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Original Article

Travel related changes in performance and physiological markers: the effects of eastward travel on female basketball players

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Abstract. [Purpose] Purpose of this study is to measure the changes in various physiological markers and performance criteria for women basketball players over the course of a travel heavy season. [Participants and Methods] Fifty one Division-II female basketball players and a control group of 54 females joined this study. Measurements began at the beginning of the competitive season and concluded with final measurements at the end of the competitive season. [Results] The female basketball players showed noticeable increases in resting salivary cortisol, visceral trunk fat, resting heart rate, and resting blood pressure. These athletes also showed diminishment in isokinetic force of leg muscles, particularly in knee flexion strength. Vertical jump measurements also indicated a slight diminishment. In contrast, the control group experienced none of the same changes. [Conclusion] Over the course of a grueling flight schedule in combination with a full-length basketball season, the female athletes in this study showed significant declinations in many indicators of overall health. It is concluded that resulting prolonged intermittent stress of a travel-heavy season can lead to significant changes in certain physiological markers with notable decreases in isokinetic force of leg muscle.

Key words: Prolonged intermittent stress, Student athlete, Female athletes

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INTRODUCTION

Bouts of intermittent stress have been proven to be a noticeable obstacle for college students[1)]. Although the stressors can result from both academic and social environments, both can lead to varying ranges of psychological impairments as well as physical ones[1–4)]. These bouts of stress not only affect the majority of students, collegiate athletes in particular are subjected to stress related to academic success, maintaining a healthy social life on top of performing well in their respective sport[1–5)]. These students may even be held to a higher standard, as they directly represent their school. Effective time-management is an important part of student success; however, that becomes increasingly challenging for the student athletes who are subjected to a demanding travel schedule throughout their competitive season[6–8)].

There are major stress factors that affect college athletes, and a number of them can be traced back to the effects of air travel. This is especially noticeable when looking at air travel going east through time zones[9, 10)]. Through various studies in human chronobiology, it is shown that it is much easier to slow down our circadian rhythm than it is to speed it up. Ultimately, this results in more negative symptoms associated with air travel when traveling east compared to when traveling west[11)]. Many physiological functions in the body are regulated by neurotransmitters, and one monoamine in particular called melatonin is especially important. Melatonin is directly affected by the day-night 24-hour cycle of our planet. There are also many symptoms associated with a disruption within the circadian rhythm, some of which include changes in heart rate, blood pressures, hormonal levels and body temperature[12)]. Often these effects are referred to simply as jet lag, or even

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travel fatigue. Jet lag is defined as the collection of symptoms that are manifested through the body's adaptations which occur due to a shift into a new time zone[13]. One of the major non chrono-biological stress factors of airline travel is the prolonged exposure to significantly lower air pressure than the norms, which results in a lower blood oxygen saturation that is stressful on the body[14–16]. In our study, travel fatigue is defined as a complex summation of the psychological, physiological, and environmental factors that affect an individual during a trip, which, in the long term, can reduce the ability to recover properly and perform at an optimal level.

Although players in this study (Female basketball team of University of Hawai'i at Hilo—WBB) were arguably in a less chronic stress environment, their frequent long duration trips might have caused episodic acute stress. The most accurate terminology that could be used to describe the level of stress the athletes faced would be prolonged intermittent stress[17–19]. It was originally hypothesized that such stress would produce notable changes in the athletes[11]. Some of these changes would include increasing of the deposition of fat in the visceral trunk area as well as waist/hip ratio[14]. Ultimately, the objective of this study is to analyze the effects of an intense, full length, travel-heavy basketball season on female collegiate basketball players, with a specific focus on anthropometric, biometric, cardiovascular, and strength/power qualities. In order to have a control group, student volunteers who were not competitive collegiate athletes were measured for the same data throughout the same time period as the WBB athletes.

One of the notable factors that sets apart the University of Hawai'i at Hilo (UHH) from other universities is that the amount of physiological and psychogenic stress factors is noticeably higher than their academic student counterparts, despite many of them having very similar academic demands. The extra stress that UHH athletes are subjected to could be the result of the unusually high travel mileage that occurs over a competitive athletic season. This places UHH athletes in a very unique position, as the "away" games become far more physically demanding due to the extensive travel time. While Hawai'i County falls under the time zone designation of Hawai'i State Time, the vast majority of the away games are scheduled in states such as California which is in the Pacific Time Zone and three time zones away from Hawai'i. In addition, there is a relatively small part of the season that occurs in the US state of Utah, which is four time zones east of Hawai'i. While the time spent in Utah is comparatively small, it is still significant when measuring physiological effects of eastward travel. Over the five seasonal years that this study was being conducted, the average length of the team's season was 112.7 days with 24.4 of those days spent traveling. Ultimately, these extensive travel days resulted in an estimated distance of travel of 16,115 miles throughout one season alone, with an estimated 15,195 of those miles being air travel to the mainland of the United States. Only 924 of the traveled miles could be attributed to inter island travel, which would begin on the Big Island of Hawai'i to Honolulu on the island of O'ahu. Each flight going from the Big Island to Honolulu was 216 miles which averages to about 51 minutes of flight time.

Collegiate athletes have to deal with many of the same stressors as their traditional college student counterparts, such as stress related to academic success, family difficulties, financial limitations, and the importance of having a healthy social life[20]. Despite the similarities, collegiate athletes are also subjected to stress that stems from their sports, such as playing the sport with other athletes, changes in nutritional habits throughout a competitive season, travel times, as well as training and game day schedules. All of these additional stressors combine to affect both the team's success as a functional unit as well as the athletes as individuals. Furthermore, one of the notable stressors is sleep pattern disruption, which occurs very easily through travel. The disruptions then alter the circadian rhythms, which can trigger or even intensify stress responses[21, 22].

Athletes that actively compete at the University of Hawai'i at Hilo, specifically on the WBB for this study, experience significant physiological and psychogenic stressors due to the immense amount of time spent traveling east and skipping time zones in order to compete with other schools over the course of a competitive season. It is hypothesized that due to the prolonged intermittent stress that these athletes are subjected to throughout the competitive season, there are negative physiological changes within the athletes. Due to the constituent eastwardly travel, some of the hypothesized physiological changes can include misalignment of circadian rhythms, lack of appetite, the inability to concentrate and lastly, lack of quality sleep and rest. It has also been demonstrated through various studies that long lasting psychogenic stressors can result in cardiovascular disease, changes in body fat deposition, inability to perform physically and mentally, and changes that can lead to dysfunctional metabolism[21–24]. Therefore, from that perspective, the objective of this study is to measure the changes in various physiological markers and performance criteria over the course of a travel heavy basketball season.

PARTICIPANTS AND METHODS

Fifty one Division II-university female basketball players who traveled with the team during the competitive season (WBB) (age=20.98 ± 1.1 yr; body mass=73.3 ± 1.6 kg, lean body mass 51.5 ± 1.1 kg, total body fat=29.7%) joined this study. Control group was comprised of 54 female university students of similar age (CT) who were not participants in any collegiate level sports or athletics (age=21.23 ± 1.7 yr; body mass=62.8 ± 1.8 kg, lean body mass 43.3 ± 1.2 kg, total body fat=31.2%). Measurements started at the beginning of the basketball season and was terminated instantly as soon as the season came to a close, roughly 15 weeks later. The only data utilized for this study came from WBB players who were a part of the travel team and played in at least 80% of the season's games. There were no measures to distinguish those that started the games from those that did not, as the barrier to entry was that the athletes had to at least play in 80% of the games.

The CT participants for this study were selected from the same academic departments as the WBB, and as a result had the similar courses in which the WBB were enrolled, whenever that option was available. Those that participated were well informed of the study as well as its protocols, and written consent was acquired before any of the measurements. This study was approved by The Institutional Review Board (IRB) of the University of Hawai'i system for over 5 years (JTN-21-186).

Both the WBB and CT participants were measured immediately before the basket-ball team competed in their opening game of the season (T1). Despite being limited in controlled testing times due to circumstances of the athletes and controls; the majority of the participants were measured between 10 am and 12 pm and each participant was measured a second time as soon as the team finished its final game of the season (T2). The time of measurement for T2 was identical to T1, and participants were asked to follow the similar sleeping and eating patterns that they would have exhibited before the T1 measurements.

The heights and body masses were measured for both T1 and T2 using digital scale and stadiometer (Seca 769, Hamburg, Germany). Each circumference measurement was performed using a Seca 200 tape measure in front of a mirror and two lab technicians to maximize accuracy. Thigh circumference was measured at the mid-point between the superior patella and the greater trochanter on the dominant side. Waist circumference was measured at the mid-point between the superior iliac crest and the inferior point of the costal cartilage. In addition, this measurement was taken horizontally upon expiration. Hip circumference was measured at the greater trochanters with modulations made in order to include the largest horizontal circumference.

Body composition analyses and bone mineral density measurements were gathered through the utilization of a GE Prodigy Lunar DXA (Dual energy X-ray absorptiometry) unit (GE Medical Systems Luna, Madison) with enCORE software (v. 16.2). Special time was dedicated to calibrating the DXA scanners before each of the trials. Each participant completed full body DXA scans, and each scan provided a three-component analysis of the individuals body composition. Following the scans, total as well as regional bone mineral densities were assessed, and then lean tissue deposition were assessed afterwards. This provided measurements (in grams) of the variety of tissues and percent body fat. In addition, it provided lean mass measurements for the total body as well as the individual arms, legs, and trunk. Participants were instructed to wear light clothing (shorts or yoga tights and t-shirt, and the same pieces of clothing were worn by participants for both T1 and T2), any rings, necklaces, or other metals were removed from the individuals prior to scanning, and each participant was set lying in a supine position with their hands by their sides in a pronated position.

Blood pressure (BP) and heart rate (HR) measurements were measured by adhering to the following protocols: Both participants and controls rested in supine position for 10 minutes prior to the first measurement. BP and HR were measured using a fully automatic monitor (OMRON M4-1 IntelliSense, Kyoto, Japan) following the 10-minute rest period, and measurements were taken again after 3 minutes. Measurements of diastolic BP, systolic BP and HR were averaged if they were within the 5% change between measurements. Differences that were higher than 5% would demand a re-measure after another 3 min rest period. There were multiple occasions which demanded multiple rest periods in order to obtain finalized results.

Cortisol levels were gathered from saliva collections, which utilized the drool-spit method[28]. Participants were instructed to avoid any kind of food, drink, or oral hygiene products for at least 1 hour prior to the time of saliva collection. When gathering the saliva, each participant was instructed to spit whole saliva into a 50 mL Falcon® tube that had been sterilized, and each participant was required to provide a minimum of 10 mL of whole saliva, and these samples were analyzed for cortisol levels for both the T1 and T2 testing sessions. Collected saliva samples were stored at −80 °C until assayed, using cortisol EIA kits (Salimetrics, State College, PA, USA). The CV% for both assays was <7%.

Vertical jump (VJ) was measured with a Vertec device (JumpUSA, Sunnyvale, CA, USA). Participants stood with feet hip width apart directly under the stratified Vertec vanes and performed a rapid countermovement jump, reaching the highest possible vane with the dominant hand. A two-minute rest was given between attempts and the highest vertical jump was registered.

Maximum voluntary dominant leg isokinetic knee extension and knee flexion strengths were determined concentrically using a Cybex Humac Norm Isokinetic Dynamometer. Settings for the instrument were 120 degrees range of motion, at 30 °/s. The participants were instructed to perform several sub-maximal knee extensions followed by knee flexions on the two-way isokinetic dynamometer for familiarization and warm-up. After three minutes' rest, the participants perform three consecutive maximum voluntary concentric knee extensions and flexions. Again, the participants rested for three minutes followed by a repeat testing bout of three concentric extensions and flexions. The maximum flexions and extensions, measured in Newton/meters, were determined from the first and second trials, and if there was an increase in any measurement from the first to the second trials, a third trial was performed. Maximum concentric knee extension and flexion measurements were recorded for data analysis and maximum peak torque reached was accepted as the measure of muscle strength.

The descriptive statistics (mean, and standard deviation) of the participants' dependent variables (blood pressure, mean arterial pressure, resting heart rate cortisol, isokinetic strength of the leg muscles, vertical jump, bone density, visceral trunk fat, total body fat, body mass, height, circumferences of the lower body) were determined. The homogeneity of the data was checked using kurtosis and skewness values. Changes in dependent variables of the participants were determined by paired sample t-test and one-way analysis of variance (ANOVA) inter-group and between groups, respectively. In addition, the two-factor ANOVA test was used in repeated measures to determine the interaction of the changes in the performance values of the participants [pre-season (T1) and final post-season (T2)] at the group level (measurement ×group effect). The significance value was set at p<0.05. Statistical analyses were performed using the SPSS 18 package program.

RESULTS

Throughout the competitive season, measurements indicated that there was a negligible change in total body fat percentage, and this was applicable for both the WBB and the CT participants. However, what was also drawn from these measurements was that the visceral fat percentage of the WBB increased significantly (p<0.05), whereas very little to no change was seen in the same measurement for the CT group (Table 1). In tandem with these findings, as presented on Table 2, were measurements which showed that WBB exhibited significant gains in waist circumference/size as well as waist/hip ratio (WHR) (p<0.01). Conversely, the CT showed no significant changes in either measure, which can also be seen on Tables 1 and 2.

Not only were there notable changes in WHR and visceral fat percentage for the WBB participants, but there were also significant raises in resting heart rate as well as both systolic and diastolic blood pressure, and mean arterial pressure (81.5 mmHg to 86.2 mmHg, p<0.01) (Table 3). Much like the WHR and visceral fat percentage measurements, no such changes were detected for the CT (Table 3). WBB salivary cortisol measures rose significantly for participants as well (7.6 nmol•L vs. 15.7 nmol•L, p<0.01), while much like the previous measurements, CT cortisol measures did not change significantly for CT (Table 3).

All performance measurements in the form of isokinetic strength testing for this study can be found in Table 4. The most significant changes here are shown by a decrease in both maximal left and right knee flexion, significant to p<0.01. These diminishments also noticeably reduced both left and right knee flexion/extension ratios (Table 4). While the CT showed no significant changes, one interesting point is that insignificant diminishment in the right knee extension force and the insig-

Table 1. Women Basketball team (WBB) and Control's descriptive characteristics

Variable	Controls (n=57)		WBB (n=51)	
	T1	T2	T1	T2
Height (cm)	162.5 ± 9.6	162.8 ± 8.6	167.5 ± 14.1	167.5 ± 13.8
Body mass (kg)	62.8 ± 11.4	63.1 ± 10.8	73.3 ± 12.1	71.7 ± 15.1
Total body fat (%)	31.1 ± 7.7	31.2 ± 7.3	27.7 ± 6.1	28.0 ± 5.7
Visceral trunk fat (%)	31.0 ± 6.2	31.1 ± 6.1	27.3 ± 6.2	31.6 ± 6.1*

T1: Pre-season; T2: Postseason; Means ± standard deviation presented.
Significant difference: p≤0.05.

Table 2. Women Basketball team (WBB) and Control's circumferences and waist/hip ratio

Variable	Controls (n=57)		WBB (n=51)	
	T1	T2	T1	T2
Thigh circumference (cm)	52.4 ± 7.2	53.7 ± 7.7	56.5 ± 8.2	55.4 ± 7.8
Hip circumference (cm)	92.6 ± 10.2	91.7 ± 9.8	97.1 ± 12.1	95.9 ± 11.7
Waist circumference (cm)	82.8 ± 7.7	81.1 ± 7.3	83.9 ± 6.1	86.9 ± 5.7*
Waist/hip ratio (%)	89.4 ± 4.0	88.4 ± 4.1	86.4 ± 3.9	90.6 ± 4.2**

T1: Pre-season; T2: Postseason; Means ± standard deviation presented.
*Significant difference p≤0.05, **Significant difference p≤0.01.

Table 3. Women Basketball team (WBB) and Control's blood pressure, heart rate, cortisol values

Variable	WBB (n=51)		Controls (n=57)	
	T1	T2	T1	T2
Systolic blood pressure (mm/Hg)	114.5 ± 3.4	119.8 ± 3.8*	111.1 ± 8.2	109.2 ± 7.9
Diastolic blood pressure (mm/Hg)	65.1 ± 3.8	69.5 ± 4.1**	68.3 ± 6.5	67.5 ± 6.2
Mean arterial pressure (mm/Hg)	81.5 ± 4.2	86.9 ± 4.3**	82.5 ± 6.0	81.4 ± 5.3
Resting heart rate (bpm)	58.4 ± 3.9	61.0 ± 3.8*	66.1 ± 6.4	66.7 ± 6.6
Cortisol (nmol/L)	7.6 ± 4.6	15.7 ± 3.9**	8.5 ± 6.5	10.7 ± 7.1

T1: Pre-season; T2: Postseason; Means ± standard deviation presented.
*Significant difference p≤0.05, **Significant difference p≤0.01.

nificant gain in right knee flexion force did cause significant changes in right knee flexion/extension ratio (59.4% to 63.8%, Table 4) when compared to the significant decreases in ratio that could be observed for the WBB. There were no significant changes in vertical jump performance for either the WBB or CT from T1 to T2. Though WBB VJ measurements decreased from 53.24 cm to 50.06 cm, this change was considered too small to be statistically relevant.

For both WBB and CT groups, bone mineral density of total body, lower body, trunk, and pelvis, had no significant changes, remaining surprisingly similar for each measurement for both WBB and CT from T1 to T2 (Table 5).

DISCUSSION

The original purpose of this study was to discover the physiological, anthropometric, biometric, and muscular strength/power changes that occur over the course of a competitive women's basketball season that plays host to one of collegiate athletics' most grueling travel schedules. Throughout the study period, the goal was also to compare the bodily changes found in those with a challenging travel schedule to their college peers of similar age who did not participate in organized collegiate athletics who could be tested at the same time as the WBB. It was originally hypothesized that the WBB group, having spent the season under the stress of travel, would show decreases in lean body mass, increases in visceral fat (specifically with no overall body fat percentage change), and significant increases in resting blood pressure as well as resting heart rate. It was also expected that the athletes would have elevated glucocorticoids present as these are the basis of many of the changes that were expected. The most relevant findings of this study were the notable increases from pre-season to post-season in trunk visceral (android) body fat despite having no changes to overall body fat percentage as well as the increases in resting heart rate and blood pressures in the players. This can be further explored by their elevated amounts of salivary cortisol in the WBB group. It should be also noted that there were no changes to fat deposition, overall body fat percentage, resting heart rate, resting blood pressure or salivary cortisol measurements in the CT group.

DXA trunk fat, waist circumference, and waist-to-hip ratio (WHR) data indicated a significant increase visceral adiposity in the WBB. A number of studies have indicated that WHR provides a strong correlation to visceral fat, despite it being a less accurate and less reliable method when compared to methods of magnetic resonance imaging, dual energy X-ray absorptiometry or computerized tomography[24, 25)]. That being said, WHR is a simple, inexpensive, and efficient method to determine changes in trunk adiposity, and could prove to be a more reliable method for predicting potential health outcomes than methods such as Body Mass Index (BMI or Quetelet Index)[26)].

The increase in resting saliva cortisol in WBB may be a result of the cortisol awakening response (CAR), a natural metabolic response initiated by negative cognitive-emotional processes that are not necessarily related to athletic competition[27)]. As stated by Kirschbaum et al., cortisol responses to single stressful incidents may not represent stable response patterns over time in young men because of the hypothalamic-pituitary-adrenal (HPA) axis is sensitive to novelty[28)]. Cortisol secretion

Table 4. Women Basketball team (WBB) and Control's performance data

Variable	Controls (n=57)		WBB (n=51)	
	T1	T2	T1	T2
Right knee extension (Nm)	122.1 ± 21.4	119.0 ± 26.1	132.9 ± 31.7	127.0 ± 27.1
Right knee flexion (Nm)	72.5 ± 19.4	75.8 ± 13.8	78.1 ± 19.4	70.8 ± 13.8**
Right knee flexion/extension (%)	59.4 ± 4.2	63.8 ± 4.3*	58.8 ± 4.2	55.7 ± 4.3**
Left knee extension (Nm)	116.7 ± 35.4	117.4 ± 32.8	126.5 ± 35.4	122.3 ± 32.8
Left knee flexion (Nm)	72.3 ± 12.8	72.0 ± 9.1	79.5 ± 13.8	72.0 ± 14.1*
Left knee flexion/extension (%)	62.0 ± 4.8	61.3 ± 4.3	62.8 ± 4.8	58.8 ± 4.3*
Vertical jump (cm)	39.3 ± 8.2	40.8 ± 7.2	53.24 ± 8.2	50.06 ± 7.2

T1: Pre-season; T2: Postseason; Means ± standard deviation presented.
*Significant difference p≤0.05, **Significant difference p≤0.01.

Table 5. Women Basketball team (WBB) and Control's bone density data

Variable	Controls (n=57)		WBB (n=51)	
	T1	T2	T1	T2
Total body bone density (g/cm^2)	1.216 ± 0.12	1.216 ± 0.13	1.282 ± 0.07	1.287 ± 0.08
Lower body bone density (g/cm^2)	1.350 ± 0.09	1.349 ± 0.10	1.473 ± 0.09	1.497 ± 0.10
Trunk bone density (g/cm^2)	0.978 ± 0.09	0.971 ± 0.09	1.053 ± 0.08	1.057 ± 0.08
Pelvis bone density (g/cm^2)	1.254 ± 0.11	1.349 ± 0.10	1.354 ± 0.09	1.497 ± 0.10

T1: Pre-season; T2: Postseason; Means ± standard deviation presented.

in response to stressful incidents is considered a healthy response[29]; and "getting used to" a novel event that was once a noticeable stressor results in "habituation", or a diminished cortisol response compared to the novel stressor[28]. Consistently high cortisol reactivity to repeated challenges, termed as "non-habituation" and it is considered an atypical response that may reflect chronic physiological stress[28]. It is a possibility that this concept of the non-habituation mechanism could have been triggered in the WBB group. Especially for young, fit females like the participants of this study, cortisol reactivity to stressors would have to be consistent and exaggerated to affect the trunk visceral fat, or android fat cells enough to increase significant fat volume of the trunk[30]. An important observation here is that must be touched on is that the majority of data that is currently published which concern fat distributions, fat distribution changes, and central adiposity and its implications are focused on middle-aged to older females. As of the time of this study, there is relatively small amount of data published that is related to these changes in younger participants, such as female college students.

It is certainly feasible that elevated levels of cortisol in the WBB could be attributed to the eastwardly multi-time zone changes that these athletes were subjected to many times throughout their competitive season. In humans, cortisol functions through a very distinct circadian secretory cycle, with the acro-phase occurring shortly after sunrise and diminishing over the course of each day, with nadir generally at sundown[31]. With the addition of airline travel, the ability to fly across multiple time zones in a matter of hours could be categorized as no less than a shock to the chronobiology of the human body, resulting in impactful disruptions. Flying east through several time zones is particularly disruptive of this circadian rhythm, and with occurrences such as the sunrise and physical activity beginning hours earlier than the starting time zone significantly affects this cycle, and may cause an earlier and more intense rebound effect. Leproult et al. found that sleep deprivation (particularly in eastern travel) and the shortening of the day causes significant alterations in cortisol levels, and concludes that a change in negative cortisol feedback regulation drastically affects the resiliency of the stress response as well as accelerating the production of cortisol[32]. The body's "internal clock", referred to as the suprachiasmatic nuclei (SCN) of the hypothalamus, is typically programmed to follow input from the retinohypothalamic tract, which is affected by light[33]. Both cortisol and melatonin (the hormone responsible for drowsiness among other functions) are controlled by the synchronization of the SCN, as are various other hormones. The stress on the SCN, caused by the eastern multi-zonal flights done by WBB, could possibly be responsible for the increased resting salivary cortisol levels found in this study, and could also contribute to the increased trunk visceral fat levels that result in an increased WHR. In addition, the increased resting HR and BP found in this study could also be partially attributed to the grueling eastward travel schedule due to the relationship of HR and BP with elevated levels of cortisol.

Travelling at altitude for 3 or more hours regardless of direction has been shown to affect the body in a way that results in a decline in oxygen saturation and an increase in glucocorticoid levels, as well as a short-term significant decline in aerobic performance[14, 15]. Regulatory guidelines for airline cabin pressurization state that cabins and compartments should be pressurized with a maximum altitude of 2,440 m (8,000 ft), however average cabin pressures are usually set at 1,520–1,828 m, which is the equivalent to an inspired oxygen pressure (PO2) of about 130 mm Hg (as compared to 159 mm Hg at sea level). In studies showing declination of oxygen saturation by pulse oximetry in elite athletes, significant decrements were observed after 3 h flight time, and that these lower levels reflect acute exposure to hypoxia at altitude[14, 34]. Time spent on long flights is to be viewed as time spent at altitude, and could be a potential factor in the overall stress response of the WBB throughout the course of their competitive travel season.

Over the course of this study, the WBB had a competitive record of 56–70. What is interesting is that the home record was 35–26, whereas the travel record was 20–45. In the opinion of the UHH athletic department, there were no indicators that pointed to the WBB playing better teams when on the road, as many of the teams were played multiple times throughout the season, some of the games being at home and others being away. It is hypothesized that disparate success at home (57.4% wins) versus on the road (30.8%) could partially be due to chronobiological alterations and is in keeping with a number of other resources[12, 37].

Jet lag is described as a circadian phase disruption that occurs when an individual experiences an alteration of external signals and cues that synchronize the body clock, the chronobiological circadian rhythmicity[16]. Disruptions like this typically take place when an individual partakes in rapid air travel spanning multiple time zones, and often results in symptoms such as fatigue, sleep pattern abnormalities, loss of concentration, loss of mental drive, gastrointestinal distress, loss of appetite, headaches, and metabolic changes including increased mean arterial blood pressure, resting heart rate, and increased glucocorticoid counts[10, 35, 36]. All of these symptoms were shown throughout this study.

While a high percentage of losses when playing games on the road can be partly contributed to by the chronobiological effects given by jet lag and travel fatigue, there is another factor that could influence the post season elevated levels of glucocorticoids: when facing a difficult game schedule, particularly on the road, repeated losses can stimulate feelings of depression and a very real lack of motivation or will to compete, which can stimulate glucocorticoid production. That is to say that it is possible that when an athletic team is performing at a subpar level, the expectation that upcoming performances will result in further losses could stimulate glucocorticoid production that is separate from the changes caused by chronobiological factors.

The performance criteria of isokinetic knee flexion and extension resulted in significant decreases (also resulting in decreases in knee flexion/knee extension ratios). Furthermore, it should be also noted that although it was not statistically significant, vertical jump decreased 3.18 cm on average.

There is a paucity of similar studies of female basketball athletes' performance responses to a season. The most similar studies have been of college soccer players, and it was observed in these studies that the players had reductions in certain performance values[38, 39)]. Furthermore, it was surmised that an acute overtraining syndrome produced from pre-season conditioning and the catabolic demands of training demands of the season may have been the cause of these changes, and may well have played an un-measurable role in the WBB declinations. That being said, UHH is a Division-II school where the athletic budget is extremely limited, and access to state-of-the-art training facilities and programs simply is not possible, resulting in an undemanding pre-season/in-season resistance-training program. In addition, the travel schedule effectively erases any possibility for meaningful resistance training over the course of the competitive season. Despite this though, the travel schedule itself could be one of the major factors in the WBB performance declinations over the course of the measured competitive season.

It should be noted that controls were chosen from the students who were taking 12 to 16 credits and most of them did not take the same exact courses as the basketball players. Therefore, arguably, controls might have had different psychological loads and/or stressors than WBB. Furthermore, although participants were well informed about the importance of high-quality sleep and nutrition prior to the testing sessions, no pre-testing data were collected to ensure that the given instructions were followed.

All of these above-mentioned factors were the limitations of this study and might have had significant effects on the results obtained.

Over the course of a collegiate basketball season, athletes are exposed to a myriad of physical and psychological stresses. Due to them being college students, they have all of the usual pressures that are caused by college life, such as academic responsibilities, managing a healthy social life, and pursuing professional goals. Not only do they have these stressors, but they are also subjected to the stressors that accompany being a part of a team and as well as the pressures of performing at a competitive level on a near-daily basis. What is interesting about the stressors in the case of these college athletes is that they also have the additional challenges that stem from having an intense travel schedule that spans multiple time zones, at the bare minimum 3, and having that travel primarily going in the eastward direction. Although this study did not measure the responses to a single 2-week eastern flight, results showed that after a full-length travel heavy competitive season, female collegiate basketball players exhibited negative anthropometric, biometric, performance, and circulatory changes.

Due to there being a paucity of comparable data of female athletes' response to a less arduous travel schedule during a season, it is difficult to discern how much the chronobiological stress of travel effected the athletes on its own, but jet lag and travel fatigue have noticeable negative effects on athletic performance of athletes following eastern travel across time zones due to the specific effects that are caused by the desynchronization of the circadian rhythm. The bulk of the research that investigated the effects of such visiting road trips and effects on athletes has dealt largely in the acute effects of stress during the travel period. In contrast, this study deduces that is possible that chronic effects could be caused by these extensive travel periods throughout competitive seasons, including increased resting heart rate and blood pressure, diminished strength and power, and, importantly, increased glucocorticoid production and resultant increases of android body fat. Not to be overlooked is the possibility that such travel and physiological changes may affect a team's overall performance. This investigation deduced that a collegiate basketball team's likelihood of success and optimal performance was heavily impaired by such rigorous travel schedule. Due to their status as young, fit, college females, the likelihood of their long-term health concerns are not yet realized due to the mere up to 15 weeks of the year that are dedicated to in-season play.

What could prompt further investigation would be data on the effects of an even more arduous travel schedule, especially eastward travel, on professional athletes that play many more games over the course of one season, and play for many more seasons than a typical female collegiate basketball player. This idea of investigating the effects of considerable amounts of air travel could be extended beyond the scope of sports. As shown in the literature, businessmen and businesswomen who frequently fly from west coast to east coast as part of their professional schedules for their careers have shown noticeable health detriments attributed to chronobiological disruptions.

It is crucial for coaches and athletic support teams to have an in-depth understanding of the effects of eastward travel, jet lag, and travel fatigue, and to develop systems and strategies that can limit the plethora of negative outcomes associated. Samuels has suggested countermeasures to provide some practically applied methods of implementing a travel management program for athletic teams[12)]. Some of these include a preflight plan component: teams adopting modified training routines that incorporate reduced volume and intensity, emphasizing getting enough sleep (and, if possible, mimicking the destination sleep pattern as much as possible) before travel to reduce sleep debt and stress levels. The next management component is modulating in-flight activities so as to assist athletes in minimizing stress insults and optimize recovery and adaptation. In addition, advising athletes to use tools of stress reduction is advised, such as adjusting all time devices to the destination time zone at boarding, creating as comfortable an environment possible, including used of pillows and elimination of distractions (e.g., electronic devices), and employing eyeshade and earplugs and noise-canceling listening devices to accentuate relaxation. Included in the in-flight component is to eat as closely to the destination schedule as possible, which may mean having athletes bring aboard their own meals to control eating times. Samuels implores maintaining proper hydration as one of the highest priorities, especially since airline cabins are usually low in humidity and athletes lose much fluid through insensitive sweating. As with eating, it is suggested that sleeping onboard should occur according to the destination schedule, and to facilitate, the strategic use of sedatives and/or melatonin and blindfolds are recommended.

This study also showed that the WBB were prone to noticeable hamstring strength reduction, though no significant quadricipital strength loss, which results in a noticeably reduced knee flexion/knee extension ratio. This bears importance from an injury prevention perspective. The exact mechanism for this result is unclear, but it may include over-training, selective undertraining of the hamstrings, selective fatigue, and the biomechanics of jumping as possible factors that effect this ratio. It is crucial that the athletic training staff understands this as a possibility and acts accordingly to maximize safety and prevent injury. This may involve performing tests periodically at points throughout the season to ensure there is not an overabundance of strength or a lack thereof in either muscle group, and develop an appropriate prophylaxis to reduce the possibility of knee or hamstring injury.

In summary, a collegiate basketball season with an arduous eastern multi-time-zone flight travel schedule has been proven to be an significantly stressful ordeal on the athletes' bodies resulting in a vast array of declinations in general health profiles, such as increased glucocorticoid levels (particularly cortisol), increased android trunk fat percentage despite there being no significant changes in overall body fat percentage, increased resting blood pressure as well as resting heart rate, and even decreased performance values when measuring knee flexion/extension maximal strength. While it has been acknowledged in the literature that being a full-time college student can be an intermittently stressful experience on its own, the student athletes that were selected for this study exhibited very significant negative responses during the period of the competitive WBB seasons compared to their non-athlete peers who were studied and measured during the same time period.

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Conflicts of interest

The authors declare no conflict of interest for this study.

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