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Comparing Performance During Morning vs. Afternoon Training Sessions in Intercollegiate Basketball Players

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Abstract

Heishman, AD, Curtis, MA, Saliba, EN, Hornett, RJ, Malin, SK, and Weltman, AL. Comparing performance during morning vs. afternoon training sessions in intercollegiate basketball players. *J Strength Cond Res* 31(6): 1557–1562, 2017—Time of day is a key factor that influences the optimization of athletic performance. Intercollegiate coaches oftentimes hold early morning strength training sessions for a variety of factors including convenience. However, few studies have specifically investigated the effect of early morning vs. late afternoon strength training on performance indices of fatigue. This is athletically important because circadian and/or ultradian rhythms and alterations in sleep patterns can affect training ability. Therefore, the purpose of the present study was to examine the effects of morning vs. afternoon strength training on an acute performance index of fatigue (countermovement jump height, CMJ), player readiness (Omegawave), and self-reported sleep quantity. We hypothesized that afternoon training sessions would be associated with increased levels of performance, readiness, and self-reported sleep. A retrospective analysis was performed on data collected over the course of the preseason on 10 elite National Collegiate Athletic Association Division 1 male basketball players. All basketball-related activities were performed in the afternoon with strength and conditioning activities performed either in the morning or in the afternoon. The average values for CMJ, power output (Power), self-reported sleep quantity (sleep), and player readiness were examined. When player load and duration were matched, CMJ (58.8 ± 1.3 vs. 61.9 ± 1.6 cm, $p = 0.009$), Power (6,378.0 ± 131.2 vs. 6,622.1 ± 172.0 W, $p = 0.009$), and self-reported sleep duration (6.6 ± 0.4 vs. 7.4 ± 0.25 $p = 0.016$) were significantly higher with afternoon strength and conditioning training, with no differences observed in player readiness values. We conclude that performance is suppressed with morning training and is associated with a decrease in self-reported quantity of sleep.

Key Words athlete monitoring, morning training, circadian rhythm, sleep

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Introduction

Time of day is a key factor that influences the optimization of athletic performance. Intercollegiate coaches oftentimes hold early morning strength and conditioning training sessions for a variety of factors including convenience. However, few studies have specifically investigated the effect of early morning vs. late afternoon training on performance indices of fatigue. This is athletically important because circadian/ultradian rhythms, player readiness, and alterations in sleep patterns can affect training ability and may be affected by time of day.

For example, technical skills are enhanced during the afternoon, such as improved juggling, chipping accuracy, and dribbling speed in soccer (18,19). In addition, it has been reported that increasing sleep duration is associated with improvement in technical skills and performance in basketball players (14). In addition, decrements in sport performance in swimmers have been observed with slower swimming speeds in the morning compared with the afternoon (4,12,15).

Although time of day is often taken into consideration when sport-specific training is performed, strength and conditioning sessions are oftentimes conducted throughout the day. Muscular strength and outcome variables associated with strength may also be affected by time of day as isolated knee torque exercises (8,24,29) and dynamic sport performance tests (5,20,27,28) have also been reported to be greater in the afternoon compared with the morning.

The purpose of the present study was to examine the effects of morning vs. afternoon strength and conditioning training on an acute performance index of fatigue, player readiness, and self-reported sleep quantity in a group of highly competitive intercollegiate basketball players. In addition, we matched training sessions for player load (PL) and duration to isolate the effect of time of day on player readiness and performance outcomes. We hypothesized that afternoon training sessions would be associated with increased levels of performance, player readiness, and increased quantity of self-reported sleep.

Methods

Experimental Approach to the Problem

As sports science data are routinely collected by the sports performance coaches at the University of Virginia, a retrospective analysis design was used to examine the effects of morning vs. afternoon strength and conditioning sessions on performance. Data were collected over the 5-week preseason training period just before the beginning of competitive season practice. During this time frame, the National Collegiate Athletic Association (NCAA) allows for 8 $h \cdot wk^{-1}$ of strength and conditioning activities (16 sessions total) and 2 $h \cdot wk^{-1}$ of basketball-related activities. All basketball-related activities (e.g., skill development, practice etc.) were performed in the afternoon, whereas strength and conditioning sessions were performed either in the morning or in the afternoon based on facility availability and class schedules of the student athletes. For the men's basketball team, the first 8 strength and conditioning sessions were performed in the afternoon and the last 8 strength and conditioning sessions were performed in the morning. This was related to the fact that one facility accommodated both the men's and women's basketball programs (the women's team had the opposite schedule). The University of Virginia Institutional Review Board approved this retrospective study.

Subjects

Ten elite male NCAA Division 1 basketball players (age 20.9 $\pm$ 1.2 years, height 188.0 $\pm$ 7.9 cm, mass 100.8 $\pm$ 9.2 kg, body mass index 25.2 $\pm$ 0.6 $kg \cdot m^{-2}$, and body fat 10.3 $\pm$ 2.2% [BodPod, Life Measurement Instruments, Concord, CA, USA]) were included in this study. Each athlete met individually with the Athletic Department Sport Nutritionist and was provided with nutrition guidelines designed to enhance performance. In addition, before each strength and conditioning session, each athlete was provided a drink that contained a combination of Gatorade, maltodextrin, and amino acids (amino acids included per athlete's ability to purchase independently). Each drink varied between athletes based on the nutritional needs of the individual (determined by the Sport Nutritionist) but did not vary within an individual athlete.

Procedures

Internal Load Monitoring. Omegawave technology was used to evaluate each athlete's current functional state of readiness before training. Each subject was provided a personal mobile unit for testing. Athletes performed the Omegawave measurements upon arrival to the strength and conditioning facility just before the strength training session (e.g., morning strength training sessions had measurements upon arriving at the facility in the morning, whereas afternoon training sessions had measurements upon arriving at the facility before their afternoon strength training session).

The performance coaching staff provided instruction and a demonstration of the procedure for the Omegawave assessment, in accordance to the manufacturer's guidelines. Athletes were instructed to soak the Omegawave electrocardiogram (ECG) chest strap electrode pads in water and place the strap around their torso at the bottom of the sternum, aligning the electrode pads on the strap with the midaxillary line of the body, ensuring the strap was taut to create good contact with the skin surface and hold it in place during the measurement. Next, the Omegawave sensor was attached onto the strap with the micro-USB port facing down. A single-use electrode was placed on the middle of the athlete's forehead, and another single-use electrode was placed on the base of the thumb of the dominant hand. The DC potential cable labeled with a head symbol was connected to the forehead electrode, whereas the DC potential cable labeled with the hand symbol was connected to the electrode positioned at the base of the thumb. These adjoined cables were then connected to the Omegawave sensor on the ECG strap via the micro-USB port. Athletes then paired the Omegawave sensors with their smart phone device via Bluetooth through the Omegawave mobile application. Once connected, the athlete laid in a quiet dark room in the supine position, with hands by their side and started the measurement. Athletes remained in that position until the measurement was complete, indicated by a beep from their smart phone device. The athlete then selected "Save & Analyze" on their device. After the measurement was complete, athletes were instructed to place the Omegawave sensor back on the charger in preparation for the following day's measurement.

Athletes were instructed to choose a dark, calm, and quiet environment to perform the measurement while avoiding caffeine, stimulants, and stress before their measurement.

All athlete measurements were sent to the Omegawave Coach's Cloud and later exported for analysis. Athletes performed the Omegawave assessments independently after the initial education of the procedures, but all assessments were required to be completed before the start of the strength training session. A coach was present and available at the facility as athletes arrived for assessment.

Omegawave technology evaluates the athlete's readiness through DC potential and heart rate variability assessment. A proprietary algorithm then generates readiness outputs, scored 1–7 arbitrary units (AU), for central nervous system readiness (CNS) and overall readiness (Overall). In addition, values for DC potential (Omega) were recorded to characterize CNS stress and fatigue.

External Load Monitoring. Subjects wore the Catapult Optieye S5 (Catapult Innovations, Melbourne, VIC, Australia) unit in a supportive harness positioned between the scapulae. Athlete monitoring and load accumulation were collected during all basketball-related training sessions and began when athletes took the floor for pre-practice warm-ups and ended when they left the floor at the conclusion of practice. The triaxial accelerometer samples at a frequency of 100 Hz. The Player Load metric was used to objectively measure the cumulative work load associated with sport practices. The Player Load metric is yielded from the triaxial accelerometer within the Catapult Optieye S5, expressed as the square root of the sum of the squared instantaneous rate of change in acceleration in each of the 3 orthogonal planes and divided by 100 (7). Only accelerometer data are collected during indoor sports; therefore, Player Load was the key metric. This technology has been shown to be reliable and valid when used to measure acceleration and PL (2,3,7) The Catapult data were downloaded and analyzed using the Catapult software (Openfield, Catapult Innovations) before being exported to a Microsoft Excel spreadsheet for further analysis.

Performance Assessment. Power output was determined by the maximal countermovement vertical jump (CMJ), as it is known to identify neuromuscular fatigue (1,6,16,17,31,32). Subjects performed testing immediately after the Omegawave assessment before their weight-training sessions 3 times per week. A standard warm-up was performed before each testing session. Subjects started tall with hands akimbo and performed a CMJ to their maximal ability. Two measurements for vertical jump were taken via The Just Jump System (Probiotics, Huntsville, AL, USA), and the highest height achieved for the day was defined as maximal vertical jump. The Just Jump System was deemed a reliable and valid tool for quantifying vertical displacement (10,13). If at any point during the jump a subject removed their hands from their hips or exhibited excessive knee flexion once airborne, the jump was declared invalid and repeated. A rest period of approximately 30 seconds was allocated between each jump trial. Verbal encouragement by teammates and coaches was propagated to ensure maximal effort. Vertical jump values were converted to peak power output via the Johnson and Bahamonde equation (11):

$$\text{Power}_{\text{Peak}}(\text{W}) = 78.6\ \text{VJ}(\text{cm}) + 60.3\ \text{mass}(\text{kg}) - 15.3\ \text{height}\ (\text{cm}) - 1,308.$$

Subjective Sleep Questionnaire. Athletes were asked to self-report the number hours of sleep, to the closest half hour, acquired the night before. Sleep was defined as the hours from bedtime to wake time.

Time of Day. Athletes performed strength training sessions in small groups. Morning strength training sessions took place between 0700 and 0900 hours. Afternoon strength training sessions took place from 1345 to 1600 hours. Basketball skill development activities always took place in the afternoon, with a start time ranging from 1500 to 1700 hours.

Statistical Analyses

SPSS (version 23; Armonk, NY, USA) was used for data analysis. A paired *t*-test was used to evaluate differences between morning and afternoon training measures of CMJ, Power, Overall, CNS, and self-reported sleep with and without matched PL intensities and duration.

Table 1. Difference in morning vs. afternoon training session performance.*,†

Variable	Morning	Afternoon	*p*
CMJ (cm)	58.3 ± 1.4	61.1 ± 1.9	0.008
Power (W)	6,373.8 ± 164.8	6,576.8 ± 177.8	0.004
Overall (AU)	5.8 ± 0.19	5.8 ± 0.15	0.916
CNS (AU)	5.9 ± 0.28	5.8 ± 0.19	0.430
Omega (mV)	14.1 ± 9.9	16.1 ± 8.7	0.103
PL (AU)	373.2 ± 20.9	283.9 ± 9.6	0.001
Duration (min)	75.8 ± 3.5	53.4 ± 1.6	0.000
Sleep (h)	7.1 ± 0.29	7.8 ± 0.19	0.029

*AU = arbitrary units.

†Countermovement JUMP (CMJ), power output (Power), overall readiness (Overall), central nervous system readiness (CNS), Player Load (PL), and duration when comparing the morning training value with the afternoon training value with matched training intensity during the previous exposure. Data are mean ± *SEM*.

TABLE 2. Morning vs. afternoon sessions with matched training intensity and duration during the previous exposure.*,†

Variable	Morning	Afternoon	*p*
CMJ (cm)	58.8 ± 1.3	61.9 ± 1.6	0.009
Power (W)	6,378.0 ± 131.2	6,622.1 ± 172.0	0.009
Overall readiness (AU)	5.75 ± 0.31	5.88 ± 0.35	0.763
CNS readiness (AU)	6.0 ± 0.44	5.7 ± 0.29	0.604
PL (AU)	275 ± 22.9	285.4 ± 13.9	0.345
Duration (min)	58.2 ± 9.9	55.3 ± 4.3	0.671
Sleep (h)	6.6 ± 0.4	7.4 ± 0.25	0.016

*AU = arbitrary units.

†Countermovement jump (CMJ), power output (Power), overall readiness (Overall), central nervous system readiness (CNS), Player Load (PL), and duration when comparing the morning training value with the afternoon training value with matched training intensity during the previous exposure. Data are mean ± *SEM*.

RESULTS

Preseason Characteristics

The mean values, over the entire preseason training and independent of time of day, for the CNS readiness score, overall readiness score, CMJ, and Power were 5.75 ± 1.02 AU, 5.75 ± 1.1 AU, 59.6 ± 5.4 cm, and 6,407.7 ± 509.9 W, respectively. The average PL recorded during a practice session was 338 ± 38.09 AU with a mean duration of 66.70 ± 32.94 minutes.

Time of Day Performance

Table 1 shows the average values obtained during morning training session compared with afternoon sessions without matching for PL and duration. CMJ and Power were significantly reduced in the morning (58.3 ± 1.4 cm; 6,373.8 ± 164.8 W) compared with the afternoon (61.1 ± 1.9 cm, $p = 0.003$; 6,576.8 ± 177.8 W, $p = 0.004$). An increase in practice duration (75.8 ± 3.5) and PL (373.2 ± 20.9) was observed in the morning sessions compared with the afternoon duration (53.4 ± 1.6) and PL (283.9 ± 9.6) ($p < 0.001$ and $p = 0.001$, respectively). In addition, subjects reported less sleep during training sessions scheduled in the morning (7.1 ± 0.2 hours) compared with training sessions scheduled in the afternoon (7.8 ± 0.1 hours, $p = 0.029$). Overall readiness (morning: 5.8 ± 0.19 AU, afternoon: 5.8 ± 0.15 AU; $p = 0.916$) and CNS readiness (morning: 5.9 ± 0.28 AU, afternoon: 5.8 ± 0.19 AU; $p = 0.430$) were not statistically different.

Table 2 shows the differences in morning training sessions and afternoon sessions when PL and duration were matched: PL (morning: 275.0 ± 22.9, afternoon: 285.4 ± 13.9 AU; $p = 0.345$) and duration (morning: 58.2 ± 9.9, afternoon: 55.3 ± 4.3 minutes; $p = 0.671$). CMJ (morning: 58.8 ± 1.3, afternoon: 61.9 ± 1.6 cm; $p = 0.009$), Power (morning: 6,378.0 ± 131.2, afternoon: 6,622.1 ± 172.0 W; $p = 0.009$), and self-reported sleep (morning: 6.6 ± 0.4, afternoon: 7.4 ± 0.25 hours; $p = 0.016$) were lower during morning compared with afternoon training, with no differences in overall readiness (morning: 5.75 ± 0.31, afternoon: 5.88 ± 0.35 AU; $p = 0.763$) or CNS readiness (morning: 6.0 ± 0.44, afternoon: 5.7 ± 0.29 AU; $p = 0.604$).

DISCUSSION

The major findings of the present study were (a) decreased performance during morning compared with afternoon sessions when PL and duration were matched, (b) reduced self-reported sleep associated with morning training sessions, and (c) decrements in performance during morning training despite no differences in player readiness. It should be noted that the first 8 strength training sessions were performed in the afternoon and the last 8 strength training sessions were performed in the morning. This order effect that was created by facility availability likely attenuated differences that would have been observed if time of day would have been randomly assigned in a prospective manner as one would expect training adaptations to continue to improve over the course of training. The fact that we still observed significant differences between time of day suggests that training should be performed in the afternoon whenever possible.

Athletic performance has been suggested to be better during the afternoon compared with the morning. Sinclair et al. demonstrated higher isokinetic strength during afternoon compared with morning measurement (26). Similarly, swimming times have been found slower in the morning when compared with evening bouts, regardless of the time the swimmer is accustomed to training (4,12,15). It has been shown that soccer performance improves in the afternoon as well (18,21). The present data add to the previous findings in that even when PL and duration were controlled for, we observed this decrement in performance in elite male basketball players.

The quantity of self-reported sleep by athletes in the present study was significantly lower during the night before morning compared with afternoon training sessions (Table 1). The decrease in sleep was paralleled by significant decreases in CMJ and Power (Table 1 and Table 2). These findings are consistent with data of Mah et al.(14), who proposed that an increase in sleep duration translated to improvements in athletic performance, reaction time, and mood in basketball players. These athletes also exhibited sport-specific task enhancement with increased free-throw accuracy (14), suggesting that sleep was directly related to improved athletic performance. Similarly, sprint performance has also been shown to decrease with sleep loss (25). Although the present study was not designed to determine how or why sleep quantity affects performance, it is likely that diurnal variation in hormonal levels played a role (23,26,29). For example, cortisol levels are elevated upon waking up (22), and decrements in performance have been correlated with levels of salivary cortisol in the morning (24). Consistent with altered stress levels, we report that morning practice was related to less sleep quantity (Table 1). Thus, our findings suggest that intercollegiate athletes do not alter their bedtime to accommodate earlier wake time and that further work is required to determine if improving sleep quantity leads to lower stress and improved morning performance in collegiate basketball players.

Many strength and conditioning coaches use readiness scores to guide daily training load to optimize training adaptation. We have reported that elevated Omegawave scores are associated with improved CMJ performance in competitive male basketball players (9). It should be noted that in the current study, time of day did not affect Omegawave readiness scores (Tables 1 and 2). This indicates that time of day influences performance independent of player readiness. This has practical implications for focusing efforts on training time of day, rather than solely relying on readiness, to improve performance. Whether increasing player readiness affects performance outcomes differently during morning compared with afternoon training remains to be investigated.

The present study has several limitations that warrant discussion. First, because of the retrospective nature of the present study and space limitations, we were not able to randomly assign time of day of strength training sessions, resulting in an order effect. However, as mentioned previously, the order effect may have attenuated the magnitude of the observed time of day differences. Second, the data examined are limited to the preseason training in male basketball players, and it is not possible to determine if morning compared with afternoon training affects performance during the competitive season. Third, the present investigation did not assess the quality of sleep obtained. Fourth, the quantity of self-reported sleep only included the hours received the night before and did not include the number of naps or daytime sleep that could alter the total quantity of sleep noted and affect performance. Although naps have been shown to blunt fatigue associated with sleep deprivation and increase motivation to perform (30), our results suggest that night time sleep was related to lower performance outcomes in the morning, suggesting that night time sleep is an important determinant of performance Finally, the present study design did not allow for the differentiation between time of day vs. sleep duration in the observed decrement in performance. Future studies should control for PL and duration and sleep duration to examine the independent effects of time of day vs. sleep on performance.

In conclusion, this study investigated the variation in performance, player readiness, and self-reported sleep between morning and afternoon training sessions in male collegiate basketball players. These athletes exhibited lower performance measures during morning compared with afternoon training sessions. These results remained significantly different after matching training load and duration during the previous exposure and with no differences in player readiness.

Practical Applications

The results of this study have several practical applications for designing training. Athlete performance is compromised during morning training. In addition, the reduced quantity of sleep associated with early morning practice, although not affecting player readiness, is associated with impaired performance. Strength and conditioning and sport coaches should consider avoiding morning training sessions and practices if normal competitions are not held in the morning, as athlete performance can be compromised during this time of day.

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