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Full Length Research Paper

Effects of menstrual periods on postural stability in eumenorrheic female group

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High rate of injuries detected during certain periods of menstrual cycle, raised the suggestion of hormonal impact on soft tissue and neuromuscular control with subsequent lost in joint stability, deterioration of postural balance and injury development. The aim of present study was to investigate possible differences in static postural balance during the preovulatory and postovulatory stages of menstrual cycle. Twenty one randomly selected eumenorrheic female university students accepted to participate in this study. Postural stability index (PSI) and sway distances were measured on a computer-based static stability force-platform with eyes open and eyes closed trials. Height, weight, waist and hip circumferences of the subjects were also measured. Evaluation of body fat percentage (BF) was made through biceps-triceps-subscapular-suprailiac skin-fold thickness measurements. Analysis of balance scores demonstrated better postovulatory comparing to preovulatory postural stability in terms of PSI (93.29 ± 4.26 versus 91.05 ± 6.21, p = 0.035), antero-posterior (0.99 ± 0.72 versus 0.77 ± 0.51 cm, p = 0.05) and medio-lateral (0.77 ± 0.64 versus 0.50 ± 0.42 cm, p = 0.04) sway distances. There was also statistically significant correlation between anthopometric and balance parameters with better postural balance in thinner participants. Our findings demonstrated that menstrual cycle does indeed influence postural stability, which also is the function of body composition in young females.

Key words: Postural balance, menstrual cycle, females, periods.

INTRODUCTION

The rise of female participation in sport is accompanied by an increase in sport-related injuries in them (Ristolainen et al., 2009) and injury incidences for some traumas related to lower extremity are higher in female athletes compared to males (Arendt and Dick, 1995; de Loes et al., 2000; Sallis et al., 2001). Recent studies demonstrated that action of main female gonadal hormones in central nervous system (CNS) is not limited to their reproductive function. Dynamic changes of estrogen and progesterone during menstrual cycle impact CNS receptor's binding ability for some neurotransmitters, responsible for human behavior (Al-Dahan and Thalman, 1996). So, the comprehension of menstrual cycle's effect on neuronal activity in terms of static balance is necessitated due to its potential role in injury prevention strategy.

Apart from central effect of gonadal hormones, both estrogen and progesterone also demonstrated their association with changes in various types of connective tissue including joint ligament, cartilage and bone (Calleja and Brincat, 2009; Cammarata and Dhaher, 2008). High injury rate related to menstrual cycle was suggested in one retrospective 12 months study, where overuse injury rate in cross-country women skiers with irregular menses were twice of those with regular menstruation (85 versus 46%, respectively, p = 0.01) (Ristolainenet al., 2009). The latter raised suggestion of hormonal impact on soft tissues, accompanied by the loss in joint stability known to be important for postural balance and injury development (McLean et al., 2005; O'Sullivan et al., 2006). Gender specific differences in joint's ligaments were related to females' poor joint stiffness, which leads to heavy load over joint neuromuscular system.

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Static postural stability is defined as an individual's ability to maintain the center of mass over the base of support, while dynamic postural stability assessment is a method to objectively quantify deviations in balance from a neutral point and may be a simple method to quantify an individual's ability to control movement of the center of mass in an objective and dynamic fashion (Paterno et al., 2010). The deviation of mass center away from the support base during dynamic athletic activities increases valgus load on the anterior cruciate ligament (ACL), creating an increase in frontal plane load through a poorly control trunk and is a potential risk factor for ACL injury in a healthy population of female athletes (Krosshaug et al., 2007; Hewett et al., 2009). Paterno et al. (2010) also showed that deficits in static postural stability predicted a second injury in previously ACL injured population with excellent sensitivity (0.92) and specificity (0.88), and participants with deficits in postural stability of the involved limb were twice as likely to incur a second injury as compared with those who did not demonstrate single-leg stability of the involved limb.

It was shown that neuromuscular control pattern for performing a drop jump sequence in females varied in accordance with different estrogen levels during follicular and luteal phases of menstrual cycle. Thus, reported estrogen receptors in skeletal muscle seem to influence neuromuscular control and myofascial force transmission pathways (Dedrick et al., 2008). The majority of previous studies on balance assessment in females covered certain periods of pre- and post-ovulatory phases of menstrual cycle. Darlington et al. (2001) investigated the effect of menstrual cycle on postural stability at 5th, 12th, 21st and 25th days of the cycle, aiming to separate low/high levels of gonadal hormones. In another study, researchers assessed the effect of menstrual cycle on postural stability by getting data on 3rd day of preovulation, during ovulation and on the 7th day of postovulation (Friden et al., 2003). So, because of varieties of the time for balance assessment in females and due to problem with adjustment of sports event to the most appropriate time of menstrual period in terms of good postural balance, it seems reasonable at least to know in which of the above mentioned phases of menstrual cycle in a whole, that is, preovulatory or post-ovulatory females have better static balance.

The present study analyzed static postural balance during different stages of menstrual period and its association with body composition parameters in young female students, with the aim to define pre- and post-ovulatory balance differences in them. Understanding of female's postural balance seems to be valuable approach for safe and coordinated movement provided by the integrated function of many body systems (Rugelj, 2010; Salminen et al., 2009). Our preference in favor of static balance test was made both due to its application in majority of studies on menstrual cycle and because of similar changes in static and dynamic balance tests (Mohammadi et al., 2012; Chuang et al., 2007). Presented assessment of females' balance during their menstrual periods would provide the ground for further studies, investigating female's hormonal impact on their sport-related injuries.

MATERIALS AND METHODS

To investigate menstrual cycle-related differences in postural performance and association between body composition parameters and postural balance, static balance in the group of randomly selected 21 young eumenorrheic female students were evaluated during their pre- and post-ovulatory periods. Delineation of these stages was based on the length of menstrual cycle and the date of the 1st day of the last menstruation. Although the former varies from 21 to 36 days, the post-ovulatory stage is known to be fairly constant and comprises an average of 14 days (Beck, 1997). The latter was utilized for calculation of corresponding menstrual stage by the time of the test procedure, based on individual length of menstrual cycle and the first day of the last menstruation. If participant, for example, reported that her menstrual cycle lasts 30 days and the first day of last menstruation was 20 days ago we concluded that her ovulation was 4 days ago, on 16th day of menstrual cycle (30 – 14 = 16) and so she was within her post-ovulatory stage.

Participants denied any history of trauma or other disease, as well as irregularities in menstrual cycle, which could impair the balance and/or interfere with pre-ovulatory to post-ovulatory assessment. Since all participants were from the School of Physical Education and Sports of the Near East University, all of them were regularly engaged in various recreational sports activities. The study protocol was approved by the Ethic Committee of the Near East University. Basic descriptive characteristics were documented for each participant by using height and weight measuring scales and measurements of waist and hip circumferences by anthropometric tapes. Evaluation of body fat percentage was made through biceps-triceps-subscapular-suprailiac skin-fold thickness measurements by Holtain Tanner/Whitehouse Skin-fold Caliper with the following reference to corresponding table (Durvin and Womersly, 1974). Post-urographic balance assessment was carried out by the computer-based Sport Expert Static Stability Platform MED-FP200 Tümer Mühendislik, Turkey. The subjects were asked to stand still on the force platform for 60 s, with 2 trials of their eyes open and 2 trials of their eyes closed. Due to the absence of unified protocols for computer-based balance assessment, our approach have been chosen as optimal among existing 10 to 30 s short, and up to 2 min long-lasting protocols (Baloh et al., 1998; Carpenter et al., 2001; Hermodsson et al., 1994). To avoid the impact of footwear and uncomfortable compulsory foot position on standing balance (Chiari et al., 2002), all participants were tested barefooted and were free to choose natural for their foot position (Salminen et al., 2009).

Standing balance was expressed as distance of antero-posterior (AP) and medio-lateral (ML) sway of the bodily center of gravity from its central point in cm during 60 s of quiet standing and as postural stability index (PSI) ranged between 0 and 100, of which 100 indicated perfect stability and zero as poor one. The equation for PSI calculation included values of subject's mass, gravity acceleration, average distance of center of gravity from the platform and stabilizing torque at the ankle at any time (t) (Chaudhry et al., 2011). Obtained results were expressed as means and standard deviations (SD) of 4 trials, 2 with eyes open and 2 with eyes closed.

Acknowledging that analysis of each of balance parameter within eyes open and eyes closed assessments separately would provide with deeper understanding of the female's static balance, preferred way of assessment was made with the purpose to get overall picture of static balance, including all its parameters. Pearson

Table 1. Mean ± SD of basic anthropometric characteristics (n = 21).

Age (years)	Height (m)	Weight (kg)	Body fat (%)	Waist (cm)	Hip (cm)
20.9±1.9	1.66±0.04	56.0±6.3	25.0±4.5	60.6±17.4	83.2 ±24.0

Table 2. Average values and SD of the postural parameters (n = 21).

Parameters	PSI	A-P sway (cm)	M-L sway (cm)
Preovulatory stage	91.05±6.21	0.99±0.72	0.77±0.64
Postovulatory stage	93.29±4.26	0.77±0.51	0.50±0.42
Probability, p, for paired t-test	0.035	0.05	0.04

PSI: postural stability index, A-P: anterior-posterior, M-L: medio-lateral.

Table 3. Coorelation coefficient (r) values for associations between anthropometric and postural stability parameters (n = 21, p ≤ 0.05).

	Body fat	BMI	Waist	Hip	Waist/hip
PSI	*-0.44	-0.27	*-0.48	* 0.46	-0.06
A-P	*0.49	0.35	*0.49	*0.47	0.08
M-L	0.24	0.003	0.37	0.36	-0.14

Waist: waist circumference, Hip: hip circumference, PSI: postural stability index, A-P: antero-posterior sway, M-L: medio-lateral sway, *p ≤ 0.05.

coefficients of correlation (r) were calculated to analyze associations between variables, and paired T-test was utilized to find statistically significant difference (p ≤ 0.05) between variables.

RESULTS

The basic body composition and athropometric characteristics presented in Table 1, were within normal limits. The parameters of postural stability, measured during 2 stages of menstrual cycle, demonstrated significantly higher values in postovulatory stage comparing to those from preovulatory stage of corresponding menstrual cycle (Table 2). Search for possible association of basic anthropometric characteristics with static balance test results revealed although weak but significant correlation between them; both PSI and anterior-posterior sway results were better in thinner participants (Table 3).

DISCUSSION

Subsequent changes of female sex hormones, regulating menstrual cycle (Sherwood, 2007) impact physical condition through acting on thermoregulation, circulatory and respiratory functions, fluid metabolism, etc. So, changes in eumenorrheic female hormonal profile allow to suggest corresponding changes in physical fitness performance, including postural balance (Constantini et al., 2005). Although, adiposity parameters in our study were within normal limits, correlative analysis demonstrated lower balance scores in subjects with higher body fat. Previous observation carried out with normal and overweight boys, revealed similar results in terms of poor level of balance in latter group, which was explained by low level of physical activity in them (Goulding et al., 2003). Recent studies demonstrated that sexually mature females likely express higher estrogen levels, which in combination with greater aromatization of androgens to estrogens in females with greater fat mass, may change many bodily functions, including tissue elasticity (Janicka et al., 2007; Pollock et al., 2007). The latter is considered today as one of the main factors contributing to lower extremity injuries in females (Hattori et al., 2010). The role of hormonal impact on postural balance in males with high adiposity would be questioned in further research.

Body sway, apart from proprioceptive regulating mechanisms, is also the function of central nervous system in terms of vestibulo-cerebellar activity. So, higher adiposity, which increases aromatase activity and subsequently boosts the conversion of androgens to estrogens, could contribute to abnormal activation of the hypothalamic pituitary-gonadotrophin axis of the central nervous system (Cleland et al., 1985; Dunger et al., 2005).

Among many factors, like advanced age, low physical fitness level, unhealthy body composition, musculoskeletal trauma or impaired vestibulo-cerebellar control, contributing to poor postural balance, the changes in female hormonal profile were also considered as risk factor for injuries in them (Cammarata and Dhaher, 2008).

However, series of studies investigating the asso-ciation of postural balance with changes in estrogen level in females demonstrated controversial results. One group of observations linked poor postural balance and sharp rise in reported falls in females with low estrogen level (Naessen et al., 1997), whereas others related increase in reported injuries to estrogen-induced changes in collagen synthesis resulted in joint laxity (Deie et al., 2002). Since menstrual cycle is characterized by dramatic changes in hormonal profile, regulating the ovulation process, we anticipated to get the difference in postural balance within pre- and post-ovulatory stages. Analysis of the static balance in our study demonstrated better postural stability index in the post-ovulatory stage of menstrual cycle. The contribution of joint stiffness to standing stability (Edwards, 2007) and impact of female hormones on joint laxity through changes in collagen synthesis (Deie et al., 2002) could probably lead to the aforementioned difference in postural stability. The great deal of inconsistency, regarding the role of estrogen in development of joint laxity and injury formation (Wojtys et al., 2002), allows to suggest that hormonal interrelationship rather than effect of estrogen alone contribute to the overall postural stability.

Conclusion

We investigated the possible differences in static postural balance during the pre-ovulatory and post-ovulatory stages of menstrual cycle with this study. Accepting the limitations of our study in terms of small sample group and multi-factorial character of postural stability, the application of paired t-test seems to allow making following suggestion. Poor static balance in females during pre-ovulatory stage of their menstrual cycles in our study probably caused unopposed effect of estrogen on knee ligamentous support, subsequently eliminated during postovulatory (that is, luteal) stage by the progesterone (Yu et al., 2001). An objective of our further research will be the clarification of possible association between hormonal dynamics and postural sways in females during different stages of their menstrual cycles.

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