INFLUENCE OF THE MENSTRUAL CYCLE ON BODY COMPOSITION

DETERMINED BY AIR DISPLACEMENT PLETHYSMOGRAPHY (BOD POD®)

by

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Abstract

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The purpose of this study was to determine if there were significant fluctuations in body composition during a normal menstrual cycle using air displacement plethysmography (Bod Pod®). Seventeen college age females were tested five times over one menstrual cycle. ANOVA Generalized Linear Models of repeated measures was used to detect changes in body fat percentage (BF%), lean weight (LW), and total body weight (BW). Test-retest for all repeated measures taken of BF%, LW, and BW were acceptable. Equality of covariance within subjects by Box's M Test was not violated for BF% ($p = .995$), LW ($p = .956$), and BW ($p = 1.00$). Mauchly's Test for sphericity was violated in BF% ($p = .032$) and BW ($p = .010$), thus epsilon adjustments were evaluated for appropriate F-value corrections resulting in a finding of no significance. There were no significant fluctuations in body composition during the menstrual cycle and therefore no adjustments in the timing of body composition assessment should be necessary.

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Chapter One

Introduction

Most women experience some type of discomfort during the menstrual cycle such as headaches, breast tenderness, mood swings and most notably, water retention (Golub, Menduke, & Conly, 1965). Since water makes up approximately 73% of lean body tissue (Neiman, 2007), fluctuations in body water due to changes in a women's menstrual cycle may affect measurements of body composition (Bunt, Lohman, & Boileu, 1989; Girandola, Wiswell, & Romero, 1977).

Minimal research has been conducted on the influence of the menstrual cycle on body composition. The few studies that have been published used hydrostatic weighing, bioelectrical impedance, hip-to-waist ratio, and skinfold analysis but not air displacement plethysmography (Bod Pod®). Byrd and Thomas (1983) reported that body composition was affected by the menstrual cycle when hydrostatic weighing was used. Twelve females were assessed three different times during each monthly menstrual cycle for a total of six measurements within a two month period. The results indicated fluctuations in body composition among the women but since the researchers did not weigh the participants every day, "peak weight gains may not have been detected" (Byrd & Thomas, 1983, p. 297). Other studies using hydrostatic weighing suggests that body weight fluctuations might be attributed to water retention (Bunt et al., 1989) or hydration levels (Girandola et al., 1977). Researchers using bioelectrical impedance analysis for body composition assessments suggest that "confounding influences in weight changes

may be due to hydration levels" (Gleichauf & Roe, 1989, p. 903). However, even though prior studies have indicated hydration levels as being a significant influence on body composition, assessments using air displacement plethysmography (Bod Pod®) have not been conducted and none of the current research has assessed whether this method may be able to detect a significant difference within specific phases of the menstrual cycle.

Review of Literature

The following literature review addresses the menstrual cycle and its influence with regards to body composition (body fat percentage, lean weight, and total body weight) along with the techniques and devices used to assess body composition such as bioelectrical impedance, hydrostatic weighing, and skinfold measurement. The literature review also addresses other aspects of the menstrual cycle that may influence changes in body composition such as fluid intake and water retention, dehydration, oral contraceptives, and exercise. The reliability and validity of the Bod Pod® for its use in the assessment of body composition was reviewed as the Bod Pod® was the instrument used in this study. At this time, no other research has been reported that addresses possible changes in body composition during one menstrual cycle using the Bod Pod® due to the changes that may occur in the timing of a body composition assessment within specific phases of the menstrual cycle.

Menstrual cycle and body weight. The menstrual cycle has been reported to influence water retention and thus weight gain in most women. Research conducted by Golub et al. (1965) on sixty-nine females at a all women's college who kept daily records of their body weight and menstrual symptoms for four months found that thirty (43.5%)

of the women experienced their highest weight during the first days of menstruation while fourteen (20%) women experienced their highest weight prior to menstruation. During menstruation, twenty-eight (41%) women experienced a mean weight gain of 0.05 lbs. In contrast, Bruce and Russell (1962) studied thirty patients in a clinical setting in which ten (33%) of the patients (control group) were restricted to hospital living conditions and meals. Each subject was weighed daily (excluding Sunday) for three months. The results indicated that the group as a whole did not experience weight gain prior to menstruation. The control group was reported to experience a slight increase in weight (< 500 g) five days prior to the onset of menses with some of the subjects experiencing an increase in weight during ovulation. The twenty (67%) women who were not restricted to hospital living conditions and meals experienced a slight change in body weight during the menstrual cycle which may have been attributed to the unrestricted living conditions outside the hospital. In a similar study, Robinson and Watson (1965) noted fluctuations in daily weight of 0.59 kg to 2.07 kg in women throughout the menstrual cycle with an increase in weight prior to menstruation and a decrease in weight eight days after the onset of menstruation. A slight increase in weight was also noted two days after ovulation. In similar study with the same subjects, Watson and Robinson (1965) noted an increase in body weight during the first half of menstruation with a drop in body weight near the end of menstruation. A slight increase in body weight was also noted several days after ovulation with a decrease in weight for up to six days prior to menstruation at which time a gradual increase in body weight occurred. In support of the results obtained by Watson and Robinson (1965), Thorn,

Nelson and Thorn (1938) noted a weight gain of +1.0 kg in twenty-four (48%) of the fifty

subjects during premenstruation with an additional nine subjects gaining weight, and then

losing (weight) during menstruation. In a similar study with the use of bioelectrical

impedance analysis (BIA), Deurenberg, Weststrate, Paymans, and van der Kooy (1998)

found a small change in BIA during the menstrual cycle with BIA measurements lower

one week prior ($p < .05$) to menstruation when compared to one week after menstruation

due to water retention and electrolytes in the eight subjects. A small increase in body

weight of 0.5 kg was also noted one week before the onset of menses.

Fluid intake and body weight. Even though fluid intake differed between women

with premenstrual symptoms to those without premenstrual symptoms, no mean weight

gain was reported according to Marean, Cumming, Fox, and Cumming (1995). Fluid

intake throughout the menstrual cycle was reported to be lower in women experiencing

premenstrual symptoms then in women not experiencing premenstrual symptoms and

thus "perceived water retention during premenstruation may be subconscious" (Marean et

al., 1995, p. 78). Also, no significant differences in body weight throughout the

menstrual cycle were reported. Similarly, Moos et al. (1968) studied fifteen women who

reported an increase in water retention from approximately day 14 (ovulation) of the

menstrual cycle to the onset of menstruation with a decrease in water retention during

days 4-6 of menstruation. Moos et al. (1968) did not report any weight gain due to an

increase in body fluid.

Research on dehydration and its effect on body weight during the menstrual cycle

have not been reported. However, there is evidence from studies conducted on male

subjects that dehydration does influence body composition and body weight. Thomas, Etheridge, Londeree, and Shannon (1979) tested eight male college distance runners to determine if endurance running influenced body fat percent (BF%). Each subject participated in two experiments; scintillation counting (^{40}K) and hydrostatic weighing (HW). The first experiment measured BF% by ^{40}K before and after a distance run of 10-12 (11 avg) miles at a 6:00-6:30 minute mile pace. The second experiment measured BF% by HW before and after a distance run of 8-12 (9.5 avg) miles with no pace per mile specified, approximately two weeks after the first experiment. The results of the ^{40}K test indicated an average weight loss of 2.0 kg (or 3.1% total body weight) and an average decrease in BF% of 42.7% (9.6 to 5.6% fat). The results of the HW indicated an average weight loss of 1.3 kg (or 2.1% total body weight) and a decrease in BF% of 14.6% (10.1 to 8.6% fat) with a significant difference ($p < .05$) in the pre- and post- test measurement of body weight, body density (D_b), and body fat percent. In agreement with the results of Thomas et al. (1979), Girandola et al. (1977) found BF% increased by 1% and body weight increased by 1.77 kg (2.4%) after ingesting 1.81 liters of water (hypohydration) on ten male subjects with the use of hydrostatic weighing (HW). A week later, the subjects sat in a sauna for 35 minutes at 170° F before being tested by HW. The results indicated a body weight loss of 0.98 kg and a decrease in BF% of 0.7% due to a decrease in D_b. A significant difference ($p < .01$) was reported in body weight, D_b, and BF% between hypohydration and dehydration.

Vukovich and Peeters (2003) conducted two experiments to determine the effects of water and creatine ingestion on body composition. During the first experiment

eighteen (non-control) males ingested 2,000 ml (~ 8.5 cups) of water (500 ml intervals) with a Bod Pod® assessment conducted after every 500 ml (~ 2.11 cups) ingestion of water. Bod Pod ® assessments were also conducted on ten males (control) without water ingestion prior to the assessment. During the second experiment, twenty-four males (12 control/12 non-control) were given two Bod Pod® assessments. Afterwards, the non-control group was given 5.25 g of creatine to be taken four times a day for seven days. After the seven days, two more Bod Pod® assessments were conducted on both groups. Water ingestion resulted in a significant increase in body mass and body volume ($p < .05$) after every 500 ml. No significant differences were noted in BF%, fat weight (FW), or body density (D_b) after 500 ml of water ingestion. A significant increase was noted in BF% and fat weight after 1000 ml with a slight decrease in D_b. Creatine intake resulted in a weight gain of 1.1 ± 0.4 kg and an increase in body volume of 0.90 ± 0.55 L. The consumption of creatine, which has been marketed as a supplement used to increase muscle mass, may actually increase body fluid and thus increase body weight.

When referencing body composition among athletes and coaches, body fat seems to be the most concern. Wells (1998) tested thirteen female athletes (nine netball and four basketball) for body weight, lung volume, and body density, with hydrostatic weighing (HW), girth measurements (upper arm, waist, thigh, mid-calf), and skinfold measurements (triceps, subscapular, suprailiac, umbilical, front thigh, and mid-calf). Each subject was measured a total of six times for each body composition assessment (HW, girth measurement, skinfold measurement) during two menstrual cycles. Measurements were taken eight days prior to menstruation (pre-8), four days prior to

menstruation (pre-4), and on the fourth day of menstruation (post-4). No differences were found between body weight, body density, and the sum of the four girth measurements. A difference was found in the skinfold measurement between the pre-8 and pre-4 test days in comparison to the post-4 test day. The sum of the skinfold measurement increased from the pre-8 to the pre-4 and then declined to post-4.

O*ral contraceptives.* The research on the impact of oral contraceptives on water retention and body weight during the menstrual cycle is mixed. Fruzzetti et al. (2007) administered an oral contraceptive (OC) containing ethinylestradiol and drospirenone (DRSP) to eighteen women with premenstrual syndrome (PMS). Thirty women not experiencing PMS were used as the control group. Body composition was conducted using body mass index (BMI), waist-to-hip ratio (WHR), and bioelectrical impedance analysis (BIA) to determine fat mass (FM), fat-free mass (FFM), total body water (TBW), and intracellular (ICW) & extracellular (ECW) water. Measurements were taken at beginning of study (baseline measurement), the third menstrual cycle, and the sixth menstrual cycle. Baseline measurements indicated that subjects experiencing PMS symptoms were significantly higher in TBW and ICW then those of the control group. After administering OC (DRSP), subjects with PMS had a mean decrease in TBW ($p <$ .01) and ECW ($p < .001$) by the sixth menstrual cycle. Baseline measurements of FM in the PMS subjects were 19.0 ± 1.8 kg with a decrease to 17.9 ± 1.5 kg by the sixth menstrual cycle. No significant change in BMI and WHR were reported over the length of the study. In contrast, Larson (1993) tested thirty-six females with BIA in which twenty (56%) subjects were non-oral contraceptive (NOC) users and sixteen (44%) were

oral contraceptive (OC) users. Measurements of body weight, and body fat percent were obtained for a minimum of twelve times, three times in each phase (premenstrual, menstrual, postmenstrual, intermenstrual), for the length of one menstrual cycle. A one-time hydrostatic weigh test was conducted during mid-cycle and used as a reference for body fat percent. Results indicated that mean body weight across the twelve measurements did not significantly change ($p > .05$) in either NOC or OC group. No significant difference ($p < .05$) was found between body fat percent in either group (NOC or OC) by BIA when compared to body fat percent from hydrostatic weighing. On an individual basis, fourteen (70%) NOC and five (30%) OC users experienced an increase in body fat percent and body weight with fluctuations in weight of 0.80 kg to 2.95 kg.

Similar results were obtained by Machado, Tachotti, Cavenague, and Maia (2006) who studied the effects of two different oral contraceptives (gestodene and drospirenone) on body weight and body composition. Eighty subjects were divided into three groups: control ($n = 26$), ethinylestradiol/gestodene (EE/GST) ($n = 25$), and ethinylestradiol/drospirenone (EE/DRS) ($n = 29$). Bioelectrical impedance analysis (BIA) was conducted on the first day of the study, day 10, and day 21, for the length of one menstrual cycle to determine total body water (TBW), fat mass (FM), and fat-free mass (FFM). No significant differences were reported in TBW, FM, and FFM across all groups. The control group experienced a decrease in FFM of 4.8% but reported no change in TBW or FM. Total body water (TBW) decreased by 2.3% in the EE/GST group, FM by 4.7%, and FFM by 4.8% while TBW decreased by 2%, FM by 3.9%, and FFM by 0.6%, in the EE/DRS group. In support of the findings by Machado et al.

(2006), body weight (BW), body mass index (BMI), total body water (TBW), and body

cell mass (BCM) were analyzed in a study conducted by Franchini, Caruso, Nigrelli, and

Poggiali (1995) to determine the effects of a low-dose oral contraceptive on body

composition. Seventy-one subjects were divided into three groups: control ($n = 10$),

ethinlyestradiol/desogestrel (EE/DST) ($n = 32$), and ethinlyestradiol/gestodene (EE/GST)

($n = 29$). Bioelectrical impedance analysis (BIA) and BMI were administered on each

subject at the beginning of the study, at six months, and at twelve months. No changes

were noted in BW, BMI, TBW, or BCM within the three groups throughout the study

indicating that body composition was not influenced by the use of the low-dose oral

contraceptives (Franchini et al., 1995).

Some researchers suggest that oral contraceptive use during the menstrual cycle

may influence electrolytes and therefore fluid retention. To address this issue, Blahd,

Lederer, and Tyler (1974) measured body sodium, body potassium, and total body water

(TBW) in fourteen oral contraceptive (OC) users and five non-oral contraceptive (NOC)

users and found no significant differences in body composition at mid (menstrual) cycle

and end (menstrual) cycle. An increase in body water was reported in the NOC during

mid-cycle which may have been associated with ovulation. A significant increase ($p <$

.01) in body sodium was found in the OC compared to the NOC. Therefore the use of

oral contraceptives does not appear to have a significant effect on body fluid and thus,

water retention.

Exercise. Participation in exercise prior to a body composition assessment may

influence the outcome of total body weight due to the amount of perspiration lost during

the activity. The possibility of dehydration may also occur depending on the type, intensity, and duration of the exercise or activity. Whether exercise together with the menstrual cycle alters body composition, has not been reported. Research does report, however, that exercise may influence the menstrual cycle itself. Bonen, (1992) studied the effects of recreational exercise on the luteal phase (end of ovulation to the start of menstruation) of the menstrual cycle. Fifty-seven females were assigned to six different running groups: less than 10 miles of running per week for two menstrual cycles (MC), less than 10 miles/week for four MC, 10-20 miles/week for two MC, 10-20 miles/week for four MC, 20-30 miles/week for two MC, and 20-30 miles/week for four MC. A detraining period the length of two menstrual cycles was assigned at the completion of the running program to "evaluate the effect of the cessation of running on the menstrual cycle", (Bonen, 1992, p. 112). The results indicated no change ($p > .05$) in the level of the luteinizing hormone (LH) across all menstrual cycles. Menstrual cycle length did not change ($p < .05$) during training in all groups nor did the length of the luteal phase change ($p > .05$) in all groups. However, there was a decrease ($p < .05$) in the luteal phase during the second cycle of detraining in the group that ran less than 10miles/week and the group that ran 10-20 miles/week for four MC. No change in body weight or body fat percent was noted and that running up to 30 miles a week did not affect the length of the menstrual cycle.

Assessing body composition. The few studies that have assessed body composition that may be influenced by the menstrual cycle have included the use hydrostatic weighing, bioelectrical impedance, hip-to-waist ratio, and skinfold

measurement. Byrd and Thomas (1983) used hydrostatic weighing as a measure of body composition to determine if a change in body weight would affect body density there by influencing a change in body fat percent. Twelve non-oral contraceptive users were measured for two menstrual cycles. Each subject was measured three times during each cycle: 2-4 days prior to menstruation, the last two days of menstruation, and 6-8 days following menstruation. The results indicated a small mean change in body weight (0.34 kg) that caused a small change in body density but not in amount that would significantly effect body fat percentage. The weight changes that did occurred did so in a manner that did not coincide with any phase (e.g. follicular, menstruation, ovulation, luteal) of the menstrual cycle. Bunt et al. (1989) tested seven females with the use of hydrostatic weighing to determine body density (D_b) and deuterium oxide (D_2O) dilution to determine total body water in order to evaluate any change between highest and lowest body weight within a menstrual cycle. A significant difference ($p < .01$) was noted between the highest and lowest body weight with a mean increase of 2.2 kg with weight fluctuations of 1.60 kg to 4.25 kg. A significant mean difference was found in total body water ($p < .05$) and D_b ($p < .01$) with a mean decrease in D_b of .0060 g·cc^{-1}. An increase in body fat percent between individual high and low body weight based on the estimation of D_b, ranged from 0.6% to 4.7%. Hydration levels may have been a contributing factor in the results of D_b, thus influencing body fat percent.

The determination of body composition with the use of bioelectrical impedance analysis (BIA) is based on the ability of an electrical current to pass through the body with the least amount of resistance. A high body fat content will minimize the ability of

the electrical current to pass through the body. The results of BIA are not only influenced by body fat but are also influenced by body fluid, electrolytes, and body temperature. Gleichauf and Roe (1989) tested twenty-five females on a daily basis (excluding Sunday) for one menstrual cycle. It was presumed that one menstrual cycle was from the start of one menstruation to the start of the next menstruation as the article did not specify the length of each subject's menstrual cycle. Daily accounts of sodium intake were also noted. The menstrual cycle was divided into four phases: menses, follicular, post ovulation, and premenstrual. The results indicated a significant difference in resistance ($p < .001$), weight ($p < .05$), and fat-free mass ($p < .05$) between the menses and follicular phase of the menstrual cycle. Differences were also noted between the follicular and luteal phase for resistance ($p < .05$) and weight ($p < .05$). A change in body weight ($p < .001$) associated with sodium intake was due to an error in the resistance measurement and no significant difference in body fat percent was reported.

Waist-to-hip ratio (WHR) is another method used to determine body composition. WHR is obtained by dividing the circumference of the waist by the circumference of the hip (Neiman, 2007). The ratio obtained is then used as an indicator of health risk (Whaley, Brubaker & Otto, 2006). Kirchengast and Gartner (2002) studied the effect of the menstrual cycle on WHR of thirty-two females. Of the thirty-two females, twenty-four (75%) were non-oral contraceptive (NOC) users and eight (25%) were oral contraceptive (OC) users. The NOC users were placed into three groups depending upon the length of their menstrual cycle: 27-30 days, 23-26 days, and 31-34 days. The OC users were group four. The results indicated a slight increase in body weight in all

groups during the second half (~ ovulation to menstruation) of the menstrual cycle with

the 27-30 day group and the 31-34 day group experiencing an increase in body weight. A

change in WHR was also noted in the 27-30 day group with a decreased in WHR at the

time of ovulation and then increased post ovulation, but remained low in comparison to

the first day of menstruation until ovulation. Lack of significant changes in WHR may be

due to subject error as each administered her own WHR measurement.

   Reliability and validity of the Bod Pod®. Hydrostatic weighing has always been

known as the 'gold standard' in the industry for its reliability and validity in determining

body composition. Since its inception in 1985, the Bod Pod® has been the subject of

numerous studies comparing its own reliability and validity to that of hydrostatic

weighing, bioelectrical impedance analysis, skin fold measurements, and dual-energy x-

ray absorptiometry (DXA). McCrory et al. (1995) compared the Bod Pod® to

hydrostatic weighing (HW) for test-retest reliability. To determine the reliability of the

Bod Pod® with HW, two trials were administered on sixteen subjects to measure body

fat percent. No significance was found between trials. Validity was measured with the

use of sixty-eight subjects indicating no significant difference in body fat percent

between the Bod Pod® and HW. A 95% confidence interval of -0.6% to 0.0% and a

mean difference of -0.3 $\pm$ 0.2 in body fat percent was found among all subjects.

Similarly, Anderson, (2007) found no difference between same day trials for body

density (D_b) (r = .97 to. 98), body volume (BV) (r = 1.00), lung volume (V_{TG}) (r = .86 to

.96), and body fat (BF) (r = .98) in eight male and sixteen females with measurements

taken twice a day for three days. Significant differences between the highest and lowest

value of the three days were found in D_b, BV, V_{TG}, and BF, therefore validating the

reliability of the Bod Pod®.

In a study conducted by Maddalozzo, Cardinal, and Snow (2002), a comparison

of BF% from the Bod Pod® and duel energy x-ray absorptiometry (DXA) was assessed

in twenty-four female athletes and nineteen non-athletes. Average BF% was 24.3 ± 1.1

from the Bod Pod® and 23.8 ± 0.8 from DXA. DXA was slightly more accurate then the

Bod Pod® in determining BF% as the Bod Pod® assessment was a predicted thoracic gas

volume assessment and not a measured thoracic gas volume assessment which is

presumed to be more accurate than that of a predicted Bod Pod® assessment. In contrast,

Ballard, Fafara, and Vukovich (2004) found no difference in BF% in athletes between the

Bod Pod® (22.5 ± 5.5) and DXA (22.0 ± 4.7), and non-athletes (28.5 ± 6.7; 28.2 ± 5.2

respectively). Test-retest on twelve non-athletes ($R^2 = .92$, SEE = .0047) and ten athletes

($R^2 = .94$, SEE = .0045) was shown to be a reliable indicator in BF%, fat-free mass, and

body density when using a predicted Bod Pod® assessment. Biaggi et al. (1999) reported

no significance in BF% between the Bod Pod®, hydrostatic weighing (HW), and

bioelectrical impedance analysis (BIA) in forty-eight (male = 24/female = 24) subjects.

The BF% obtained from the Bod Pod® was significantly correlated with HW ($r = .944$;

$p < .001$) and BIA ($r = .859$; $p < .01$) although the Bod Pod® "underestimated BF% in

men by $-1.24 \pm 3.12\%$ and overestimated BF% in women by $1.02 \pm 2.48\%$" (Biaggi et

al., 1999, p. 898) in comparison with HW. Underestimated BF% in men may be due to

the isothermal effect influenced by excessive body hair (Life Measurement, operational

manual).

Measured thoracic gas volume assessment of the Bod Pod® was compared to gas dilution by Davis et al. (2007) to determine the reliability of body composition based on functional residual capacity (FRC). The Bod Pod® measures FRC at mid-exhalation where as FRC is measured at end-exhalation in hydrostatic weighing (Davis et al., 2007). Ninety-two (male = 46/female = 46) subjects completed two measured Bod Pod® assessments and one gas dilution measurement for FRC. Bod Pod® test-retest reliability was in excellent agreement to that of gas dilution with a correlation coefficient of .966 for males and .948 for females, supporting the reliability of the Bod Pod® as a valid measurement of body composition based on FRC. Similarly, McCrory, Molé, Gomez, Dewey, and Bernauer (1998) compared predicted thoracic gas volume (V_{TGpred}) to measured thoracic gas volume (V_{TGmeas}) in fifty (male = 14/female = 36) subjects and found no significant difference between V_{TGpred} and V_{TGmeas} (mean difference $\pm$ SEE 53.5 $\pm$ 63.6 ml) and no significant difference in BF% (0.2 ± 0.2%). Body fat percent did vary on an individual basis of $\pm$ 2.0% in 23 (46%) of the subjects.

Statement of problem

The menstrual cycle may influence body composition due to water retention and thus affect body fat percent, lean weight, and total body weight. If significant differences in body composition exist within specific phases of the menstrual cycle, researchers may need to address the timing of a body composition assessment in their study design.

Purpose

The purpose of this study was to determine if there were significant fluctuations in body composition during a normal menstrual cycle using air displacement plethysmography (Bod Pod®).

Hypothesis

The Bod Pod® will detect significant changes in body fat percent, lean weight, and total body weight within specific phases of a women's menstrual cycle.

Operational Definitions

Air displacement plethysmography. A method used to determine body composition by measuring the volume of air in an empty chamber to that of the amount of the air displaced by a human upon entering the test chamber. The Bod Pod® is a two compartment chamber (reference and testing chamber) manufactured by Life Measurement, Inc. of Concord, CA, used to assess body composition.

Fat weight. The amount of body fat in kilograms, used in the assessment of body composition. In this study, fat weight is expressed as a percent (i.e. body fat percent or BF%).

Lean weight. The amount of lean weight in kilograms. Lean weight consists of the water, bone, mineral, and protein (muscle), used in the assessment of body composition. Lean weight is also referred to as fat-free mass.

Menstrual cycle. A continuous cycle of physiological occurrences in reproductive females with an average length of 28-33 days.

Assumptions

In this study, certain assumptions were understood to be implied in the design and implementation:

1. Subjects were honest in answering all questions during the study including verbal questions and written answers on the questionnaire.

2. Subjects kept an accurate record of their current and previous menstrual cycle and menstruation.

3. Based on the subjects' accurate record of current and previous menstrual cycle and menstruation, assigned Bod Pod® assessments were within the four phases of the menstrual cycle.

4. Subjects followed Bod Pod® protocols of no consumption of a heavy meal three hours prior to each assessment and no exercise four hours prior to each assessment. Subjects were assumed to have maintained normal hydration levels prior to each assessment.

5. Menstrual cycle assumed to be 28-33 days with menstruation length of 3-5 days for women who do not take oral contraceptives. Women who do take oral contraceptives may have menstrual cycles and menstruation that vary in length.

6. Subjects were not participating in a weight reduction program during the study.

7. Subjects were not participating or planning on starting an endurance exercise program during the study that may influence their menstrual cycle and menstruation.

8. Subjects were healthy individuals with no known diseases or disabilities.

9. The Bod Pod® was in standard working condition with no known or foreseen mechanical difficulties arising throughout the duration of the study.

Delimitations

The following delimitations are noted as they may have affected the outcome of this study:

1. Subjects were females attending Humboldt State University and between 18-23 years of age.

2. Study was only 4-5 weeks in duration.

3. Subjects must have had a consistent monthly menstrual cycle for the past twelve months with no interruptions in menstruation to participate in the study.

4. Subjects were non-intercollegiate and non-club team athletes. Subjects were allowed to participate in an exercise program during the study but it was suggested not engage in an endurance type activity (e.g. marathon training) that may interrupt a normal menstrual cycle.

5. Females who took oral contraceptives were allowed to participate in the study along with those females who were not oral contraceptive users.

6. Subjects had to be available for a Bod Pod® assessment once a week for four to five consecutive weeks with assessments conducted in the Human Performance Lab.

Limitations

The following limitations are noted as they may have affected the outcome of this study.

1. Menstrual cycle was determined by the subjects' personal record using a calendar starting with the first day of menstruation to the last day of the menstrual cycle, prior to the start of the next menstruation. No other determinations were used in this study.

2. Dietary intake of food and fluids were not monitored during the study.

3. Biological responses to stress due to school, work, living accommodations, and personal relationships may have influenced the regularity of the menstrual cycle.

Significance of study

Results from this study enabled researchers to decide if adjustments in the timing of body composition assessments need to be conducted within specific phases of a women's menstrual cycle. If the menstrual cycle significantly affected body composition results, adjustments to the timing of these assessments would be necessary.

Chapter Two

Methods

 Subjects. Twenty-one ($n = 21$) female students attending Humboldt State University (HSU) volunteered to participate with seventeen ($n = 17$) (80%) completing the study. Subjects were recruited at two separate times during the 2007-2008 school year; once during the fall semester and once during the spring semester from several kinesiology and physical education activity classes. Only females between the ages of 18-23 years of age with a consistent menstrual cycle and no missed cycles within the last twelve months were allowed to participate. Subjects were also required to be in good health with no known disease or disabilities, could not be pregnant or plan on becoming pregnant during the study, and could not be an intercollegiate or club team athlete. Oral contraceptive use and participation in recreational exercise was not controlled for in this study and therefore allowed. A brief ten minute presentation on the proposed research project was described in several classes to recruit volunteer subjects. Flyers describing the study and the requirements for participation were posted (with permission) throughout campus on the general information bulletin boards. Subjects were informed that the study would last approximately four to five weeks for a total of five Bod Pod® body composition assessments. Depending on the subject's menstrual cycle, subjects were required to be available, if necessary, for further assessments beyond 4-5 weeks. Once it was determined that the subject met the minimum qualifications of the study, the subject was asked to read, sign, and date a consent form. In addition, each subject

completed and signed a questionnaire pertaining to information such as exercise

participation and menstrual cycle symptoms. Following the procedures and requirements

for the use of human subjects in research, permission was granted to proceed with the

study by the Internal Review Board #07-15 (Appendix A) of Humboldt State University.

The name of the subject and all information associated with her participation in the study

is kept anonymous and confidential and has not been used in any written portion of the

final research project.

 Prior to testing, each subject was provided with information on the procedures

and protocols of the Bod Pod® and what was expected of each subject in order to obtain

a successful body composition assessment. Past menstruation dates were requested

although not required in order to determine the average length of each subjects'

menstrual cycle. Subjects were assigned days and times to report for a Bod Pod®

assessment based on their last menstrual cycle. Assigned days varied throughout the 4-5

week study with some days scheduled for Saturday or Sunday. The time of day that each

subject was to report was consistent in order to minimize possible circadian rhythm

influences. For instance, if the subject was scheduled to report for her first body

composition assessment at 10:00am, all other assessment dates were scheduled for the

same time (i.e. 10:00am). Assigned assessment days (2-4 days prior to menstruation, last

two days of menstruation, and 6-8 days from end of menstruation) followed the study

design of Byrd and Thomas (1983) based on the subjects' past menstrual cycle with the

addition of two assessment days (day 15 and day 16) established by the researcher of this

study. It was necessary to establish two additional Bod Pod® assessments [day 15 and

day 16] in order to coincide with start of the luteal phase of the menstrual cycle and also

to determine the validity of the day-to-day reliability of the Bod Pod®.

Study design. Each subject was measured a minimum of five times during the 4-5

weeks of the study: 2-4 days prior to menstruation, the last day or second to the last day

of menstruation, 6-8 days following menstruation, and day 15 and day 16 following

menstruation.

Instrumentation. The Bod Pod®, a device that measures body composition based

on air displacement plethysmography, was used to assess body composition. The Bod

Pod® (Life Measurement, Inc., version 2.0, 2005) is an egg-shaped, two compartmental

chamber that measures body volume based on the relationship between pressure and

volume in each compartment. This relationship between pressure and volume represents

Boyle's Gas Law of $P_1/P_2 = V_1/V_2$ (Life Measurement, operational manual). To assess

body composition, the subjects enter the test chamber located at the front of the Bod

Pod®. The reference chamber is located to the rear of the Bod Pod® and is used as a

point of reference for volume. The Bod Pod® uses the principle of whole body

densitometry to calculate the amount of body fat and fat free mass. In order to calculate

body fat, body density must be determined by dividing body mass (body weight) by the

volume of the subject in the test chamber. Once body density is determined, the number

is inserted into a formula to determine body fat (percent). Lean weight and total body

weight are then calculated once body fat is determined. The Brozek formula (%fat =

$(4.75/Db – 4.142)*100$) was used in this study and is based on cadaver studies of lean and

obese individuals (Life Measurement, operational manual). The Siri formula (%fat =

4.95/Db – 4.50)*100) was not considered as it is characteristic of the general population and not representative of the subjects in this study.

Procedures. To obtain accurate test results the subjects followed specific protocols prior to each Bod Pod® assessment. Each subject was instructed to refrain from eating a heavy meal three hours prior to each assessment and refrain from engaging in strenuous exercise four hours prior to each assessment. Subjects were also instructed to maintain a constant fluid level by not ingesting large quantities of fluid prior to assessment or be dehydrated prior to each assessment. Subjects were required to wear tight fitting clothing, such as a swim suit or tight fitting shorts, to minimize the isothermal effect that can occur around clothing, hair, epidermis, and within the lungs (Life Measurement, operational manual). Each subject was also required to wear a tight fitting swim cap that was supplied by the Human Performance Lab. Subjects removed all jewelry and eye wear before each assessment unless the item was unable to be removed and therefore the subject was required to continue to wear the item for each assessment. Subjects were requested to void prior to each assessment and to refrain from foods that could cause intestinal discomforts or bloating.

A predicted and measured assessment was given on each of the assigned days that the subject was to report. Prior to the first day of assessment, the subject's height was measured to the nearest centimeter, using a height rod located on a standard balance beam body weight scale. A predicted body composition assessment was administered prior to the measured assessment. Subject's information (identification number, age, gender, height) was entered into the computer component of the Bod Pod®. When

instructed by the researcher, the subject stepped on the scale component of the Bod Pod®
device to calculate body mass. Once body mass (body weight) was determined and the
Bod Pod® system had completed the calibration process, the subject was instructed to
enter the test chamber. Subjects were asked to remain still while maintaining a normal
breathing rhythm throughout the assessment. Two, fifty-second tests were administered
unless the results of the first two fifty-second tests were inconsistent at which time a third
fifty-second test was administered. Upon the completion the predicted assessment, a
measured assessment was performed. The same testing procedures were followed for the
measured assessment with the addition of a final test in order to determine body volume
by measuring the volume of air in the thoracic cavity (V_{tg}) (Life Measurement,
operational manual).

Prior to the measured Bod Pod® assessment, a plastic tube was placed into a
designated area inside the chamber of the Bod Pod®, located near the subjects left ear.
When instructed to do so, the subject placed a nose clip on her nose and the plastic tube
her mouth, maintaining a normal breathing rhythm. When signaled, the subject gently
'puffed' three times into the tube. The measured body composition assessment was
complete when the merit indicator (a mathematical analysis between the airway pressure
curve and chamber pressure curve) (Life Measurement, operational manual) was less than
1.00 and the airway indicator which is the maximum airway pressure generated during
the puffing maneuver was less than 35cm H_2O (Life Measurement, operational manual).

Statistical Analysis

Body fat percent, lean weight, and total body weight was evaluated during five body composition assessments on each participant ($n = 17$). Descriptive statistics of the mean and standard deviation of body fat percent and lean weight were calculated for predicted Bod Pod® body composition assessment, and body fat percent, lean weight, and total body weight was calculated for measured Bod Pod® body composition assessment. The independent variable was the designated times (2-4 days, menstruation, 6-8 days, day 15, day 16) the subjects reported for an assessment. The dependent variable was the result obtained of body fat percent, lean weight, and total body weight. As a result of the importance between predicted and measured assessments, a repeated measures of ANOVA Generalized Linear Model (GLM) was performed to determine body composition differences at the designated times. Statistical analysis was performed using SPSS version 15.0.

Chapter Three

Results

The assessment of body composition was analyzed to determine whether the influence of the menstrual cycle affected body fat percent, lean weight, and total body weight within specific phases of a women's monthly cycle. A total of seventeen ($n = 17$) female students at Humboldt State University completed the study of which five (29%) of the subjects were oral contraceptive users and twelve (71%) were non-oral contraceptive users. Analysis of oral contraceptive users ($n = 5$) and non-oral contraceptive ($n = 12$) users found no significant differences ($p > .20$) between groups for body fat percent, lean weight, and total body weight. As a result birth control was not included as a separate independent variable. The independent variable was the time of each Bod Pod® body composition assessment (2-4 days prior to menstruation, last two days of menstruation, 6-8 days from end of menstruation, and the average of the combined assessments taken on day 15 and day 16 from the end of menstruation). The dependent variables were body fat percent, lean weight, and total body weight as measured by the Bod Pod®.

Descriptive statistics of the mean and standard deviation for body fat percent and lean weight of the predicted Bod Pod® assessment, and body fat percent, lean weight, and total body weight of the measured Bod Pod® assessment of the subjects are listed in Table 1. Total body weight of the predicted Bod Pod® assessment was not included as total body weight remained the constant during both assessments. Test-retest reliability was established and found to be acceptable for all repeated measures taken on body fat

percent ($r = .953$ and $.977$), lean weight ($r = .827$ and $.987$), and total body weight ($r =$ .997 and .999).

Table 1
Mean and Standard Deviation: Predicted and Measured Bod Pod® Assessment

Assessment	2-4 days	Menstruation	6-8 days	Avg 15/16 days
Predicted ($n = 17$)				
Body fat (%)	27.15 ± 5.8	27.24 ± 5.7	27.51 ± 5.3	27.12 ± 5.6
Lean weight (kg)	47.92 ± 4.4	47.67 ± 4.5	47.47 ± 4.6	47.89 ± 4.4
Measured ($n = 17$)				
Body fat (%)	26.75 ± 5.3	26.35 ± 5.2	26.75 ± 5.0	27.12 ± 5.1
Lean weight (kg)	48.22 ± 4.5	48.25 ± 4.4	47.98 ± 4.7	47.90 ± 4.6
Total body weight (kg)	66.54 ± 10.3	66.08 ± 10.4	66.04 ± 10.4	66.30 ± 10.5

Repeated measures of ANOVA Generalized Linear Models (GLM) was used to determine the statistical significance of body fat percent, lean weight, and total body weight of the seventeen ($n = 17$) subjects at each time point. Analysis of the results for body fat percent found that the equality of covariance matrices assumption for within subjects as determined by the Box's M Test ($p = .995$) was not violated. Mauchly's Test for sphericity was violated due to a significant *p*-value (.032) within subjects therefore epsilon adjustments were evaluated to determine the appropriate correction in the *F*-value. The Greenhouse-Geisser (.808: $F_{(2.42, 17)} = 1.579$, $p = .208$) and Huynh-Feldt (.906: $F_{(2.72, 17)} = 1.579$, $p = .204$) indicated no significant mean differences of predicted and measured Bod Pod ® body fat percent between time points at 2 to 4 days before menstruation (predicted = 27.15, measured = 26.75), during menstruation (predicted = 27.24, measured = 26.35), 6 to 8 days after menstruation (predicted = 27.51, measured =

26.75), and the average of day 15 and 16 after menstruation (predicted = 27.12, measured
= 27.12). Figure 1 represents the mean body fat percent for predicted and measured Bod
Pod® assessments.

Figure 1. Mean body fat percent for predicted and measured Bod Pod® body
composition assessment over time (*n* = 17).

Analysis of results for lean weight (kg) found that the equality of covariance
matrices assumption for within subjects as determined by the Box's M Test (*p* = .956)
was not violated. Mauchly's Test of sphericity was not violated and therefore resulted in
no significance (*p* = .194), indicating that the assumption of sphericity were met and no
additional epsilon adjustments were needed. There was no significant mean differences
of predicted and measured Bod Pod ® lean weight between time points at 2 to 4 days
before menstruation (predicted = 47.92, measured = 48.22), during menstruation

(predicted = 47.67, measured = 48.25), 6 to 8 days after menstruation (predicted = 47.47, measured = 47.98), and the average of day 15 and 16 after menstruation (predicted = 47.89, measured = 47.90). Figure 2 represents the mean lean weight (kg) for predicted and measured Bod Pod® assessments.
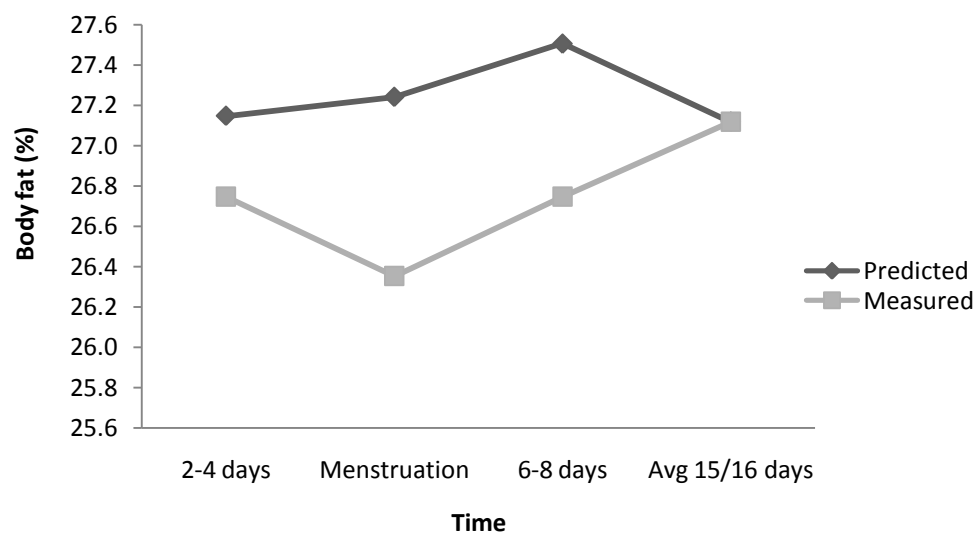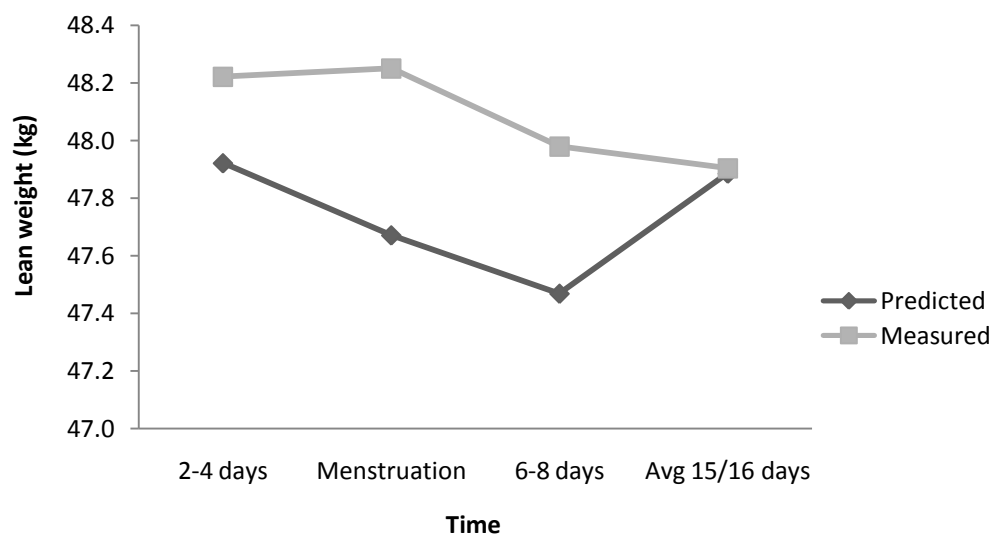

Figure 2. Mean lean weight (kg) for predicted and measured Bod Pod® body composition assessment over time ($n = 17$).

Analysis of results for total body weight (kg) found that the equality of covariance matrices assumption for within subjects as determined by the Box's M Test ($p = 1.00$) was not violated. Mauchly's Test for sphericity was violated due to a significant p-value (.010) within subjects therefore epsilon adjustments were evaluated to determine the appropriate correction in the F-value. The Greenhouse-Geisser (.786: $F_{(2.36, 17)} = .007$, $p = .997$) and Huynh-Feldt (.879: $F_{(2.64, 17)} = .007$, $p = .998$) indicated no significant mean

differences of measured Bod Pod® for total body weight between time points at 2 to 4

days before menstruation (66.54), during menstruation (66.08), 6 to 8 days after

menstruation (66.04), and the average of day 15 and 16 after menstruation (66.30).

Figure 3 represents the mean total body weight (kg) for a measured Bod Pod®

assessment.

Figure 3. Mean total body weight (kg) for a measured Bod Pod® body composition

assessment over time (*n* = 17).

Chapter Four

Discussion

It appears to be a common experience by most women during the menstrual cycle: headaches, breast tenderness, mood swings and water retention (Golub et al., 1965). An increase in food and calories has been known to be influenced by the hormonal changes within the menstrual cycle (Dalvit, 1981) and may account for an increase in body weight, fluid retention, and body fat. An argument could be made that the symptoms experienced by women during the menstrual cycle are "subconscious" (Marean et al., 1995, p. 78) and not necessarily physical in nature. Based on the answers given on the questionnaire completed by the participants ($n = 17$) in this study, six (35%) experienced a change in appetite and a change in the way their clothes fit prior to menstruation, while five (29%) subjects experienced no change in appetite or the way their clothes fit. The purpose of this study was to determine if the menstrual cycle influenced body fat percent, lean weight, and total body weight and if women should refrain from any type of body composition assessment during a specific phase within the menstrual cycle.

Results of no significance in body fat percent was consistent with the findings of Larson (1993), who conducted body composition assessments with the use of bioelectrical impedance analysis (BIA) and found no significant difference in body fat percent between or within subjects. Larson (1993) also reported that oral contraceptives had no affect on body fat percent which supports the findings by Chumlea, Roche, Guo, and Woynarowska (1987) who also found that the menstrual cycle and oral

contraceptives had no affect on body composition with BIA. Gleichauf, and Roe (1989) also conducted body composition analysis using BIA and found no significance in body fat percent but found a significance in fat-free mass (lean weight) and total body weight during menstruation. Wells (1988) noted an increase in skinfold measurement from premenstrual to post menstrual in his study involving athletes. It was reported that the increase in skinfold measurements was due to "the redistribution of body fluid in subcutaneous compartments" (Wells, 1998, p. 18)

Unlike the results of no significance in body fat percent with BIA, Bunt et al. (1989) found significance in the mean difference of body fat percent and total body weight with the use of hydrostatic weighing (HW). The use of HW for body composition can be the subject of questionable results depending on the status of the hydration level of the participant. Thomas et al. (1979) and Girandola et al. (1977) reported findings of decrease body fat percent when participants were in a state of dehydration due to the presumption that the body appears to be more dense in water indicating an increase in lean body mass. Although the participants in both of these two studies were male, similar results would be expected if the participants were female. In contrast, dehydration levels of participants in air displacement plethysmography (Bod Pod®) would appear to have an increase in body fat percent as less fluid is stored within the muscle fibers, indicating a decrease in lean body weight and body density.

The results of lean weight in this study reported no significance and therefore not influenced by the menstrual cycle. Total body weight fluctuations can be seen in Figure 3, although overall, the results indicate no significance even after epsilon adjustments

were administered to validate sphericity. The increase in total body weight 2-4 days prior

to menstruation and during the average 15/16 days with a decrease in weight during

menstruation, is evident in Figure 3, suggesting that women do experience an increase in

body fluid prior to menstruation which is then (water) excreted at the time of menses.

The increase in body fluid prior to menstruation is presumed to be due to body's increase

level of the hormone progesterone and the increase in body temperature during the luteal

phase (~ last two weeks prior to menstruation) of the menstrual cycle. During

menstruation, progesterone levels appear to decrease which may suggest that the decrease

in total body weight is due to the excretion of body fluids. Although Larson (1993)

reported an increase in body weight in fourteen (70%) of the twenty non-oral

contraceptive users and five (31%) of the sixteen oral contraceptive users, the increase in

body weight "was not correlated with any particular phase of the menstrual cycle"

(Larson, 1993, p. 40). Byrd and Thomas (1983) also reported a small increase in mean

total body weight but the increase in weight was found not to be consistent within the

menstrual cycle. Other research supports the notion that there is an association between

an increase in total body weight prior to menstruation. Bruce and Russell (1962),

Deurenberg et al. (1988), Kirchengast and Gartner (2002), Robinson and Watson (1965),

and Thorn et al. (1938), reported that the subjects in their research experienced an

increase in total body weight prior to menstruation and a decrease in total body weight at

the time of menstruation. Bruce and Russell (1962) and Thorn et al. (1938) also noted an

increase in total body weight during ovulation, therefore suggesting that an increase in

body weight may not coincide with a specific phase of the menstrual cycle.

Conclusion

To date, no other study has used air displacement plethysmography (Bod Pod®) to determine if the menstrual cycle affects body composition. No significant differences were found in body fat percent, lean weight, and total body weight during specific phases of the menstrual cycle. Therefore, it is not necessary to adjust the timing of a Bod Pod ® body composition assessment within the menstrual cycle.

Additional research is needed on the menstrual cycle and its influence on body composition with the use of air displacement plethysmography (Bod Pod ®). Future research may include the need to evaluate non-oral contraceptive and oral contraceptive use as separate variables, not combining data results. It is also suggested that future studies may need to broaden the age range of the participants (e.g. 24-40 years of age), include the use of intercollegiate athletes & women who do not participate in physical activity, and monitor nutritional & dietary habits.

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Appendix A
Human Subject Approval Letter

HUMBOLDT STATE UNIVERSITY

Office of the Dean
Research, Graduate Studies & International Programs

MEMORANDUM

DATE: October 8, 2007

TO: Brenda Francek, Principal Investigator
Dr. Kathy Munoz, Faculty Adviser
Department of Kinesiology and Recreation Administration

FROM: Yvonne Everett, Ph.D.
Committee for the Protection of Human Subjects in Research

Your Proposal: Influence of the Menstrual Cycle on Body Composition as
Determined by Air Displacement Plethysmogrpahy (BodPod)
Approval #07-15

Thank you for submitting your proposal to the committee for the protection of human subjects in research. I agree that your proposal falls under the category of **expedited** because the subjects are over the age of 18, you have secured anonymity of respondents and they are participating voluntarily.

This memo constitutes formal approval of your research proposal. This approval is for one calendar year, and will expire on **October 8, 2008**. If you find it necessary to continue your research beyond this date, please apply for renewed approval in advance of this date to prevent interruptions in your project. If your research plan must be altered, please notify this office according to the policies established for Humboldt State University.

Thank you for your careful attention to the protection of the human subjects of your research.

Appendix B
Participant Consent Form

Participant Consent Form

The purpose of this research study is to determine if the menstrual cycle effects body composition in college-age females. The procedures and the measurement of body composition will be performed using air displacement plethysmography (Bod Pod®), by Brenda Francek, the graduate student responsible for and conducting this research study. Body composition procedures and measurements will take place in the Human Performance Lab located in room 124 of the Forbes Complex on the campus of Humboldt State University (HSU).

Risks Associated With Your Participation

There are no known risks involved in the use of the Bod Pod® for assessing body composition. Your name and all information associated with your participation in this study will be kept anonymous and confidential. Your name will not be used in any written portion of the final research project. Instead you will be assigned a number for data identification purposes to protect your anonymity.

Benefits Associated With Your Participation

By participating in this research study, you will have a better understanding of your own body composition and how it may be influenced by your menstrual cycle. At the end of the study, you will receive a copy and a consultation of your body composition results.

Consent to Participate

I hereby agree to participate in the research study conducted by Brenda Francek based on the following understanding:

- I understand that my participation in this study is entirely on a volunteer basis and that I may terminate my participation at any time without penalty. I understand that Brenda Francek has the right to terminate my participation at any time without penalty.

- I understand that my participation in this study will last for a minimum of 4-5 weeks with the possibility of the study extending to 8-9 weeks. Extension of this study after five weeks will depend on the participant's desire and availability along with the non-interruption of scheduled test dates due to school holidays and/or the end of the scheduled semester, and the relocation of the Kinesiology department and equipment to its new location.

- I agree to have my body composition tested in the enclosed, air displacement plethysmography chamber known as the Bod Pod®. Although the enclosed chamber has a large window, the feelings of anxiety or claustrophobia may exist. I understand that Brenda Francek will make every effort to ensure that my participation in this research study is as comfortable as possible.

- I agree to perform two tests within the Bod Pod® chamber on every day that I am scheduled to report for testing. I am aware that one of the tests to be conducted will be a predicted body composition assessment the other test to be conducted will be a measured body composition assessment.

- I understand that I must be at least 18 years or older in order to participate in this research study.

- I understand that I will not receive any compensation for my participation in this research study other than the copy of my body composition results.

- I understand that I may contact Brenda Francek or Dr. Munoz, Dr. MacConnie, or Dr. Braithwaite, either by telephone or in person at any time should I have any concerns about the procedures or my participation in this research study.

Contact information about the study:
Brenda Francek – Graduate Student: (707) 826-4979
Dr. Kathy D. Munoz – Committee Chairperson: (707) 826-3840
Dr. Susan E. MacConnie – Committee Member: (707) 826-4536
Dr. Rock Braithwaite – Committee Member: (707) 826-4543

This information was explained to me by Brenda Francek.

X _____   _____
   Research Participant (print name)   Date

X _____
   Research Participant (signature)

Appendix C
Participant Questionnaire

Participant Questionnaire

Please answer the following questions to the best of your ability. If you do not understand a question, please ask for help. Feel free to elaborate on an answer to a question (other than yes or no) if you feel it would be a benefit to the study.

1. Name: _____

2. Age _____(years)

3. Telephone number(s) with area code: _____

4. E-mail address: _____

5. Do you have a menstrual cycle (menstruation) every month?   Yes ☐   No ☐

    If you answered no, please stop here.

6. Within the last year, have you had a menstrual (menstruation) cycle every month

    without interruption?   Yes ☐   No ☐

7. When was the first day of your last menstruation? _____

8. When was the last day of your last menstruation? _____

9. Are you a healthy individual, free from any known diseases such as diabetes,

    cancer, or heart disease?   Yes ☐   No ☐

    If you answered no, please stop here.

10. Do you currently smoke, including recreationally?   Yes ☐   No ☐

11. If you answered *no* to question #10, have you smoked within the last 6 months?

    Yes ☐   No ☐

12. Are you currently an intercollegiate athlete here at H.S.U.?   Yes ☐   No ☐

    If you answered yes, please stop here.

13. Do you currently participate in an exercise program/activity? Yes ☐ No ☐

14. If you answered *yes* to question #13, how many times per week do you participate in an exercise program/activity? _____

15. On the average, how much time do you spend on a daily basis participating in an exercise program/activity? (e.g. 30 minutes per day of yoga) _____

16. What types of exercise program/activity do you participate in? _____

17. Are you currently taking oral contraceptives (OC)?   Yes ☐   No ☐

18. If you answered *yes* to question #17, how long have you been taking OC? ___ yrs.

19. Do you know the type/brand name of the OC that you are taking? Yes ☐ No ☐

20. If you answered *yes* to question #19, list the name of the OC here: _____

21. As you near the start of menstruation do you notice a change in your appetite such as the craving of salt or sugar products?   Yes ☐   No ☐

22. Do you notice a change in the way your clothes fit prior to menstruation?

Yes ☐   No ☐

23. Are you taking any medications (other than OC, if applicable) that may cause your body to retain fluids?   Yes ☐   No ☐

24. If you answered *yes* to question #23, list the medications here: _____

25. Do you take diuretics to relieve fluid retention prior to menstruation or at any other time during the month?   Yes ☐   No ☐

Thank you for volunteering to be a participant in my study – Brenda Francek

Appendix D
Participant Recruitment Announcement

WANTED

RESEARCH VOLUNTEERS

to participate in a study of the menstrual cycle and its
influence on body composition

Requirements:

Female, 18 - 23 years of age

Must have a monthly menstrual cycle

Must be willing to complete the five week study
and report on assigned days for a Bod Pod®

Must not be an intercollegiate athlete

Must be healthy – No known diseases

The benefit to you as a volunteer subject:

Body composition analysis (Bod Pod®) and
consultation at the end of the study

A great experience that you can include on your
resume

For more information, contact Brenda – **blf10@humboldt.edu**

or call/stop by the Human Performance Lab at (707) 826-4979