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Original research

Transitioning from daytime to nighttime operations in military training has a temporary negative impact on dynamic balance and jump performance in U.S. Army Rangers

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ABSTRACT

Objectives: Explore the impact transitioning from daytime to nighttime operations has on performance in U.S. Army Rangers.
Methods: Fifty-four male Rangers (age 26.1 ± 4.0 years) completed the Y-Balance Test (YBT), a vertical jump assessment, and a grip strength test at three time points. Baseline testing occurred while the Rangers were on daytime operations; post-test occurred after the first night into the nighttime operation training (after full night of sleep loss), and follow-up testing occurred six days later (end of nighttime training).
Results: On the YBT, performance was significantly worse at post-test compared to baseline during right posteromedial reach (104.1 ± 7.2 cm vs 106.5 ± 6.7 cm, p = .014), left posteromedial reach (105.4 ± 7.5 cm vs 108.5 ± 6.6 cm, p = .003), right composite score (274.8 ± 19.3 cm vs 279.7 ± 18.1 cm, p = .043), left composite score (277.9 ± 18.1 cm vs 283.3 ± 16.7 cm, p = .016), and leg asymmetry was significantly worse in the posterolateral direction (4.8 ± 4.0 cm vs 3.7 ± 3.1 cm, p = .030) and the anterior direction (5.0 ± 4.0 cm vs 3.6 ± 2.6 cm, p = .040). The average vertical jump height was significantly lower at post-test compared to baseline (20.6 ± 3.4 in vs 21.8 ± 3.0 in, p = .004). Baseline performance on YBT and vertical jump did not differ from follow-up.
Conclusions: Army Rangers experienced an immediate, but temporary, drop in dynamic balance and vertical jump performance when transitioning from daytime to nighttime operations. When feasible, Rangers should consider adjusting their sleep cycles prior to anticipating nighttime operations in order to maintain their performance levels. Investigating strategies that may limit impairments during this transition is warranted.

Practical implications

- After the first night of transitioning from daytime to nighttime operations, male Rangers may experience impairments in their lower extremity power and dynamic balance.
- There was no observable impairment to lower extremity power and dynamic balance in male Rangers within one week after transitioning to nighttime operations (on new reverse sleep cycle).
- Male Rangers should consider adjusting their sleep cycles (reverse their sleep cycle) within a week of anticipating nighttime operations in order to maintain their level of performance.

1. Introduction

Insufficient sleep and sleep disturbances are common amongst military service members.[1,2] The reason for this is complex and multifactorial considering the requirements and environmental factors of the job.[3,4] One common requirement of military service that impacts sleep is to transition from daytime (diurnal) to nighttime (nocturnal) operations. Nighttime operations are a critical part of the combat strategy, especially in the Special Operations community, which makes training for such operations critical. Nighttime operations can vary depending on the mission and military person-

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nel often need to utilize both their mental and physical resources in the process. Considering the commonality of these operations in the military, it is imperative to be aware of how the health and performance of its personnel are impacted during the transition into nighttime operations. While the negative impact of shift work on health and performance has been studied in a civilian population,[5] there is a paucity of research in military personnel.

Poor sleep has been found to have a negative impact on service member health and readiness,[6] including performance on critical tasks like marksmanship.[7] Insufficient sleep can also adversely affect more basic functions, such as mood,[8] and has been related to the development of psychological disorders following combat deployments.[9] Outside of a military context, sleep loss has been associated with impaired physical performance, including skill execution, submaximal strength, and muscular power.[10] Although sleep loss in military populations appears to have the greatest negative impact on aerobic capacity, muscular endurance and military-specific performance, there is currently insufficient literature investigating the effects of sleep loss on military physical performance.[11] In addition, little is known about how physical performance in military personnel is impacted during the transition period from daytime to nighttime operations. This study aimed to address this gap. Understanding the impact on physical performance during this time period may provide insight on when physical vulnerabilities are present and may also inform the reason military-specific performance may be impacted.

The purpose of this study was to explore the impact that transitioning from daytime to nighttime operations during military training has on physical performance (i.e., handgrip strength, dynamic balance and vertical jump performance) in U.S. Army Rangers from the 75th Ranger Regiment, an elite Special Operations unit. This was assessed in a field environment during a real military training event that simulated an actual contingency operation, which may help inform how Rangers may be impacted during real-world operations. The nighttime training event included many common training exercises for the unit, including an airborne operation, mounting/dismounting military vehicles, loading/unloading aircraft, carrying heavy loads to and from an objective, walking and running over uneven surfaces and terrain, etc. The battery of physical tasks, which involved both upper and lower extremities, was chosen to explore how different aspects of performance, which may be operationally meaningful, may be impacted during this altered sleep schedule. Depending on the mission, Rangers often need to travel over uneven surfaces (maintain their balance), jump over natural and man-made obstacles, and carry or hold on to various objects, such as their weapon or parachute risers. Therefore, the physical battery may be able to provide some insight on whether any of the common physical requirements for Rangers are impacted during this transition period. It was hypothesized that physical performance would be negatively impacted after the first night into nighttime operation training due to sleep loss associated with the shift in the sleep/wake cycle and fatigue, but would recover at the end of the training exercise after six nights due to the Rangers adjusting to the reverse sleep cycle.

2. Methods

This study was approved by the Walter Reed Army Institute of Research Scientific Institutional Review Board (IRB) and the United States Army Special Operations Command Research Advisory Council (RAC). It was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki. All participants provided written informed consent.

This study was part of a larger study investigating how reverse cycle (nighttime) operations in a military operational context impact the health and performance of elite Army Soldiers. The elite Soldiers were members of the 2nd Battalion of the 75th Ranger Regiment stationed at Joint Base Lewis McChord, WA and completed physical performance assessments, namely the Y-Balance Test (YBT), a vertical jump assessment, and a grip strength test, at three time points (baseline, post-test, follow-up).

Baseline testing was conducted 14 days prior to switching from daytime to nighttime operations during military training (getting on a “reverse sleep cycle”). At baseline, the Rangers were conducting standard duty day operations, and testing started mid-afternoon (at approximately1400). The post-test occurred after the first night into the nighttime operation training (testing started after a full night of sleep loss at approximately 0400), when Rangers were transitioning from sleeping at night to sleeping during the day. Follow-up testing occurred six days later (testing started at the end of their nighttime operation training at approximately 0800), after participants had a brief period to adjust to the reverse sleep cycle. The nighttime operation exercise/activities that occurred prior to the post-test and follow-up testing were similar. Testing session times and durations were determined based on availability of the Rangers during their real-world training.

The YBT was conducted to measure lower extremity balance and neuromuscular control,[12,13] which has been shown to have good reliability.[14] The YBT is commonly used to evaluate dynamic balance (maintaining balance while in motion) and stability by examining a participant’s ability to maintain a unilateral stance centered on a platform while the opposite leg reaches maximally in the anterior, posteromedial, and posterolateral directions. At baseline, participants received verbal instruction on how to properly perform the YBT and observed the tester performing each direction correctly. Participants did not wear shoes/footwear during the test and performed two practice trials to demonstrate understanding. Participants demonstrated proper technique in each direction before being evaluated. Participants then started the test by standing on the right foot with their hands just above their hips. While maintaining single leg stance, the participant reached with the free limb (left leg) as far as possible in the anterior direction by sliding the indicator box. Participants completed three valid trials prior to switching to the contralateral stance leg. A trial was considered invalid if the participant (1) failed to maintain unilateral stance, (2) touched down on the reaching foot, (3) failed to return to the starting position while maintaining the hands on hips, or (4) pushed or kicked the indicator to increase distance. Testing order was as follows: right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral. Absolute reach for each trial was recorded to the closest half centimeter (cm). The three valid trials for each direction were averaged. A composite score for each leg was also calculated by summing the measurements of each direction. In addition, leg asymmetry was determined by calculating an absolute difference in the maximum reach distance in centimeters for each limb for each anterior, posteromedial, and posterolateral direction. Normalized scores were not calculated for this study. At post-test and follow-up testing, because of time restraints associated with the field training event, the aforementioned methods were the same except that the Rangers only performed one valid trial in each direction after the practice trials.

Vertical jump height was calculated using the Just Jump System (Perform Better, West Warwick, RI), which measures the time between leaving and landing on a computerized mat. The Just Jump System has been validated as a measure of vertical jump when compared to the three-camera system.[15] Participants received detailed instructions on how to perform the jump and demonstrated understanding by performing the jump properly prior to testing. Participants started on the mat with their feet approximately shoulder-width apart and their hands reaching overhead.

The participant then naturally moved their hands/arms downward as they moved into a squat position prior to jumping as high as possible while reaching up with their hands, all in a fluid motion. Participants would land with both feet at the same time in a manner that is natural when returning from a jump. Prior to each jump, participants were asked to jump as high as possible. Participants performed three maximal jumps, with no more than 60 s of rest between jumps. The average height (in) of the three jumps was calculated. Participants did not wear shoes/footwear during the jumps.

Upper extremity grip strength was measured by dynamometer. Dynamometers have been shown to be both reliable and valid in the measurement of grip strength in a normal population.[16] Participants performed the grip strength test (with their self-identified dominant hand) seated with their feet supported, shoulder in a neutral position (by side), elbow flexed approximately 90°, forearm in neutral position, and wrist with approximately 0 to 30° extension. Participants received instruction to squeeze the dynamometer as hard as possible for 5 s, and then performed a practice trial properly to demonstrate understanding. After proper demonstration, the participant performed a maximum isometric contraction for 5 s (participants heard, "Ready, set, go, 4, 3, 2, 1, Stop") and the peak force was recorded by the tester. Each participant performed 2 maximum isometric contractions. The average peak force (kg) of the two trials was calculated.

Sleep (via actigraphy; Actiwatch Spectrum; Philips Respironics, Murrysville, PA) was recorded continuously, starting at the baseline time point and ending at the follow-up time point. Sleep/wake data were collected in 30-s epochs and sleep-wake determination was computed by the Actiware 6.02 scoring algorithm.

All statistical analyses were performed using SPSS 26.0 (SPSS Inc., Chicago, IL, USA).

Mean scores on each test were calculated at baseline, post-test, and follow-up. To assess if there were performance differences across time (baseline, post-test, follow-up), a repeated measures ANOVA was conducted. If Mauchly's test of sphericity was significant, a Huynh-Feldt correction was made (only necessary on the vertical jump test and the right composite scores of the YBT, which did not change the results of the ANOVA). Post hoc analysis of the repeated measures ANOVAs included performing paired t-tests to evaluate the within-group mean scores between each testing period (pre-test, post-test, and follow-up). Partial eta squared was calculated using the variance associated with the effect and its associated error variance in order to quantify effect size. P values <0.05 were considered statistically significant. Standard deviations were recorded with mean values. In addition, frequencies and percentages were calculated to further describe the prevalence of the reach asymmetries.

3. Results

Fifty-four male Rangers (age 26.1 ± 4.0 years) completed all physical tasks, including the Y-Balance Test (YBT), a vertical jump assessment, and a grip strength test, at the three time points (baseline, post-test, follow-up) described above. Demographic information is listed in Table 1.

Table 1
Demographic information of participants.

# of participants, n	54
Male gender	54 (100%)
Age, years	26.1 ± 4.0
Ethnicity	
American Indian	1 (1.9%)
African American/Black	1 (1.9%)
Asian	2 (3.7%)
Caucasian/White	49 (90.7%)
Hispanic	2 (3.7%)
Years of military service	4.5 ± 3.1
1	13 (24.1%)
2–3	12 (22.2%
4–5	10 (18.5%)
6–7	8 (14.8%)
8–9	5 (9.3%)
10–12	6 (11.1%)
Military job (AOC)	
Infantry (11 series)	45 (83.3%)
Field artillery (13 series)	5 (9.3%)
Signal (25 series)	3 (5.6%)
Missing	1 (1.9%)
Number of deployments	
0	20 (37.0%)
1	9 (16.7%)
2	7 (13.0%)
3–4	5 (9.3%)
5–6	9 (16.7%)
7+	3 (5.6%)
Missing	1 (1.9%)
Highest level of civilian education	
High school diploma/GED	15 (27.8%)
Some college/associate's degree	18 (33.3%)
Bachelor's degree	20 (37.0%)
Graduate degree	1 (1.9%)

Data are presented as mean ± standard deviation unless otherwise indicated. AOC = area of concentration.

Forty-one of the Rangers in this sample wore the actigraph from baseline to the follow-up time point. Between baseline and post-test (i.e., during a standard duty day schedule), participants slept 429.22 ± 146.29 min per night. At the time of post-test data collection, the morning after the first nighttime training, participants had been awake for 19:16 ± 1:04 h. Lastly, between post-test and follow-up (i.e., during the training exercise), participants slept 437.23 ± 111.16 min per night (sleep occurred during the day because of the reverse sleep cycle). At the time of follow-up data collection, the morning after the sixth night of nighttime training, participants had been awake for 19:26 ± 1:01 h.

Performance on the physical tasks across the three time points can be found in Table 2. For the YBT performance, there was a significant main effect of time on right anterior reach (F (2, 106) = 3.27, p = .042, η_p^2 = .06), left anterior reach (F (2, 106) = 4.39, p = .015, η_p^2 = .08), right posteromedial reach (F (2, 106) = 4.85, p = .010, η_p^2 = .08), left posteromedial reach (F(2, 106) = 6.43, p = .002, η_p^2 = .11), right composite score (F (1.86, 98.72) = 5.30, p = .080, η_p^2 = .09; Fig. 1), left composite score (F (2, 106) = 4.82, p = .010, η_p^2 = .08; Fig. 1). There was no significant main effect of time on posterolateral reach (right or left). Post hoc tests showed that performance was significantly worse at post-test compared to baseline during right posteromedial reach (p = .014) and left posteromedial reach (p = .003), as well as for the right composite score (p = .043; Fig. 1) and left composite score (p = .016; Fig. 1). There were no other significant reach differences between post-test and baseline. Post hoc tests showed that performance significantly improved at follow-up compared to post-test during right anterior reach (p = .005), left anterior reach (p = .007), right posteromedial reach (p = .010), left posteromedial reach (p = .017), and right posterolateral (p = .023), as well as for the right composite score (p = .001; Fig. 1) and left composite score (p = .005; Fig. 1). There were no other significant reach differences between follow-up and post-test. There was no difference in performance between baseline and follow-up in any direction (right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral) or composite scores.

In terms of asymmetry on the YBT, there was a significant main effect of time on posterolateral asymmetry (F (2, 106) = 3.42, p = .036, η_p^2 = .06; Fig. 2). There was no significant main effect of time

Table 2
Performance on physical tasks throughout the entire study. Results of the repeated measure analysis of variance (ANOVA).

Outcome/assessment	Baseline Mean ± SD	Post-test Mean ± SD	Follow-up Mean ± SD	Time effect p-Value (η_p^2)
Y-Balance test (cm)				
Anterior left	70.2 ± 5.6	69.2 ± 6.7**	71.7 ± 6.6	**.015 (.076)**
Anterior right	69.2 ± 5.4	67.9 ± 7.1**	70.1 ± 7.1	**.042 (.058)**
Posteromedial left	108.5 ± 6.6	105.4 ± 7.5*,**	107.5 ± 7.6	**.002 (.108)**
Posteromedial right	106.6 ± 6.9	104.1 ± 7.2*,**	106.3 ± 7.5	**.010 (.084)**
Posterolateral left	104.5 ± 7.5	103.3 ± 8.4	104.3 ± 7.6	.374 (.018)
Posterolateral right	103.9 ± 8.6	102.8 ± 8.2**	104.8 ± 7.6	.092 (.044)
Composite left	283.3 ± 16.7	277.9 ± 18.1*,**	283.5 ± 18.5	**.010 (.083)**
Composite right	279.7 ± 18.1	274.8 ± 19.3*,**	281.3 ± 19.0	**.008 (.091)**
Asymmetry anterior	3.6 ± 2.6	5.0 ± 4.0*	4.6 ± 3.7	.094 (.044)
Asymmetry posteromedial	4.0 ± 3.1	4.5 ± 3.1	4.0 ± 3.2	.469 (.014)
Asymmetry posterolateral	3.7 ± 3.1	4.8 ± 4.0*,**	3.6 ± 3.1	**.036 (.061)**
Vertical jump (in)	21.8 ± 3.0	20.6 ± 3.4*,**	22.2 ± 3.3	**<.001 (.183)**
Hand grip strength (kg)	53.8 ± 7.1	57.2 ± 8.5*,**	59.7 ± 8.7***	**<.001 (.262)**

SD, standard deviation. Y-Balance test measurements were absolute reach values. p-Values and effect sizes (η_p^2) reflect the Time effect from the ANOVA. Bold p-values indicate significant time effects, $p < 0.05$.
* Indicates significant difference between baseline and post-test, $p < 0.05$.
** Indicates significant difference between post-test and follow-up, $p < 0.05$.
*** Indicates significant difference between baseline and follow-up, $p < 0.05$.

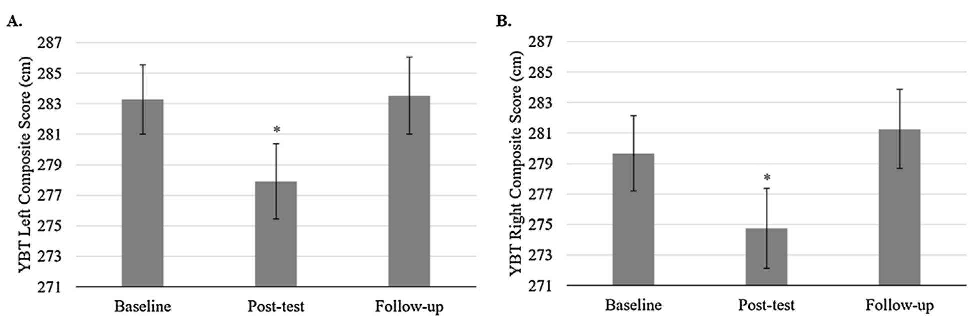

Fig. 1. Performance on the Y-balance test (YBT) throughout the study. Composite scores (A: left lower extremity; B: right lower extremity) on the YBT significantly decreased at post-test (morning after the first night into nighttime training after a full night of sleep loss) and returned to baseline at follow-up (morning after sixth night of nighttime training while on reverse sleep cycle). Mean ± standard error. * p < .05.

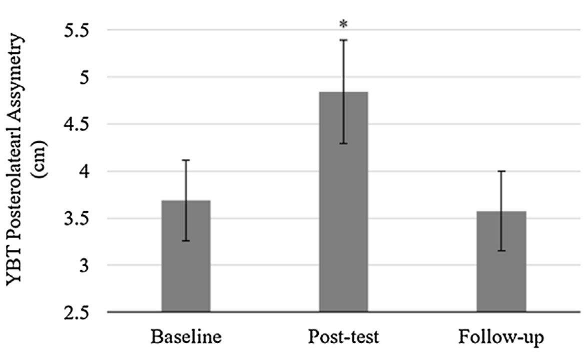

Fig. 2. Performance on the Y-balance test (YBT) throughout the study. Posterolateral asymmetry on the YBT was significantly worse (increased) at post-test (morning after the first night into nighttime training after a full night of sleep loss) and returned to baseline at follow-up (morning after sixth night of nighttime training while on reverse sleep cycle). Mean ± standard error. * p < .05.

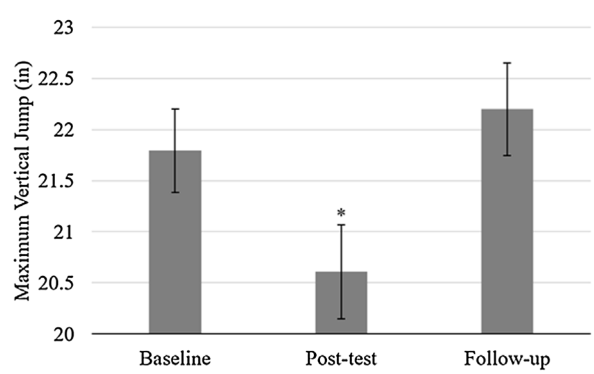

Fig. 3. Performance on the vertical jump test throughout the study. The average maximum vertical jump was significantly worse at post-test (morning after the first night into nighttime training after a full night of sleep loss) and returned to baseline at follow-up (morning after sixth night of nighttime training while on reverse sleep cycle). Mean ± standard error. * p < .05.

on anterior or posteromedial asymmetry. Post hoc tests showed that asymmetry was significantly higher (worse) at post-test compared to baseline in the posterolateral direction ($p = .030$) and the anterior direction ($p = .040$). Posterolateral asymmetry then significantly improved (decreased) at the follow-up compared to post-test ($p = .035$). There was no difference in posterolateral asymmetry between baseline and follow-up. At baseline, reach asymmetries of 4 cm or greater were noted in 44.4% (24/54) of the subjects during the anterior reach, 48.1% (26/54) during the posteromedial direction, and 38.9% (21/54) during the posterolateral reach. At post-test, reach asymmetries of 4 cm or greater were noted in 53.7% (29/54) of the subjects during the anterior reach, 50.0% (27/54) during the posteromedial reach, and 57.4% (31/54) during the posterolateral reach. At follow-up, reach asymmetries of 4 cm or greater were noted in 51.9% (28/54) of the subjects during the anterior reach, 44.4% (24/54) during the posteromedial reach, and 33.3% (18/54) during the posterolateral reach.

There was a significant main effect of time on the average vertical jump height (F (1.80, 95.36) = 11.88, $p < .001$, $\eta_p^2 = .18$, Fig. 3).

Post hoc tests showed that the average vertical jump height was significantly lower at post-test compared to baseline ($p = .004$) and compared to follow-up ($p < .001$). There was no difference in vertical jump performance between baseline and follow-up.

There was a significant main effect of time on the average grip strength ($F(2, 106) = 18.81$, $p < .001$, $\eta_p^2 = .26$). Post hoc tests showed that average grip strength was significantly higher at post-test compared to baseline ($p = .002$). Follow-up grip strength was significantly higher than post-test ($p = .006$).

4. Discussion

This study was the first to investigate how different aspects of physical performance are impacted during the transition from daytime to nighttime operations during a military training exercise in U.S. Army Rangers. During the transition, there was a decrement with dynamic balance and vertical jump performance, but not on upper extremity grip strength. These decrements in balance and jumping returned to baseline when the Rangers were retested six days into their reverse sleep cycle (awake during night, asleep during the day), with the preceding operational exercise and amount of sleep loss the Rangers experienced being similar to what was experienced prior to the post-test. In the morning after the first night into training (after a full night of sleep loss), Rangers performed worse bilaterally in the posteromedial direction and on the composite scores on the YBT. Both fatigue, which has shown to negatively impact dynamic balance,[17] and sleep loss are speculated to be contributing factors to the impaired balance. Other research in a similar population showed that sleep loss has a negative impact on static balance.[18] The present findings expand on this prior research by showing that dynamic balance, as measured by their ability to maintain unilateral stance while the opposite leg reaches maximally in different directions, appears to also be negatively impacted after being awake for an extended period of time during the transition from daytime to nighttime operations.

Impaired balance is a risk factor that has been associated with lower extremity injury rates.[13,19] On the YBT, some studies have demonstrated asymmetries greater than 4 cm in the posteromedial direction[20] and anterior direction[13,21] are associated with increased risk of lower extremity injuries. At baseline, there was a notable percentage of Rangers with these balance asymmetries. Compared to baseline, however, at post-test there was an increase in asymmetry in the anterior and posterolateral direction. The asymmetry in both directions changed by over 1 cm, which moved each direction above the 4 cm threshold some have shown to be associated with injury risk. At post-test, reach asymmetries of 4 cm or greater were noted in over 50% of the participants in each direction, which was a 9.3% increase from baseline for the anterior reach and an 18.5% increase for the posterolateral reach, indicating over 1 in every 2 Rangers may potentially be at an increased risk for injury during this transition time. Not all studies have found that performance on the YBT is indicative of injury risk,[22] therefore, future research should evaluate whether the altered balance during this transition period has any impact on injury rates in this population. Injuries are a significant health problem for all military branches[23] and insufficient sleep has been associated with increased risk of injuries in Soldiers from the US Army Special Operations Command.[24] Future research should investigate the potential mechanisms associated with this sleep/injury relationship, including whether impairments in balance during times of altered sleep plays any role.

Similar to dynamic balance, vertical jump performance significantly decreased after the first night into training (after a full night of sleep loss) and returned to baseline after six days on the reverse sleep cycle. Another study found that sleep deprivation resulted in a decreased vertical jump performance in a healthy non-military population.[25] However, in that study, sleep deprivation was for 64 h, much longer than the sleep loss experienced by the Rangers in this study, which was closer to 19 h spent awake. While a recent review stated that there is currently no clear consensus on the effects of sleep loss on lower-body anaerobic performance in a military population,[11] this study provides some evidence that after approximately 19 h spent awake during the transition from daytime to nighttime operations, vertical jump performance is negatively impacted. Other factors, such as the physical fatigue from the tasks conducted during the operation, likely contributed to this change in performance. A recent study found that lower-body muscular fatigue had a negative effect on vertical jump performance, but interestingly, not on balance performance.[26] Performance on both the YBT and vertical jump did return to baseline at follow-up testing after the Rangers had been on the reverse sleep cycle for six nights. It is reasonable to assume that the Rangers may have been more fatigued at the follow-up testing considering they were on their sixth consecutive day of nighttime operations and had a similar length of time awake prior to the testing. Compared to the balance testing, the effect size calculated was larger for the vertical jump test indicating that during the transition there may be more of an effect on lower extremity power. Similarly, while it could be debated whether a decrease in vertical jump of approximately 1 inch is operationally meaningful, it would stand to reason that even small reductions in lower-body power output may possibly have significant consequences in military settings, especially in a combat situation. Rangers often carry heavy loads and have to move fast in unpredictable environments during nighttime operations and thus maintaining power and dynamic balance at any point during these operations is critical.

Interestingly, although dynamic balance and vertical jump performance decreased during the transition to nighttime operations and then returned to baseline after six days, hand grip strength progressively increased throughout the study. To date, the effects of sleep loss on hand grip strength has been shown to be inconsistent in military populations.[11] Hand grip strength has reported to improve after a five-day simulated combat exercise, where infantry Soldiers slept approximately five hours per day, however, the authors speculated that these results may have been because of an increase in Soldier morale and motivation following the military exercise.[27] In field artillery Soldiers, hand grip strength was found to decrease after eight days of restricted sleep (3–4 h of sleep per day).[28] Another study showed that handgrip strength did not change after one night of sleep deprivation (similar to the sleep loss participants in this study experienced),[29] which is consistent with a review in healthy populations showing that handgrip strength is often maintained regardless of the sleep loss protocol.[10] Certainly, neuromusculoskeletal adaptations or learning effects could be a reason for the grip strength findings in this study; however, one would expect to see that across all of the physical assessments. As this was not the case, there is the possibility that sleep loss may have a more profound effect on physical tasks with greater neuromotor complexity, such as dynamic balance and vertical jump performance, compared to more simple tasks such as grip strength.

This study had limitations. The main limitation is that testing was conducted during different times of day between pre-test (started ~1400), post-test (started ~0400), and follow-up (started ~0800). Circadian rhythms are known to impact performance depending on the time of day, however, some have shown handgrip strength and balance to be stable across wake periods,[30] suggesting this limitation may have had less of an impact on those results. Second, because of time restraints associated with the training event, during post-test and follow-up, the Rangers only performed one accurate trial in each direction on the YBT. However, the calculated intraclass correlation coefficient (ICC) at baseline for the three trials in each direction (and extremity) ranged from 0.729−0.939, making it reasonable to believe that the one trial conducted at the post-test and follow-up would not be impacted by variability in measurement and therefore would be comparable to the average of three trials. There is still a chance that the average of three accurate trials may have been different, and thus, the YBT metrics from the dynamic balance at the two latter time points may have been less valid than those from baseline. In addition, the frequency and timing of the follow-up testing limited the ability to describe how long the noted physical impairments were observable. Future research should consider conducting the follow-up testing after each day of the training exercise if the unit training schedule allows for it. Third, there was no separate familiarization session outside of the familiarization session immediately preceding the participant's recorded trails for each of the separate tasks. Having an additional familiarization session prior to baseline testing may have mitigated any potential learning effect that may have occurred between any of the testing sessions. Fourth, all of the participants were male and members of an elite group of Soldiers and thus the results may only be applicable to that population and not generalizable to the greater military. Similarly, the majority of the participants in this study had less than five years of military service, which may limit the generalizability to Rangers with more experience. Additionally, it is unclear how much other contributing factors, such as morale, motivation, stress, anxiety, and fatigue from the training operation inherently affected the results versus the loss of sleep during the transition period. An adjustment for multiple comparisons in the analyses was not made, however, adjustments of multiple comparisons are built on the assumption of independence of the tests being evaluated and the majority of the comparisons were on different components of the YBT. Future studies should aim to replicate and expand these findings while addressing these limitations, as well as add other military relevant performance tasks, such as marksmanship.

5. Conclusion

Elite male Army Rangers experienced an immediate, but temporary, drop in dynamic balance and vertical jump performance when transitioning from daytime to nighttime operations during military training. Performance on these tasks returned to baseline after being on the reverse sleep cycle for six days. Whenever feasible, Rangers should consider adjusting their sleep cycles prior to anticipating nighttime operations in order to maintain their level of performance. Investigating potential strategies that may limit these physical impairments during the transition from daytime to nighttime operations is warranted. Future research should also investigate how other potential confounding variables associated with the military training impacts Ranger performance and whether the noted impairments have any subsequent impact on other health-related outcomes (i.e., injury risk).

Declaration of Competing Interest

The authors report no declarations of interest.

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