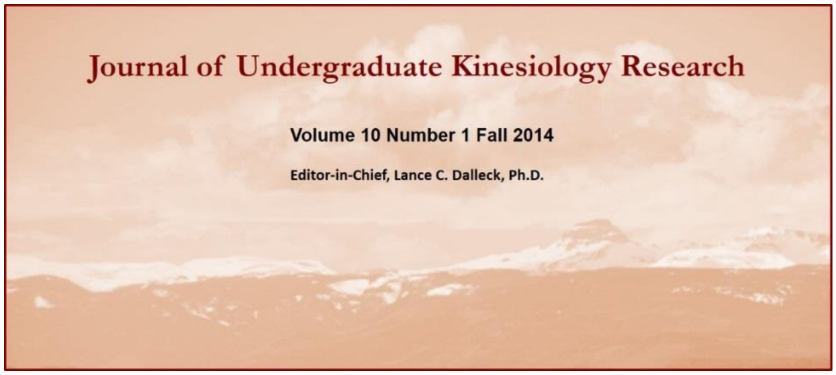

IMPACT OF NON-TRAINING PHYSICAL ACTIVITY ON MENSTRUAL DYSFUNCTION IN COLLEGIATE CROSS-COUNTRY RUNNERS

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ABSTRACT

Nell A, Soresnsen J, Albrecht K, Kompelien A, Aschenbrenner R. *Journal of Undergraduate Kinesiology Research 2014*; (10)1:40-51. **Purpose:** The Female Athlete Triad (Triad) is highly prevalent in collegiate cross-country runners and has a multitude of negative health ramifications. Menstrual dysfunction is one component of the Triad and is highly influenced by energy availability. The purpose of this study was to measure non-training physical activity (NTPA; defined as any activity outside of scheduled practice including light-intensity daily physical activities) using accelerometers as a predictor of menstrual dysfunction. **Methods:** A total of 22 female cross-country athletes (ages 18-23 years) participated in this study. This study was designed with three independent variables: EAT-26 scores (needing referral vs. not needing referral), NTPA (kcals/day), and skeletal muscle mass (SMM; kg) impacting menstrual status (no menses missed in the past 12 months, 1-5 menses missed, and ≥ 6 menses missed). Multinomial logistic regression was employed with alpha level of .05. **Results:** Examination of the classification table illustrated that 66.7% of participants having normal menstrual status, 66.7% having 1-5 missed menses in the past 12 months, and 71.4% having missed ≥ 6 menses in the past 12 months were correctly classified. Overall, 68.2% of participants were classified correctly with respect to their menstrual status. The Nagelkerke R^2 measure of strength of association revealed that 41.6% of the variance in menstrual status was explained by this 3-variable regression model. According to the Wald criterion, NTPA, SMM, and EAT-26 were not significant predictors of a menstrual status 1-5 menses missed in the past 12 months. However, NTPA significantly predicted a menstrual status of missing ≥ 6 menses in the past 12 months, while controlling for SMM and EAT-26. More specifically, the greater amount of

NTPA increased the odds of missing ≥ 6 menses, Wald (1, N =22) = 3.87, p = .049. **Conclusions:** The present data suggest, that with eating behavior and SMM accounted for, an increased amount of NTPA significantly influenced menstrual irregularities, particularly the more severe state of missing 6 or more menses in a given year. Monitoring activity levels outside of training is necessary to avoid menstrual dysfunction among female cross-country runners.

Key Words: body composition, eating attitude, energy availability, female athlete triad, accelerometer

INTRODUCTION

While exercise produces a multitude of benefits for females, excessive exercise along with diet restriction can produce deleterious health effects such as changes in hormone levels. Hormonal imbalances may in turn affect the reproductive system, potentially causing menstrual dysfunction that could lead to complete loss of menses, termed amenorrhea (1). The Female Athlete Triad (Triad) showcases this abnormality, along with its interaction with two other components: low energy availability (lacking dietary energy necessary for body functions) and compromised bone mineral density (amount of mineral matter per square centimeter of bone) (2).

The Triad predominantly affects young female athletes. The “prevalence of amenorrhea increases from 3% to 60% as training distance increases”, which puts young cross-country runners at great risk of developing menstrual dysfunction (3). Furthermore, research supports that “athletes who appear to be at the greatest risk of developing menstrual dysfunction usually begin training prior to menarche” (1). Risk factors for developing the components of the Triad include but are not limited to: bone mineral density of < 1 mg/cm^2, a body mass index (BMI) < 21 kg/m^2, 12 or more hours of purposeful exercise per week, participation in sport or activity that emphasizes leanness, elevated dietary restraint, and presence of oligomenorrhea/amenorrhea (4).

Cross-country running emphasizes leanness, and practices often exceed twelve or more hours each week. However, energy expenditure encompasses movement outside of scheduled practice, and since the Triad “starts with low energy availability (with or without eating disorders), which in turn causes amenorrhea and a reduction in estrogen levels,” accounting for all activity is necessary for accurately measuring energy availability (3). Non-training physical activity (NTPA) is defined by the authors of this article as any activity outside of scheduled practice including light intensity daily physical activities and accumulates over time.

The main purpose of this study examined the correlations between NTPA and menstrual dysfunction among female athletes at a collegiate level, ages 18-23 years. Data were analyzed to determine how given levels of NTPA affect menstrual dysfunction while accounting for structured training time and energy intake. Little, if any, research has been done regarding activity outside of scheduled practices as one of the potential contributors to negative energy balance. As Márquez and Molinero (2013) found, “the main element underlying all the aspects of the [Triad] is low energy availability, so that loss of caloric balance results in menstrual dysfunction and, therefore, inadequate estrogen production and loss of bone health” (3). Thus, menstrual dysfunction could lead to a struggle with other components of the Triad. This study hypothesized an increased amount of NTPA would correlate with menstrual irregularities.

METHODS

Participants

After gaining permission from the cross-country coach at a university in the Midwest region, participants were recruited through verbal request at a weekly team meeting. Each collegiate athlete was given a cover letter and informed consent by the investigators. The protocol and requirements were explained to them, and informed consent was signed by each volunteer prior to beginning data collection. The purpose and the hypothesis of the study were withheld to keep participants from changing any behavior while participating. The protocol was approved by the Institutional Review Board.

The sole inclusion criterion for this study entailed being a female collegiate cross-country runner who engaged in structured training on a regular basis. Participant age, number of years dedicated to running on a cross-country team, and age of menarche were self-reported at the beginning of the study (Table 1).

Table 1. Characteristics of the 22 female college cross-country runners included in the study.

Variable	Mean ± SD
Age	19.36 ± 1.40
Years on a Cross-Country Team	5.78 ± 2.05
Height (cm)	167.87 ± 8.50
Body Mass (kg)	57.88 ± 7.31
BMI (kg/m^2)	20.49 ± 1.96
Age of Menarche (years)	14.41 ± 1.84

Measurements and Testing

Body Composition. The InBody 770 is a body composition analyzer used to obtain participant mass (kg), skeletal muscle mass (kg), body mass index (BMI), body fat percent, and basal metabolic rate (BMR). This technology provides impedances and reactance values by segments and at multiple frequencies. This eight-polar bioelectrical impedance analyzer (BIA) InBody has a .984 correlation coefficient with dual energy X-ray absorptiometry, which is the gold standard equipment for whole body composition analysis.

The InBody 770 was operated by the qualified investigators conducting this study and was used during the initial assessment portion of the study. All initial assessments were taken in the early morning to ensure that participants had fasted for a minimum of eight hours. Participants were asked to be adequately hydrated, to wear lightweight clothing (shorts and a T-shirt), and to remove jewelry and shoes upon arrival. A basic Seca stadiometer was used to measure height of each participant. This measurement was necessary to input into the InBody 770 machine prior to beginning the test. Participants used an antibacterial InBody Tissue on the soles of their feet and the palms of their hands for sanitation purposes and to assure proper electrical conductivity. While administering the one-time, 45-second long InBody test, the screen was covered with a piece of paper to prevent participants from viewing their results and possibly modifying their eating behaviors or physical activity levels in response to their results. Participants were told they would be given their results after the completion of the study during a debriefing session.

Non-Training Physical Activity. Participants wore actical accelerometers outside of their designated practice times for four consecutive days to measure NTPA. The actical monitors are water resistant, lightweight (17.6 g), small (28 x 27 x 10 mm^3), and have a data storage capacity of 32 MB. Programming of the actical accelerometers, along with downloading data, took place using a serial port computer interface. Excel spreadsheets held exported data for analysis. This multidimensional device allows for measurement of physical activity and energy expenditure by recording the degree and intensity of movement in an “activity count”. The activity counts measured movement every 60 seconds. Each actical device was preset with the height, weight, and age of participant before being distributed for monitoring. The participants wore the devices securely on their right hip based on previous research conducted supporting increased accuracy of predicting energy expenditure using actical accelerometers (5). Qualified investigators instructed proper use of the actical accelerometers and monitored collected data on a daily basis using the following process.

Data from the initial assessments was programmed into an accelerometer for each participant to ensure individualized kcal measurements. The investigators distributed each calibrated device to its respective runner after practice on the first day of NTPA monitoring. Participants were asked to wear the device at all times except when swimming, bathing/showering, or during their designated practice time. If they took off the accelerometer for any of these reasons, the amount of time and reason the device was taken off was recorded. Participants also were asked to record the time they woke up each morning, the time they went to bed each night, and the time and type of training outside of scheduled practice each day if applicable.

Before scheduled practice times, participants returned the accelerometers to investigators for data retrieval. At the end of practice, accelerometers were redelivered for the participants to wear until the next practice. This procedure was followed for the subsequent three days. Energy expenditure and average energy expenditure were determined via accelerometery (actical accelerometers) in the following manner. Total energy expenditure (kcals) of the four days was determined by multiplying the energy expenditure recorded by the accelerometers (kcals/min/kg) by the participant's mass. Average energy expenditure was then calculated by dividing total energy expenditure by four.

One limitation of the accelerometers is that the devices do not measure cycling activity, therefore participants recorded the total duration biked during the four days of measurement. Time spent biking per day was calculated by averaging time spent biking for the week. To calculate energy expenditure during cycling, the number of minutes and speed were computed by myfitnesspal (http://www.myfitnesspal.com/). Adding energy expenditure from cycling to the energy expenditure in of NTPA/day from the accelerometers yielded total expenditure. Positive energy availability was calculated by subtracting total expenditure by intake/day. Total daily expenditure accounted for caloric expenditure measured by the actical accelerometer, kcals spent biking, and BMR.

Calcium/Vitamin D_3 Intake. Each participant completed food logs on randomly assigned days during the monitoring week for NTPA; two occurred on weekdays and the last one on a weekend day to measure dietary caloric intake (6) and dietary calcium intake (7). After completion of each food log, it was retrieved for analysis. Recording names/brands of food eaten, liquids consumed, quantity, and serving size, as well as any calcium or vitamin D_3 supplementation within a 24–hour time frame provided the information to calculate caloric dietary intake on myfitnesspal. The rapid assessment method (RAM) calculated dietary calcium intake. It assigns calcium values for serving sizes of various foods (8). Each group of food needed to be matched with a value in order to record number of servings and amount of calcium in each food item for data analysis. After summation of these values, averages of daily caloric and calcium intake were found by dividing each respective total by three. To classify as meeting calcium recommendations, participants needed an average daily calcium intake $\geq$1200mg.

Menstrual Dysfunction. Participants reported their age at menarche, the date of their last menstrual period, and if they missed a menstrual period within the last 12 months via a questionnaire. If they answered “yes” to missing their period within the past 12 months, participants marked how many menstrual periods they missed by choosing between the following responses: >9 menses in past 12 months, 6-9 menses in past 12 months, or < 6 menses in past 12 months. Additionally, participants responded to whether or not they have ever used birth control, if they were currently taking birth control, and if yes, for how long. Those participants who reported taking birth control indicated why they were taking birth control by choosing between these responses: for contraceptive purposes, for acne treatment/diminish premenstrual syndrome symptoms, or to induce a menstrual period/keep it regular.

Eating Attitude. Implementation of the Eating Attitudes Test (EAT-26) examined participant’s eating patterns and attitudes. The EAT-26 is an abbreviated, more recent version of the EAT-40, created by Garner, Olmstead, Bohr, & Garfinkel (1982) (9). It assesses distorted body image, tendency toward bulimic behavior, and self-control behavior such as dieting in three parts (10). Part A of the EAT-26 requires date of birth, gender, height, current weight, highest weight (excluding pregnancy), lowest adult weight, and ideal weight. Part B consists of 26 statements pertaining to eating patterns, attitude towards eating, and perception of body image using a 5-point Likert Scale of “Always,” “Usually,” “Often,” “Sometimes,” “Rarely,” or “Never”. Self-reflection questions in Part C of the EAT-26 necessitate thought of eating, exercise, and dieting behaviors within the past six months. The first four of five questions in Part C use a 5-point Likert Scale of “Never,” “Once a month or less,” “2-3 times a month,” “Once a week”, “2-6 times a week,” or “Once a day or more.” The fifth question requires a “Yes” or “No” answer. To prevent participants form altering responses, participants took a paper version of the test with no title. After participants completed the EAT-26, the website scored each questionnaire accurately based on the answers entered in from the three parts of the questionnaire. The given “referral index” takes into account the total score from answers on the EAT-26, answers to the behavioral questions related to eating and weight loss, and the BMI calculated from self-reported height and weight.

Statistical Analyses

This study is correlational in nature with three independent variables: (1) EAT-26 scores, (2) NTPA, and (3) skeletal muscle mass (SMM; kg) impacting the dependent variable, menstrual status (no missed menses; missed 1-5 menses; or $\geq$ 6 missed menses in the past 12 months). Multinomial logistic regression was employed with alpha level of .05. Data were analyzed using SPSS version 19.0.

RESULTS

Descriptive Statistics

Of the 30 athletes on the women’s cross-country team from a university in the Midwest region, 25 agreed to participate in the study. Twenty-four attended the initial assessment, and 22 participants completed the study (91.67% compliance). The mean $\pm$ standard deviation age of participants was 19.36 $\pm$ 1.40. BIA, diet record, and accelerometer data are presented in Table 2. Categorization of study participants based on nutritional behaviors/beliefs and menstrual status are presented in Table 3.

Table 2. BIA, diet record, and accelerometer data (*n*=22). Abbreviations: % BF = body fat percentage; BMR = basal metabolic rate; NTPA = non-training physical activity.

Variable	Mean ± SD
% BF	18.02 ± 3.80
Skeletal Muscle Mass (kg)	26.34 ± 3.49
BMR (kcals)	1391.41 ± 126.84
Calcium Intake/Day (mg)	850.86 ± 318.96
Caloric Intake/day (kcals)	1943.00 ± 518.96
NTPA (kcals/day)	424.62 ± 91.25

Table 3. Categorization of study participants based on nutritional behaviors/beliefs and menstrual status (*n*=22). * -- Calcium recommendations are > 1200 mg/d for teenagers or adults up to 24 years of age.

Variable	Classification	%	*n*
Energy Balance	Meeting BMR	86.4	19
	Not Meeting BMR	13.6	3
Calcium Intake	Meeting 1200mg/d*	22.7	5
	Not Meeting 1200mg/d	77.3	17
Menstrual Status	No missed menses	40.9	9
	Missed 1-5 menses	27.3	6
	Missed $\geq$ 6 menses	31.8	7
EAT-26	Needing Referral	31.8	7
	Not Needing Referral	68.2	15

Impact of NTPA on menstrual status

Multinomial logistic regression analysis was performed initially to estimate menstrual status (no missed menses; missed 1-5 menses; or $\geq$ 6 missed menses in the past 12 months) based on NTPA (kcals/day), while controlling for SMM (kg) and EAT-26 (needing referral vs. not needing referral) values. Examination of the classification table (Table 4) from the analysis demonstrated that 66.7% of participants who were categorized as having normal menstrual status, 66.7% of participants who were categorized as missing 1-5 menses in the past 12 months, and 71.4% of participants who were categorized as missing $\geq$ 6 menses in the past 12 months were classified correctly. Overall, 68.2% of participants were classified correctly with respect to their menstrual status. The Nagelkerke R^2 measure of strength of association revealed that 41.6% of the variance in menstrual status was explained by this 5-variable regression model.

Table 4. Classification table for menstrual status (*n*=22)**.** The “percentage correct” columns equals the percentage correctly classified for each of the three groups.

Observed menstrual status (past 12 months)	**Predicted menstrual status**			
	None missed	**Missed 1-5 menses**	**Missed $\geq$ 6 menses**	**Percentage correct**
No missed menses (%)	6	1	2	66.7
Missed 1-5 menses (%)	2	4	0	66.7
Missed $\geq$ 6 menses (%)	2	0	5	71.4
Overall (%)	45.5	22.7	31.8	68.2

Table 5 presents regression coefficients, Wald’s statistics (a test of significance of each independent variable in the model), and odds ratios for the predictor and control variables in the logistic regression analysis for menstrual status. According to the Wald criterion (the criterion value to reject the null hypothesis that a particular effect coefficient is zero), NTPA, SMM, and EAT-26 were not significant predictors of a menstrual status < 6 menses missed in the past 12 months, *Wald* (1, *N* = 22) = .93, *p* =

.335 *Wald* (1, *N* = 22) = .40, *p* = .530, and *Wald* (1, *N = 22*) = .26, *p* = .108, respectively. According to the Wald criterion, greater NTPA significantly predicted a menstrual status of missing ≥ 6 menses in the past 12 months, *Wald* (1, *N* = 22) = 3.87, *p* = .049. In contrast, SMM and EAT-26 scores were not significant predictors of missing > 6 menses in the past 12 months, *Wald* (1, *N* = 22) = 1.41, *p* = .235 and *Wald* (1, *N = 22*) = .21, *p* = .648, respectively.

Table 5. Results of logistic regression predicting menstrual status (*n*=22). Abbreviations: B = regression coefficient; O.R. = odds ratio; SE = standard error; SMM = skeletal muscle mass.

Variable	B	SE	Wald	O.R.	*p*
Menstrual Status: missed < 6 menses in past 12 months					
(Constant)	0.92	4.73	0.37		.847
Daily NTPA (kcals/day)	0.01	0.01	0.93	1.01	.335
SMM (kg)	-0.15	0.24	0.40	0.86	.530
EAT-26 (Parts B & C)					
No Physician Referral	-2.08	1.30	2.58	0.13	.108
Physician Referral	reference				
Menstrual Status: missed ≥ 6 menses in past 12 months					
(Constant)	-3.33	4.78	0.49		.486
Daily NTPA (kcals/day)	0.02	0.01	3.87	1.02	.049
SMM (kg)	-0.25	0.21	1.41	0.78	.235
EAT-26 (Parts B & C)					
No Physician Referral	0.82	1.80	0.21	2.28	.648
Physician Referral	reference				

DISCUSSION

Impact of NTPA on menstrual health

The purpose of this study was to determine whether NTPA played a significant role in determining menstrual function of collegiate cross-country runners. An observed 31.8% of participants missed 6 or more menses in the past 12 months. These results compare to previous studies completed by Hoffman, Wolcott, and Lannen (1998) and Thompson (2007) who also studied menstrual dysfunction in the female collegiate cross-country population. They found 33% were amenorrheic or oligomenorrheic and 23% had irregular menstrual cycles, respectively (11, 1). Missing menstruation in this severity is associated with risk of osteopenia and foreshadows osteoporosis along with other health complications (12). The two most common health problems correlated with low hormone levels are decreased bone mineral density and increased risk for musculoskeletal injuries (13). Due to sustaining a musculoskeletal injury, athletes may have to modify or cease exercise which may lead to chronic diseases such as hypertension, diabetes, and obesity (14). With eating attitude scores and lean body mass accounted for, an increased amount of NTPA significantly influenced menstrual irregularities, particularly the more severe state of missing more than 6 menses in a given year. The current finding demonstrates higher level of NTPA as potential contributor of negative energy balance, which is associated with menstrual dysfunction (15) leading to developing the Triad among athletes.

Health status and calcium outcomes

The average body fat percentage was 18.02 $\pm$ 3.80. This classifies individuals at the low end of optimal health and in the lean category. Our participants represent a lean population with high SMM considering their training program focuses on building lean muscle mass. Having high SMM leads to a higher BMR (16). This factor impacts energy availability, which is especially important considering that 13.6% participant's daily caloric intake did not meet BMR. Further, 77.3% of the participants did not meet the calcium recommendation of 1200mg/day for teenagers and adults up to 24 years of age. This finding is a major concern because adequate calcium consumption improves bone health which lessens frequency of bone stress injuries (BSIs) (17). A key component of the Triad is the relation of low bone mineral density to menstrual dysfunction (3); hence, examining calcium intake was a variable worth measuring.

Energy availability status

Due to participants' in-season training convenience, the present study did not involve accelerometry monitoring during the structured team practices. Despite the fact that caloric expenditure from scheduled practice times was not factored into total caloric expenditure, close to half of the participants were in a state of negative energy availability, re-emphasizing the importance of educating female athletes to be aware of adequate caloric intake to balance caloric expenditure associated with in-season training regimen (18). Educating athletes is imperative to reduce frequency of the Triad and prevent the menstrual dysfunction attributed to causing other repercussions such as BSIs in female athletes (19). Increased knowledge and a better understanding about the interaction of the factors putting female athletes at risk will enhance effectiveness of education efforts. Gaps still exist in how menstrual dysfunction, low energy availability, and compromised bone mineral density interrelate (3).

Strengths and Limitations

The use of accelerometers to examine NTPA among college-level cross-country female runners makes this present study novel. Participants wore actical accelerometers for four days, which, according to Matthews et al. (2002), achieves a reliability of .80 for measuring daily energy expenditure (20). In addition, the cross-country team was an appropriate target population due to the prevalence of the Triad in sports that emphasize leanness (21). This study also accounted for factors other than NTPA, including calcium intake, BMR, caloric intake, and the EAT-26 (Parts B & C). By controlling these factors that have the potential to contribute to menstrual dysfunction in female collegiate cross-country runners, NTPA was isolated.

One limitation of this study is the self-reporting nature of food logs. No previous research validates the use of myfitnesspal to estimate daily caloric intake. Although participants were compliant in completing food logs over three randomly selected days (two weekdays and one weekend day), minimal reporting of food brands and serving sizes reduced the accuracy of estimating caloric intake each reported day. Future research should account for this limitation and set aside time to meet with each participant upon completion of their food log each day. During this meeting, the investigators should review with the participant that the food names/brands and serving sizes are all accounted for to ensure accuracy of caloric intake per day. Additionally, myfitnesspal was used to estimate activity energy expenditure during biking or swimming based on the athletes' self-reporting of activity. We also acknowledge the limitation of having a small sample size (n = 22) which limited the ability to have greater number of sample size per category of menstrual status in the analysis. A larger sample size would provide more opportunity to find significant correlations impacting menstrual function. Having a bone density scanner to compute z-scores would allow for accurately assessing bone health as one of the critical components of the Triad.

CONCLUSION

Almost one-third of the participating cross-country runners missed 6 or greater menses in the past 12 months which correlated with increased levels of NTPA. This has implications for current musculoskeletal health and performance as well as future bone health and prevention of other health complications.

Extending the time in which participants wear the accelerometers would provide more consistent NTPA and stronger statistical significance. More accurate ways of measuring caloric, calcium, and Vitamin D_3 intake should be employed in the future, such as an analysis performed by a licensed dietician, to accurately compute energy balance. Future research should include various athletic populations, such as dancers, gymnasts, divers, swimmers, and figure skaters in addition to cross-country runners as these athletes are also highly susceptible to developing the Triad (1,20). A longitudinal intervention study would help to illustrate how behavior changes toward physical activity and eating behaviors impact menstrual status, and ultimately bone health status.

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