



RESEARCH ARTICLE

Within-Day Energy Balance in Mexican Female Soccer (Football) Players - An Exploratory Investigation

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Background

To assure optimal performance and reduced risk of illness and injury, athletes require a food and fluid intake that optimally satisfies normal physiological requirements plus the additional demands of physical activity. Both macronutrient (i.e., carbohydrate, fat, and protein) and micronutrient (i.e., vitamins and minerals) intakes are essential for maintaining health, optimal body composition, and the desired athletic performance [1-3]. Female athletes have been found to be at risk of restrictive eating behaviors that fail to optimally satisfy energy needs, resulting in multiple health and performance problems that include dysmenorrhea, low bone mineral density, higher injury risk, poor recovery from exercise, and higher risk of developing an eating disorder [4-6]. These athletes may experience eating anxiety, fearing that consumption of exercise appropriate foods will increase weight and negatively alter body composition [7-9]. Female athletes who have chronically experienced an inadequate level of energy consumption appear to have compensatory/adaptive mechanisms that allow them to sustain a relatively stable weight and body composition. This is likely the result of a reduction in resting metabolic rate and improved exercise efficiency, but also the result of negative alterations in energy-reliant reproductive function [10-12].

The traditional means of assessing athlete energy intake adequacy has been through the analysis of 24-hour food records or food recalls, coupled with an es-

timate of energy expended during the same 24-hour period. The result is an estimate of 24-hour energy balance (energy consumed - energy expended), to determine the adequacy of energy consumption [13,14]. However, this 24-hour assessment system fails to consider the real-time endocrine responses that occur with large energy surpluses or large energy deficits. For instance, an athlete who eats a large dinner but little before that may spend most of the day in a significant energy balance deficit, despite appearing to be in a 24-hour energy balance [15]. Such an eating pattern would produce low blood sugar during the day, which would result in an elevated serum cortisol that is associated with low bone mineral density, catabolism of lean mass, and reduction in estrogen production.¹⁵To compound these problems, the low blood sugar is likely to result in a hyperinsulinemia response at the next eating opportunity, which is associated with increased fat storage. In addition, the appetite stimulating hormone, ghrelin, is turned off with a normoinsulinemia, but remains elevated with hyperinsulinemia, resulting in greater food consumption than normal [15,16]. None of these possible outcomes could be adequately predicted through a 24-hour energy balance assessment, and none are desirable outcomes for the athlete.

There is an increasing body of evidence that assessing energy balance at a more real-time interval (i.e., hourly) is effective at determining relative energy deficiency and associated problems [4,14,15,17,18]. For instance, a recent study by Fahrenholtz, et al. assessed a

Table 1: Subject age, height, weight, and BMI (N = 8).

Measure	Mean	Standard deviation	Range
Age (yr)	22.5	3.9	19-31
Height (cm)	161.8	8.9	150.0-174.0
Weight (kg)	61.9	9.5	50.5-78.8
BMI	23.8	3.9	18.0-31.0

Table 2: 24-Hour and Within-Day Energy Balance (EB) Values (N = 8).

Value	Mean	Stand Dev	Range
24-Hour EB (Kcal)	-685.1	372.5	-1196 to +50
Kcal/Kg Total	20.2	5.6	12.3 to 30.2
Kcal/Kg While Active	3.6	2.7	0.0 to 6.5
Hr +/- 400 Kcal EB	16.3	4.5	8.0 to 24.0
Hr > 400 Kcal EB	0.0	---	---
Hr < 400 Kcal EB	7.8	4.5	0.0 to 16.0
Hr Anab (> 0 Kcal EB)	5.3	5.5	2.0 to 17.0
Hr Catab (< 0 Kcal EB)	18.8	5.5	7.0 to 22.0

EB = Energy Balance; Hr = Hours; Anab = Anabolic (above 0 Kcal EB); Catab = Catabolic (below 0 Kcal EB).

Table 3: Spearman Correlations Between BMI and Within-Day Energy Balance Values (N = 8).

	EB +/- 400 Kcal	EB < -400 Kcal	EB > 0 Kcal	EB < 0 Kcal
BMI				
Corr	r = -0.393	r = 0.393	r = -0.766	r = 0.766
Signif	p = 0.336	p = 0.336	p = 0.027	p = 0.027

group of female athletes who were all in a 24-hour state of energy balance, but with some having menstrual dysfunction and others without menstrual dysfunction [17]. It was found that the females with menstrual dysfunction spent significantly more hours in energy deficits exceeding -300 kcal energy balance, had significantly lower resting metabolic rate ($p = 0.018$), significantly higher serum cortisol ($p = 0.019$), and significantly lower estradiol ($p = 0.009$), when compared to female athletes with normal menstrual function who had fewer hours in a state of negative energy balance during the day.

Study Protocol

It was the purpose of this exploratory investigation, therefore, to perform an hourly assessment of energy balance in a group of Mexican female soccer players (N = 8; Ages 19-31 y) to determine if these initial findings would warrant a larger study that included assessment of body composition, serum cortisol, bone mineral density, resting metabolic rate, and serum estradiol. The protocol involved obtaining 3 days of food and activity data, recorded hourly, on each player. Players were members of the soccer team at a private university in Mexico, coming from relatively upper socio-economic status home environments, typically with college educated professional parents. The capacity to access appropriate good quality foods was not an issue for these players. The participating soccer players voluntarily joined in the study, primarily because of an interest in helping to find ways to improve their sports performance. Data were

obtained and analyzed by a Registered Dietitian for both hourly and 24-hour energy balance.

Results

The subjects in this preliminary study consisted of 8 female soccer players, with a mean age of 22.5 yr. (SD = 3.9), mean height of 161.8 cm (SD = 8.9), mean weight of 61.8 kg (SD = 9.5), and mean BMI of 23.8 (SD = 3.9). (See Table 1).

Using Spearman(nonparametric) correlation analysis, we found that the greater the number of hours spent in an energy balance state of ± 400 kcal was associated with in a non-significant association with lower BMI ($r = -0.393$; $p = 0.336$); players with more hours in an anabolic state (> 0 kcal energy balance) had significantly lower BMI ($r = -0.766$; $p = 0.027$); players with more hours in a catabolic state (< 0 kcal energy balance) had significantly higher BMI ($r = 0.766$; $p = 0.027$). (See Tables 2 and Table 3).

Conclusions

These finding strongly imply that the maintenance of energy balance during the day to reduce large periods of time spent in a significant energy balance deficit is an important factor in BMI and, therefore, warrants further investigation in this population.

The findings of this preliminary investigation are consistent with other studies assessing energy balance assessment in smaller time periods (smaller than 24 hours), suggesting it is an appropriate strategy for predicting outcomes. As sustaining a reasonable energy balance throughout the day may require greater eating frequency than this athlete population is currently accustomed to, future findings are likely to suggest that a re-education of appropriate eating behaviors within the soccer community is needed to help assure that there is a real-time dynamic relationship between energy consumed and energy expended.

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