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Profile of the female athlete triad among elite Kenyan endurance athletes and non-athletes

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Abstract

Women participating in endurance sports are at risk of presenting with low energy availability (EA), menstrual dysfunction (MD), and low bone mineral density (BMD), collectively termed the female athlete triad (FAT or TRIAD). Therefore, the purpose of the study was to determine the profile of the TRIAD among elite Kenyan female athletes and among non-athletes. There were 39 participants (athletes: 25, non-athletes:14) who provided the data for this study. Exercise energy expenditure (EEE) was deducted from energy intake (EI), and the remnant energy normalized to fat free mass (FFM) to determine energy availability (EA). Weight of all food and liquid consumed during three consecutive days determined EI. EEE was determined after isolating and deducting energy expended in exercise or physical activity above lifestyle from the total energy expenditure output as measured by Actigraph GT3X+. Dual energy x-ray absorptiometry (DXA) determined both FFM and BMD. Menstrual function was determined from a daily temperature-menstrual log kept by each participant for nine continuous months. Low EA (<45 kcal/kgFFM$\cdot$d^{-1}) was evident in 61.53% of the participants (athletes: 28.07 ±11.45 kcal/kgFFM$\cdot$d^{-}1, non-athletes: 56.97 ±21.38 kcal/kgFFM$\cdot$d^{-1}). The overall 36% MD seen among all participants was distributed as 40% among the athletes, and 29% among non-athletes. None of the athletes was amenorrheic. Low BMD was seen in 79% of the participants (athletes: 76%, non-athletes:86%). Overall, 10% of the participants (athletes: 4, non-athletes: 0) showed simultaneous presence of all three components of the TRIAD. The Independent sample *t*-test showed significant difference (t=5.860; p< 0.001) in prevalence of the TRIAD between athletes and non-athletes. The hypothesized higher prevalence of the TRIAD among athletes compared to non-athletes was partially accepted. To alleviate conditions arising from low EA, both athletes and their coaches need regular education on how to ensure they adequately meet specific dietary and nutritional requirements for their competition events.

Keywords: Energy availability, menstrual dysfunction, bone mineral density, exercise energy expenditure.

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Introduction

Understanding the female athlete triad (FAT) or the TRIAD, its recognition, prevention, and management has evolved with ever-increasing research (Warren, 1999; Gibbs, Williams & De Souza, 2013). Prior to 2007, an active woman was deemed to be experiencing the TRIAD if she presented with all three interrelated entities of disordered eating (DE), amenorrhea and osteoporosis (Nattiv et al., 2007). Currently, the TRIAD is conceptualized as a complex syndrome arising from relationships among the three components of energy availability (EA), menstrual function (MF), and bone mineral density (BMD). Redefinition and consideration of each entity along a continuum from health to disease state (Manore, Kam & Loucks, 2007; Pantano, 2009), from the previous strict criteria of disordered eating, amenorrhea and osteoporosis, has allowed wider scope for inclusion of those with less severe conditions (Sanborn, Horea, Siemers & Dieringer, 2000; Thein-Nissebaum et al., 2011). The essence of interrelatedness among the three basic entities of TRIAD associated with dimensions of eating behaviour and food, menstrual function and bone health has been reaffirmed in the new ACSM's (2007) Position Stand (De Souza & Williams, 2010; De Souza et al., 2010).

Disturbances in each component have varying possible causes. Low EA could result from intentional or unintentional/inadvertent eating behavioural practices or from expending more energy relative to intake (Thein-Nissenbaum, 2013). Though anatomical anomalies in the uterus or vagina, or disruptions in endocrine signals have been identified as causative factors in menstrual disorders (Redman & Loucks, 2005), low EA has been recognized as a leading instigator in menstrual dysfunction (Nattiv et al., 2007). Any one factor or more from among genetics, nutrition, hormones, weight-bearing exercise, alcohol consumption, and cortisol levels could be implicated in low BMD (Papanek, 2003). The cumulative effect of energy/nutritional deficiency and subsequent hypoestrogenism suppresses bone formation and increases bone resorption, effectively establishing potential for bone demineralization (De Souza & Williams, 2004). In the context of the composite TRIAD, there appears to be a sequential pattern in the avalanche of events instigated by inadvertent or intentional low EA that subsequently impairs menstrual/reproductive and skeletal health (Nattiv et al., 2007). Though these conditions could occur independent of each other, it is possible that an athlete experiencing deterioration in one component may also have problems in the other components (De Souza & Williams, 2010).

Most research concerning the TRIAD has focused on interrelatedness among individual entities rather than the whole TRIAD (Nichols *et al.*, 2006; Thein-Nissenbaum & Carr, 2011). There has been a dearth in epidemiological research looking into simultaneous occurrence of all three entities constituting the TRIAD, under both, the former definition of disordered eating, amenorrhea and osteoporosis (Beals & Meyer, 2007) and the revised 2007 ACSM version of EA, MF and BMD (Thein-Nissenbaum & Carr, 2011). A recent stringent review to evaluate prevalence of the TRIAD between 1971 and 2011 reported, that among the nine studies (n=991) that investigated prevalence of all three entities; 0% to 15.9% athletes presented with all three conditions (Gibbs et al., 2013).

Increasing number of girls and women in Kenya are taking up competitive running to alleviate their families out of poverty (Onywera et al., 2006). Despite phenomenal success achieved by Kenyan female athletes since their first international appearance in 1965, very few studies have investigated factors that could affect Kenyan female athletes' health and performance. Evidently, elite Kenyan male runners often function under energetically-challenged environment (Fudge et al., 2006). In view of the instigation of low EA in sequential disruption of MF and subsequent bone health, such evidence among male athletes raises concern for the Kenyan female athlete. No study that looked at the simultaneous occurrence of EA, MF and BMD in elite Kenyan athletes could be found. Therefore, the purpose of this study was to determine the female athlete triad profile among elite Kenyan female athletes compared to non-athletes. It was hypothesized that elite Kenyan female athletes would show significantly higher profile of the female athlete triad than non-athletes.

Methodology

Study design

This investigation was part of a larger study that sought to establish status of EA, MF and BMD, associations/relationships between these variables of the TRIAD, and to determine the profile of female athlete triad among elite Kenyan runners. In view of the fact that the researchers had no control over the diet and training programmes of the participants; and that the results would be evaluated in retrospect, the study specifically used the ex-post facto/causal-comparative design.

Ethical approval

The Kenyatta University Ethics Review Committee (KU-ERC), Athletics Kenya (AK) and the National Council for Science and Technology (NCST) in Kenya gave ethical approval, relevant permissions, and research permits respectively. The participant signed the informed consent after receiving verbal and written information about her expected role in the study, both, in *Swahili* (the Kenyan athlete's native language) and English. The respective Provincial Medical Officer certified non-athletes as medically fit to participate in the study.

Participants

Initially, 16 long distance and 16 middle distance actively training elite Kenyan female runners, and 16 age-matched non-athletic controls volunteered to participate in the study. For parity, these were four in each age-group cluster of 18-20, 21-23, 24-26, and 27-30 years (N = 48). Out of these, the 39 participants (Long distance = 13, Middle distance = 12, Non-athletes = 14) who completed all the requirements, provided data for the study.

Measuring instruments

Energy availability (EA) was determined by deducting exercise energy expenditure (EEE) from EI, then standardizing the remaining energy to fat free mass (FFM), so that EA = (EI-EEE)/FFM·d, and was expressed as kcal/kgFFM·d^{-1}(Manore et al., 2007). The threshold for healthy energy availability was set at >45 kcal·kgFFM·d^{-1}. Therefore, any value below the threshold for healthy energy availability was deemed low EA (Nattiv et al., 2007).

Energy and nutrient intake (EI) evaluations took cognisance of the lack of variety in a Kenyan athlete’s diet throughout the week (Onywera et al., 2004), and the view that recording intake over three days could elicit adequate data (Thompson & Byers, 1994) to measure EI during three consecutive days. Initially, the principal investigator trained 48 female trainee research assistants in food weighing and in the administration of a standardized questionnaire during six training sessions. Out of these, only the 25 who showed proficiency and had attended at least four sessions were recruited as research assistants. The food-weighing and questionnaire exercise was repeated every evening at the training venue, starting on the day of arrival at the athlete’s training centre.

The principal investigator randomly attended any meal-time food-weighing session. Except when the athlete was training, the individually assigned trained research assistant was with the participant from 5.30am till after the last meal each evening during the three consecutive days when EI was assessed. The Research assistant (RA) used a digital scale (Aston Meyers, model: 7766), accurate to the nearest 0.1kg, to weigh all food and liquid consumed by her participant during these hours. At the end of a meal or a snack, weight of each item not consumed or remaining on the plate was deducted from the original amount to record the actual amount consumed. The Research assistant also instructed her participant on how to use a spoon, cup or bowl to note portions consumed after the departure of the RA each evening. The next morning, the RA weighed these items and recorded them against the appropriate date. Subsequent to entering the weight of actual food and liquid consumed into the programme, the Nutrisurvey for Windows 2007 (Erhardt, 2007) software programme was used to determine the daily average energy and nutrients intake in kilocalories (kcals). The estimated energy requirements (EER) of the participants for their activity levels was based on the joint guidelines of the American Dietetic Association (ADA) (2009), Dieticians of Canada, and the American College of Sports Medicine were used to establish whether participants' EI met minimum levels for their activity levels. When estimating energy requirements (EER), the physical activity coefficients used were 'very active' coefficient of 2.5 for the athletes and the 'moderate' 1.6 for the non-athletes (ADA, 2009).

Exercise energy expenditure (EEE) was assessed using the Actigraph GT3X plus (GT3X+) tri-axial accelerometer (Actigraph, 2011). The device, worn upright and flat on the right iliac crest for 72 hours continuously during the same period coinciding with the measurement of energy intake, was only removed when bathing. Initialization, downloading and final analysis was done using Actilife, version 5.6 software (Actigraph LLC, Pensacola, FL, USA). The Freedson work energy combination formula incorporating participant weight was used to determine energy expenditure (Freedson, Melanson & Sirard, 1998). By setting initialization at 1 s epoch length, the monitor was able to record the shortest activity counts at various intensities and their durations during wear time. Each participant's weight, accurate to nearest 0.1 kilogrammes (kg) on a digital scale (A & D Precision Health Scale, Model: UC-322), as required by the Freedson formula, was entered into the analysis template to determine her total energy expenditure. According to Actilife output, activity counts higher than 1952 correspond to 3-6 Mets intensity, a level at which energy expenditure is considered higher than lifestyle energy expenditure. The manual-intensive daily living activities could account for substantial energy expenditure among the non-athletes. Therefore, all hourly activity counts above 1952 were identified and their corresponding kcal values deducted from total energy expenditure to account for both, the athletes' and non-athletes', exercise energy expenditure.

Eating behaviour practices (EBP), considered contributory factors to EA, were explored using the validated Fairburn and Beglin (Fairburn & Beglin, 2008) Eating Disorder Examination Questionnaire (EDE-Q). The questionnaire assesses eating psychopathologic behaviour in the sub-scales of dietary restraint, eating concern, shape concern and weight concern on a seven point (0–6) severity score. A score of 0 denotes absence of the subscale feature, every increase in a score is indicative of increase in severity in the subscale such that the score of 6 denotes the most extreme presence of that feature. The questionnaire was administered during the same period when EI and EEE were being measured. Though the questionnaire was available in both, English and *Swahili*, the participant completed the questionnaire she found more comprehensible. This was done in the presence of the principal investigator who, as a native speaker of *Swahili*, was able to provide further clarification/explanation when necessary.

Fat free mass (FFM) was among several body composition assessments completed using dual energy x-ray absorptiometry (DXA) with Hologic®, Discovery (USA) at the Aga Khan University Hospital in Nairobi, Kenya. This was done under the direction and supervision of the head of the hospital's Nuclear Medicine. No scan was performed unless the system passed the daily quality control (QC) using a phantom. In addition to providing whole/total body BMD, measurements were taken at the lumbar spine (L1 – L4, CV = 1.0%) and left femoral neck (CV = 1.0%). The International Society of Clinical Densitometry (ISCD) (Lewiecki et al., 2008) guidelines, requiring comparison of BMD against expected norms for age, sex and population/ethnic match, and their expression as *Z*-scores, were used for initial evaluations. In the ISCD guideline, a *Z*-score of less than -2.0 is considered the threshold below the expected limit for age, sex and population.However, since runners are expected to have better BMD than the general population, the American College of Sports Medicine (Nattiv, et al., 2007) cautions that athletes with slightly better BMD values than the ISCD threshold could be at risk of fracture and/osteoporosis in the future. Similarly, the daily-living physical activity level of the non-athletes also had the potential of affecting their BMD. Therefore, as recommended by the ACSM (2007), all participants with *Z*-scores lying below -1 were categorized further as having low BMD.

Menstrual function (MF) was based on a nine-month daily temperature-menstruation log (US Department of Health and Human Services, 2014) kept by the participant. Each participant was instructed on how to: (i) measure her temperature using an oral thermometer (Royal Flexible Waterproof Digital Thermometer, CEO197) (ii) record her temperature immediately on waking up every morning in the menstruation-temperature log, and (iii) complete the log every day for nine continuous months beginning on the morning after signing the informed consent. In this menstruation-temperature log, a complete cycle began on the day of first appearance of menstruation since start of the log and ended on the day previous to appearance of the next menstruation that denoted start of the next cycle. Only complete cycles within the nine months of actual recording were considered for establishing menstrual functional status. The status was categorized as eumenorrheic (21–35 days), oligomenorrheic (35–90 days) and amenorrheic (>90days) (Nattiv et al., 2007). When determining menstrual function in profile of the TRIAD, oligomenorrhea and amenorrhea were grouped together as menstrual dysfunction (MD).

In addition, the research assistant administered a standardized questionnaire that sought information about the participant's menstrual history since menarche and her daily living activities since childhood.

Statistical analysis

Data were analysed using IBM SPSS Statistics Version 20. Analysis was done by participant category as athletes and non-athletes; and by distance category as long and middle distance athletes and non-athletes. Means and standard deviations were computed for EI, EEE, EBPs, carbohydrate (CHO) and calcium intakes. The Pearson correlation coefficient was conducted to determine level of statistical significant contributory association between EBPs and EA. Independent samples T-tests were used to determine significant difference in means of EI, EEE, EA, CHO and calcium intakes. An analysis of variance (ANOVA) was used to determine significant differences in the means of EI, EEE, and EA by distance categories of long and middle distance and non-athletes. A significant F value warranted use of Tukey's honestly significant difference (HSD) to establish specific inter-group differences. Frequencies and percentages of EA, MF and BMD were also determined. Though the three categories of menstrual function that emerged were ranked from eumenorrheic/normal status that descended to the lesser oligomenorrheic dysfunction to the most serious dysfunction of amenorrhea, oligomenorrhea and amenorrhea were grouped together as menstrual dysfunction in the TRIAD profile.The 0.05 α level was set to determine statistical significance.

Results

Demographic, anthropometric, and energy characteristics presented in Table 1 revealed significant differences between athletes and non-athletes in the demographic factors of weight ($p< 0.001$) and BMI ($p< 0.001$). As evident from Table 1, whereas the non-athletes met the EER, the athletes with an EI of 2754.1 kcal were 59% short of the EER. The mean global psychopathological EBP score for the whole group stood at the 0.68. The Pearson correlation coefficient between EBPs and EA ($r = 0.142$) was not significant ($p = 0.390$), suggesting that psychopathological EBPs were not a contributory factor to the participants' low EA of 38.44 (±20.89) kcal/kgFFM$\cdot$d^{-1}. Overall prevalence of low EA was 69% (Athletes = 23, Non-athletes = 4). Further scrutiny revealed that 62% of these had EA <45 kcal/kgFFM$\cdot$d^{-1}, 36% had EA between 30 and 45 kcal/kgFFM$\cdot$d^{-1}, and 56% had EA <30 kcal/kgFFM$\cdot$d^{-1}. The breakdown of CHO percentage constituting overall EI revealed no significant difference between the athletes' 73% (±7%) and the non-athletes' 75% (±6%). The athletes' calcium intake was 723.3 (±438.8 mg$\cdot$d), while the non-athletes' calcium was 792.1 (± 325.5) mg$\cdot$d (t=.468; $p = 0.643$). Frequencies and percentage distribution of the three components of the TRIAD by participant category and by distance category are presented in Table 2.

Table: 1Demographic, anthropometric, and energy characteristics of athletes and non-athletes

Characteristics	**Athletes (*n*=25)**	**Non-Athletes (n=14)**	***p*-value**
Demographic			
Age (years)	25 ± 3.2	25 ± 3.2	.921
Age at Menarche (years)	15.8 ±2.0	14.1 ± 1.0	.005**
Weight (kg)	49.8 ± 5.5	58.6 ± 5.8	<.001**
Height(m)	1.62 ± 0.05	1.60 ± 0.04	.209
BMI (kg/m^2)	18.7 ± 1.3	22.8 ± 2.8	<.001**
Fat Free Mass (FFM)(kg)	38.6 ± 3.8	38.6 ± 2.6	.971
Energy Related			
Estimated Energy Requirements (EER) (kcal)	4648.10 ± 224.63	2406.85 ±58.88	<.001**
Energy Intake (kcal)	1894.0 ± 516.1	2258 ± 799.0	.091
Exercise Energy Expenditure ($kcal/kgFFM \cdot d^{-1}$)	760.3 ± 222.1	78.14 ± 19.34	<.001**
Energy Availability ($kcal/kgFFM \cdot d^{-1}$)	28.1 ± 11.5	57.0 ± 21.4	<.001**
Global EBP	.62±.56	.57±.66	.813

Notes: *p*-value computed using independent t-test, *$p \leq 0.01$; **$p<0.001$.

Menstrual function (Table 2) among the 39 participants as a group showed that 5% (non-athletes = 2), were amenorrhoeic 31% (long distance = 6, middle distance = 4, non-athletes = 2) were oligomenorrheic, and 64% (long distance = 7, middle distance = 8, non-athletes = 10) were eumenorrheic. Out of the 44% (long distance = 8, middle distance = 7, non-athletes = 2) who had reported primary amenorrhea, 21% (long distance = 4, middle distance = 4) revealed current oligomenorrheic status.

Results of BMD (Table 2) revealed that 80% (long distance =10, middle distance = 9, non-athletes = 12) of the 39 participants presented with low BMD. Characteristic of BMD by region (Table 3) did not show significant difference between athletes and non-athletes. Further breakdown of low BMD distribution by region showed that while there was 3% (non-athletes =1) presentation with low BMD at the neck of femur, the lumbar spine accounted for remaining the 97% low BMD and was distributed as 63% among the athletes (long distance = 9, middle distance = 10), and 37% (*n* = 11) among non-athletes.

Table 2: Frequencies and percentage distribution of energy availability, menstrual function and bone mineral density (BMD) by participant category and by distance category

Characteristic	**Athletes (n=25)**	**Non-athletes (n=14)**	**Long Distance Athletes (n=13)**	**Middle Distance Athletes (n=12)**
Energy Availability				
≤30 kcal/kgFFM·d^{-1}	14 (56%)	1 (7%)	11 (85%)	3 (25%)
>30 and ≤45 kcal/kgFFM·d^{-1}	9 (36%)	3(21%)	1(8%)	8 (67%)
>45 kcal/kgFFM·d^{-1}	2 (8%)	10 (71%)	1 (8%)	1 (8%)
Menstrual Function				
Eumenorrhea	15 (60%)	10 (71.4%0	7 (54%)	8 (67%)
Oligomenorrhea	10 (40%)	2 (14.3%)	6 (46%)	4 (33%)
Amenorrhea	0	2 (14.3%)	0	0
Primary Amenorrhea	15 (60%)	2 (14.3%)	8 (62%)	7 (58%)
Bone Mineral Density				
Low BMD	19 (76%)	12 (86%)	10 (7)	9 (75%)
Normal BMD	6 (24%)	2 (14.3%)	3 (23%)	3 (25%)

Table 3: BMD characteristics among athletes and non-athletes

BMD Characteristic	**Athletes (*n*=25)**	**Non-Athletes (*n*=14)**	***p*-value**
Lumbar Spine (L1-L4) (g/cm^2)	.945 ± .021	0.968 ± 0.3	.102
Neck of Left Proximal Femur (g/cm^2)	.945 ± .0731	.983 ± .0995.	.181
Total Body BMD (g/cm^2)	1.045 ± .584	1.016± .0710	.176
Z-score (g/cm^2)	1.24 ± 0.44	1.14 ± 0.40	.484

Note: p-value computed using independent t-test; p>0.05 (All differences were not significant).

Dysfunctions among the three components of the female athlete triad in dual combinations, and as the combined trio in the female athlete triad are presented in Table 4. Combination of low energy availability and menstrual dysfunction were seen in 15% (*n* = 5) of the participants (long distance = 3, middle = 2, non-athletes = 1). Low energy availability and low BMD revealed an overall 56% (*n* = 14) presence, all among the athletes (long distance = 6, middle distance = 8). The combination of menstrual dysfunction and low BMD an 8% (*n* = 3) overall presence (middle distance = 1, non-athletes = 2). Simultaneous dysfunctional presence of the three entities was seen in 10% (n=4) of the participants (long distance = 3, middle distance = 1). Out of the 39 participants, 4% (long distance = 1) had healthy EA, MF and BMD.

The results of the *t*-test comparing the prevalence of the TRIAD components between athletes and non-athletes showed significant difference (t=5.860; $p<$ 0.001). The one way ANOVA comparing long and middle distance athletes and non-athletes also indicated significant difference (F=16.708; $p<$ 0.001).

Table 4 Prevalence of components in dual combinations and as the trio in the female athlete triad

Prevalence by components of the female athlete triad	**Athletes (*n*=25)**	**Non-Athletes (*n*=14)**	**Long Distance Athletes (*n*=13)**	**Middle Distance Athletes (*n*=12)**
Low energy availability	23 (92%)	4 (29%)	12 (92%)	11 (92%)
Menstrual dysfunction	10 (40%)	4 (29%)	6 (46%)	4 (33%)
Low bone mineral density	19 (76%)	3 (21%)	9 (69%)	10 (83%)
Low energy availability and menstrual dysfunction	5 (20%)	1 (7%)	3 (23%)	2 (17%)
Low energy availability and low bone mineral density	14 (56%)	0	6 (46%)	8 (67%)
Menstrual dysfunction and Low bone mineral density	1 (4%)	2 (14%)	0	1 (8%)
Low energy availability, menstrual dysfunction and low bone mineral density	4 (16%)	0	3 (24%)	1 (8%)
None	1 (4%)	6 (42%)	1 (8%)	0

The Tukey's post-hoc HSD test identified non-athletes as being significantly different from the long and middle distance athletes. The hypothesized higher profile of the female athlete triad among athletes compared to non-athletes was accepted.

Discussion

Prevalence of the female athlete triad, based on both, the previous entities of disordered eating, amenorrhea and osteoporosis, and the revised entities of low energy availability, menstrual dysfunction and low bone mineral density (Nattiv et al., 2007), have been reported as being between 0% and 16% (Gibbs et al., 2013). While the profile of the female athlete triad at 16% prevalence among the current elite Kenyan female athletes appears to concur with this report, the Kenyan athletes seem to be at the higher end of prevalence range. None of the Kenyan non-athletes experienced all three components simultaneously. It must however, be noted, that menstrual function in the current study did not include hormonal and steroidal assessment that prevented identification of subtle and sub-clinical menstrual dysfunctions. Consequently, the 16% prevalence of low EA and MD in the current participants may not be a true reflection of actual presence. Hoch et al. (2009) were among the few studies to have examined the TRIAD using the revised concept. They identified one (1%) soccer player and one (1%) sedentary control out of 80 high school athletes, and 80 sedentary controls with simultaneous presence of all three components (Hoch et al., 2009). However, participants in the Hoch study, drawn from varied sports, were younger than those in the current study by about nine years. Elite Kenyan runners' showing of 16% simultaneous presence of all three components compares well with elite British endurance runners' showing of 15.9% presence (Pollock et al., 2010). However, the dimension of energy in the British study was examined based on disordered eating. Torstveit and Sundgot-Borgen (2005) drew 186 athletes from the entire mixed-sports population of elite female athletes in Norway, aged between 13 and 39 years, and an age matched control group of 145 in Norway to determine existence of the TRIAD. They reported that both, elite athletes (4%) and controls (4%) met criteria for all three components of the TRIAD. Beals and Hill (2006) also explored prevalence of disordered, menstrual dysfunction and low BMD varsity students aged about 19 years, and reported simultaneous presence of the three components in one cross-country runner and among two athletes in lean-build sports. The variance in population ages, mix of sports, and differences in definitions among the few studies that have examined prevalence of the TRIAD makes it difficult to compare to the present study with others. Of concern should be the over representation of chronic low EA among the elite Kenyan female athletes that could lead to more serious health consequences such as endothelial dysfunction and unfavourable lipid profile (Rickenlund, Eriksson, Schenck-Gustfsson & Hirschberg, 2005) and osteoporosis (Nattiv et al., 2007).

It is possible that the three conditions of low EA, MD and low BMD of the TRIAD may not be present simultaneously at the extreme ends along respective health continuums. However, De Souza and Williams (2010) cautioned that because of the interrelatedness among the disorders, an athlete presenting with one condition, may be experiencing minor or subtle signs and symptoms in the other conditions. Low EA has been recognized as an instigator in MD (De Souza et al., 2008); and directly and indirectly in low BMD (Ihle & Loucks, 2004). The elite Kenyan athletes showed predominance of low EA, but an apparent menstrual status on the healthier side of the continuum. In this low EA and apparently healthy MF environment, elite Kenyan athletes showed 20% and non-athletes 23% prevalence in the combined components of low EA and MD, compared to the Hoch et al. (2009) study that reported 14% simultaneous presence of EA and MD among varied sports athletes, and 10% among sedentary controls.

Torstveit, Rosenvinge and Sundgot-Borgen (2008) reported 26.9% in athletes and 13.8% prevalence in disordered eating/eating disorders and MD. Like Torsveit et al. (2008), Quah, Poh, Ng and Noor (2009) investigated the incidence of disordered eating and reported that out of all the combinations explored by them, at 24.1%, eating disorder and MD presented the highest occurrence. In contrast to the latter studies, results of the EBPs revealed that Kenyan participants were least likely to present with eating disorders. The negative difference between EER and EI among Kenyan athletes is probably more to do with inadvertent restriction or ignorance about ensuring adequate balance IE and energy expenditure (Pantano, 2009). Whereas independently low EA and low BMD showed prevalence of 92% and 76% among the athletes and 29% and 21% among the non-athletes, athletes were the only ones to show concurrent presence of 56% in low EA and low BMD. Comparatively, the much younger high school athletes (4%) and sedentary controls (5%) showed a lower simultaneous occurrence of low EA and low BMD (Hoch et al., 2009). Similarly, elite Malaysian athletes from various sports showed a much lower 9.4% presence in the same combination (Quah et al., 2009) compared to Kenyan athletes. Regardless of the difference in the energy dimensions evaluated, the considerably higher showing among Kenyan athletes is cause for concern for their bone health in the future. While oestrogen remains a key element in bone health, as cautioned by Ihle and Loucks (2004), chronic under-nutrition may affect bone impairment through factors that are independent of oestrogen. Though Kenyan non-athletes' EI met the EER, Kenyan athletes' EI short of the EER. Low EI relative to EEE usually results in low EA and concurrent deficiency in micronutrients such as calcium (ADA, 2009). Calcium's significant role in bones structure and metabolic integrity cannot be underscored (Lorincz et al., 2009). Athletes with low EA and hypoestrogenism are advised to consume 1500mg·d (ADA, 2009). It was clear that at 723.3 (±438.8 mg·d) Kenyan athletes consumed approximately 48% less than the recommended amount.

Whereas simultaneous occurrence of MD and low BMD was seen at 4% in the athletes, at 14%, Kenyan non-athletes showed a higher occurrence of this combination. In exploring prevalence of the female athlete triad among elite Malaysian athletes, Quah et al. (2009) also considered simultaneous occurrence in the same combination of MD and low BMD. Compared to the current Kenyan athletes, elite Malaysian athletes showed an even lower occurrence of simultaneous presence of MD and low BMD (Quah et al., 2009). The high school athletes, however, showed a slightly higher of 8% occurrence among athletes and a 4% lower showing among sedentary controls (Hock et al., 2009). Neither study provides sufficient grounds for comparison. Though exact numbers for each sport were not indicated, the athletes were drawn from aesthetic sports, martial arts, fencing, archery, shooting, field hockey and squash. Apart from being much younger than the Kenyan participants, the high school athletes were also drawn from a wide range of sports, making it difficult to compare appropriate findings. However, in the paucity of relevant comparisons, it is worth noting that hormonal and steroidal investigation reported lowered BMD especially at the lumbar spine in oligo-amenorrheic endurance runners with deficient dietary intake (Gremion, Rizzoli, Slosman, Theintz & Bonjour, 2001). In view of the dominance of the lumbar spine as the weakest region among athletes and non-athletes in Kenya, there is need for further investigation of their hormonal and steroidal profiles.

Strengths and Limitations

Contributory factors to the strength of the study were the presence of an individually assigned trained RA from 5.30am till after the last meal to do the direct weighing of EI, measurement of EEE using objective accelerometry, and assessment of FFM using the gold standard DXA scanning. Apart from the principal investigator visiting the training centres at least once a month to meet with each participant individually, each RA also had bi-weekly mobile phone communication with her assigned participant. While motivating the participants, this communication also enhanced compliance.

However, conversion of activity counts per minute to estimate energy expenditure using accelerometry could be accompanied by errors in analysis. Though enthusiasm and compliance enhanced accuracy in determining start and finish of each menstrual cycle in the temperature-menstrual log, mistakes in reading temperature reading did not allow estimation of ovulatory cycles. This, combined with the lack of hormonal and steroidal assessments could be considered limitations in the study.

Conclusion

In this study, the hypothesized difference of a higher profile among athletes as compared to non-athletes was realized. Apart from the combination of MD and low BMD, athletes showed a higher presence among all other combinations. Despite the dominant low EA presentation, these elite Kenyan athletes showed an apparently healthy eumenorrheic menstrual status. In the absence of hormonal and steroidal evaluations, subtle sub-clinical dysfunctions of anovulation and LPD, usually associated low EA, were not identified. Therefore, this apparent healthy menstrual status may be an overestimation. The over representation of chronic low EA among the elite Kenyan female athletes could lead to more serious health consequences such as endothelial dysfunction and unfavourable lipid profile (Rickenlund et al., 2005) and osteoporosis (Nattiv et al., 2007). While the results showed almost negligible presence of psychopathological EBPs, Kenyan athletes should be encouraged to increase IE forcefully rather than waiting until hungry (Loucks, 2005). It is recommended that both, athletes and their coaches be regularly educated about dietary and nutritional requirements specific to training and competition distance. Regular health screening should become a matter of policy for early identification of pathologies and timely implementation of appropriate intervention.

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