 8 out of 11 Brazilian WB athletes with spinal cord injuries showed poor sleep quality.[6] However, the use of objective measurements (i.e., actigraphy) have shown suboptimal sleep in wheelchair rugby athletes.[7,8] To the best of our knowledge, only Thornton et al.[9] have analyzed the effect of competition on WB athletes' sleep quality, documenting the negative impact of international air travel duration on WB athletes' sleep prior to and during competition through actigraphy.

On top of that, despite the broad interest in understanding the relationship of sleep to training and recovery, inconsistent, unreliable, and invalid research methods have produced poor evidence.[10] In this context, it has been concluded that

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high training loads represent a primary risk factor for chronic sleep disturbance.[10] Concurrently, the impact of training volume on sleep quality is poorly characterized in the Parasport community. For instance, a higher training volume may lead to better sleep quality in blind soccer players.[11] However, the cross-sectional nature of this study prevents the assumption of causal relationships between training volume and sleep quality; thus, a longitudinal design is warranted to explore this complex relationship.[11]

Surprisingly, to our knowledge, no study has examined the relationship between training load, sleep quality, and recovery in WB. Given that sleep plays an important role in the quality of training and its implications for peak performance during competition,[2] a longitudinal assessment using actigraphy and other validated tools would allow for a greater understanding of the factors associated with training and competition, which could affect sleep quality in WB athletes. The latter should aid practitioners when planning training regimens and the associated recovery practices for this population.[3,10]

Therefore, this study aimed to analyze the actigraphy-based sleep parameters in WB athletes during the three weeks leading up to the playoffs, the week of playoffs, and the week after playoffs. Secondarily, the relationship between training load, sleep quality, and recovery was evaluated.

Material and Methods

Participants

A total of 10 male Spanish elite WB athletes (mean ± SD; height 177.4 ± 10.3 cm, BMIbody mass 76.5 ± 17.5 kg) belonging to the same team participated in this study (►**Table 1**). The eligibility criteria were: a) not using sleep medication during the data collection period; b) not showing sleep disorders based on the Pittsburgh Sleep Quality Index (PSQI) questionnaire.[12] They were asked to maintain the same hydration, sleep, and physical activity habits during the study. Athletes who completed at least 80% of the scheduled training sessions were selected for further analysis. Written informed consent was obtained from all participants. The local Ethics Committee approved the protocol according to the Declaration of Helsinki.

Procedures

The study extended over 5 consecutive weeks: regular training sessions and games for 3 weeks, training sessions and two playoff games in the fourth week, and training sessions but no games in the fifth week (►**Figure 1**). Every week, the athletes performed three training sessions (6:30 to 8:30 pm) with a mean duration of 120 minutes.

In order to quantify the training load and competition load, the session rating of perceived exertion (sRPE) was obtained approximately 30 minutes after each training session/game.[13] Athletes had to respond to how hard the training session/game was by providing a rating of perceived exertion (RPE 10-point scale) score. They were allowed to mark a plus sign (interpreted as 0.5 points) alongside the integer value. Subsequently, to calculate the sRPE, each score was multiplied by the training/game duration (minutes). In addition, the athletes' quality of recovery was measured daily, every morning, 1 hour after getting up, using the Total Quality Recovery (TQR) scale.[14] All participants were familiar with these procedures before the start of the study.

Athletes wore a ActiGraph wGT3X-BT triaxial accelerometer (ActiGraph LLC., Pensacola, USA) on the non-dominant wrist to evaluate their sleep. The sampling frequency was 30 Hz, and the epoch activity counts were 60 seconds. Moreover, athletes completed a sleep diary when going to sleep and when getting up, noting the bed and wake time.

Table 1 Characteristics of the sample of wheelchair basketball players.

Player	Physical disability	IWBF Class*	Age (years)	Injury Time (years)	Training experience (years)	Competition experience (years)	Weekly physical activity (hours)
1	Cerebral palsy	1	29	28	15	7	5
2	SCI (T4)	1	36	14	12	12	8
3	Spina bifida (T12)	1.5	28	29	19	19	0
4	SCI (T12)	2	50	21	19	19	2
5	SCI (T10)	3	42	32	32	18	3
6	Hip and knee injury	3.5	28	10	2	0	5
7	Unilateral LLA	3.5	38	12	10	10	8
8	Hip injury	4	25	17	2	0	5
9	OA congenital	4	30	18	3	1	1
10	Knee injury	4.5	29	7	6	6	2
Total sample ($n = 10$)		–	35 ± 8	19 ± 9	12 ± 10	9 ± 8	5 ± 4

Abbreviations: IWBF, international wheelchair basketball federation; SCI, spinal cord injury; LLA, lower limb amputation; OA, osteoarthritis. **Notes:** *Players were classified according to the norms of the Classification Committee of the IWBF.

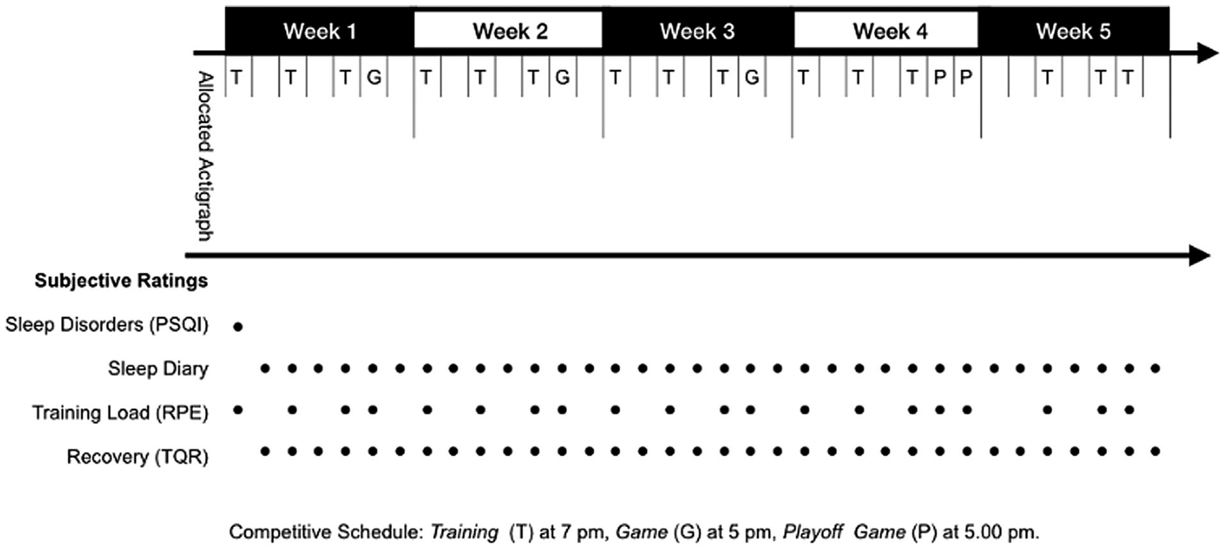

Fig. 1 . Schematic outline of the study design including collection of objective sleep data (wristwatch actigraphy) and subjective ratings.

Actigraphy Data Analysis

Each day of actigraphy data was scored individually by a trained researcher using the ActiLife software (ActiLife LLC., Pensacola, USA) version 6.13.3. The low-frequency filter and the Cole-Kripke algorithm were used to process the raw data. Prior to deriving the various sleep parameters, the sleep diary times were manually scored into the software package. Subsequently, four sleep parameters were directly extracted from the output of the software package and were examined in this study: total sleep time (TST, the number of 60 s epochs in a sleep episode scored as "sleep", excluding any time scored as "wake"), sleep latency (SL, the time between bedtime and sleep onset time), wake after sleep onset (WASO, the periods of wakefulness occurring after sleep onset), and sleep efficiency (SE, the amount of time the participants were asleep over the amount of time they were in bed). The mean TST, SL, and WASO were calculated in minutes, and the mean SE was expressed as a percentage.

Statistical Analysis

The assumption of normality was verified using the Kolmogorov-Smirnov test. A repeated-measures analysis of variance (ANOVA) was used to establish differences between the 3 weeks leading up to the playoffs, the week of playoffs, and the week after playoffs. The Bonferroni post hoc comparison was used to establish significant differences between means. The magnitude of the effect was assessed by calculating the Cohen *d* (ES),[15] and rated as trivial ($<$0.2), small (0.2–0.49), moderate (0.5–0.8), or large ($>$0.8). The Pearson product-moment correlation coefficient (r) was calculated to evaluate the relationship between variables. Statistical significance was set at $p < 0.05$ and the statistical treatment was conducted using Statistical Package Social Sciences (SPSS, IBM Corp. Armonk, NY, USA) version 22.0.

Results

There were no significant differences ($p > 0.05$) in any of the studied parameters between the 3 weeks leading up to the playoffs, the week of playoffs, and the week after playoffs. ►**Table 2** displays the data from the 4 competitive weeks versus the week after playoffs. For all assessed variables moderate effect sizes were identified, except for the WASO, sRPE, and TQR scores. No significant relationship between training load, sleep parameters, and recovery values was detected (►**Table 3**).

Discussion

This study found no difference in sleep parameters, training load, and perceived recovery values between the 3 weeks leading up to the playoffs, the week of playoffs, and the week after playoffs in WB athletes. These findings are in accordance with most studies in elite non-disabled athletes, which do not report significant changes in SE and SL between regular training pre-competition nights and the night following a late-night competition.[16,17] Besides, the current results do not support the evidence of degraded sleep quality among Chilean Paralympic athletes based on subjective measurements (PSQI questionnaire) before a crucial competition.[18] In this regard, a modest correlation between subjective and objective measures of sleep quality was found.[19] Furthermore, the PSQI questionnaire has not been validated for assessing sleep problems in athletes.[19] These circumstances highlight the recommendation of measuring SE in team sport athletes by actigraphy due to its high validity and reliability.[19]

Interestingly, the levels of SE observed in this investigation did not differ when comparing the three weeks leading up to the playoffs and the week of playoffs versus the week after playoffs. It is possible that most participants, who had previous experience competing in playoff games, were able to deal with the stress related to competition,[1] so their SE was not critically affected during the whole study period. On the other hand, it should be noted that all games were played at home, which meant that the players avoided concerns about the negative aspects of travel.[1,9] Overall, the SE obtained in this study can be considered as normal

Table 2 Actigraphy-based sleep parameters and TQR values before (pre) and after (post) the playoff games.

		Mean ± SD	Difference in means ± 90% CI	Cohen *d*
Sleep actigraphy data				
Total sleep time (*min*)	Pre	378.2 ± 69.9	17.00 ± 19.00	0.70 moderate
	Post	361.1 ± 57.8		
Sleep latency (*min*)	Pre	0.7 ± 0.7	−0.30 ± 0.82	0.57 moderate
	Post	1.0 ± 1.3		
Wake after sleep onset (*min*)	Pre	45.8 ± 39.6	−10.00 ± 15.00	0.35 small
	Post	55.8 ± 42.6		
Sleep efficiency (%)	Pre	89.4 ± 7.7	2.20 ± 3.40	0.65 moderate
	Post	87.1 ± 8.6		
Subjective ratings				
sRPE	Pre	4.6 ± 2.2	−0.14 ± 1.30	0.48 small
	Post	4.7 ± 1.1		
TQR	Pre	13.5 ± 1.3	−0.22 ± 0.83	0.44 small
	Post	13.7 ± 1.8		

Abbreviations: CI, confidence interval; SD, standard deviation; sRPE, session rating of perceived exertion; TQR, total quality recovery. **Notes:** Values expressed as mean ± SD.

Table 3 Relationship between training load and actigraphy-based sleep parameters and recovery measures.

Variable		TST	SL	WASO	SE	TQR
Training Load	*r*	−0.276	−0.249	−0.240	0.416	0.074
	p	0.239	0.290	0.209	0.193	0.756

Abbreviations: TST, total sleep time; SL, sleep latency; WASO, wake after sleep onset; SE, sleep efficiency; TQR, total quality recovery; *r*, the Pearson product-moment correlation coefficient. The *p*-values < 0.05 were considered statistically significant.

(≥85%),[12] and was better than that recently reported in wheelchair rugby athletes (≤80%).[8] This discrepancy might be due to these latter athletes' greater impairment compared to their WB counterparts, as those with cervical spinal cord injuries report poorer night's sleep.[8] In addition, the training frequency of the athletes of this study (2–3 recovery days) might condition the SE analyzed. The detrimental effect of increasing weekly training load or training frequency on SE has been reported.[20] Our results coincide with those previously obtained in WB athletes using actigraphy,[8] with SE values ranging from 86 to 88% prior to a major competition.[9] Sleep efficiency of the present work was similar to that found in actigraphy studies performed in nondisabled competitors (<90%).[16]

It must be noted that, when accounting for all nights slept throughout the entire research period, our athletes did not achieve the minimum recommended sleep duration of at least 7 hours.[9] This is in line with other investigations involving wheelchair athletes, in which TST was in the range of 5 to 7 hours.[4,7–9,18] Hence, distinct strategies and appropriate planning should be considered to achieve sufficient restorative sleep during crucial phases of the season.

Finally, no associations between the training load and sleep parameters were observed in this study. The training frequency and the design of the training sessions remained constant throughout the 5 weeks analyzed, which might explain the results obtained.[10] In addition, taking into account the competitive schedules, the athletes of this study always trained at the same time (7:00 pm), which might have contributed to not affecting the sleep duration or fatigue levels.[16]

Some limitations of the current investigation need to be addressed, such as the small size and heterogeneity of the sample, with a wide range of physical disabilities and different years of competition experience. Although common in actigraphy studies in wheelchair athletes,[7–9] this reduced sample could be related to *p*-values not reaching statistical significance. Effect sizes were reported to overcome this issue, with results suggesting that competition had small to moderate effects in the analyzed metrics.

Conclusions

The results suggest that competition does not affect sleep quantity and quality of WB athletes when comparing the three weeks prior to playoffs and playoff week to the week after playoffs. Although sleep efficiency is normal during the 5 weeks analyzed, more hours of sleep should be achieved to comply with international recommendations. Thus, practitioners are advised to track their athletes' sleep since short durations are apparent from the present work, and sufficient sleep could help avoid undesired fatigue and injuries in the long term. Finally, the training load was not related to sleep and recovery in the present sample. These findings should be further confirmed in larger studies, which could present long-term measurements (a whole season) to better understand the relationships between the training load and the sleep quality when comparing training/competition days with rest days.

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Conflict of Interests
The authors have no conflict of interests to declare.

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