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Using Rating of Perceived Exertion in Assessing Cardiorespiratory Fitness in Endometrial Cancer Survivors

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Abstract

For cancer survivors, who also often present with co-existing health conditions, exercise testing is often performed using submaximal protocols incorporating linear heart rate response for estimating cardiorespiratory capacity and assessing exercise tolerance. However, use of beta-blockers medications, during sub-maximal protocols based on linear HR response can be problematic. Rating of perceived exertion (RPE), which takes into account an individual's overall perception of effort, can be used as a complementary tool that does not rely solely on heart rate response to increased workload. We compared heart rate response (VO_2HR) and self-rating of perceived exertion (VO_2RPE) in a graded submaximal exercise test (GXT) in 93 endometrial cancer survivors. Results of the GXT were stratified according to whether participants were taking beta-blocker (BB) medications or not (non-BB). Among non-BB participants, there was no difference between the mean VO_2HR and the mean VO_2RPE estimates of cardiorespiratory capacity ($mlO_{2/}$ /kg/min), (20.4 and 19.3, respectively; $p = 0.166$). Among BB participants, the mean VO_2HR approached significant difference than the mean VO_2RPE, (21.7 $mlO_{2/}$ /kg/min and 17.6 $mlO_{2/}$ /kg/min, respectively; $p = 0.087$). Bland-Altman plots for both methods showed a proportional bias for the non-BB group; but not the BB group. Our results suggest that sub-maximal protocols based on Borg's Rating of Perceived exertion (RPE) produce differing results from sub-maximal protocols based on HR response when applied to clinical population taking BB medications. Using RPE instead of HR for participants on BB medications, may be a better method for assessing exercise tolerance for estimating cardiorespiratory capacity in sub-maximal exercise testing.

Keywords

cardiorespiratory fitness; exercise testing; perceived effort

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Declaration of Interest
The authors report no conflicts of interest.

INTRODUCTION

Currently there are approximately 14.5 million U.S. cancer survivors, a number projected to continue to escalate dramatically (American Cancer Society, 2014; National Cancer Institute, 2013). Many cancer survivors tend to decrease their activity levels after diagnosis, and even for those who had been active, few return to their former levels of activity after treatment (Bourke et al, 2014; Courneya and Friedenreich, 1997; Schmitz et al, 2010). Adopting and maintaining a physically active lifestyle is an important intervention for cancer survivors because it can improve their emotional well-being (Benton, Schlairet, and Gibson, 2014; Courneya, 2003; Cuevas et al, 2014) and physical functioning (Hughes et al, 2015; Schmitz et al, 2010; Winters-Stone et al, 2012), as well as reduce the risk of other chronic diseases such as: cardiovascular disease (Kirkham et al, 2016; LaCroix et al, 1996); and cancer recurrence (Ballard-Barbash et al, 2012; Holmes et al, 2005; Schmitz et al, 2010).

For survivors to benefit from structured exercise, both exercise testing and recommended exercise programs need to be safe and at levels consistent with their medical history and current physical functional capacity. Although previously sedentary participants, are generally healthy for exercise programs, they often can have high levels of apprehension and concerns with the novelty of strenuous exertion as can be encountered during exercise testing. Use of sub-maximal protocols can help with such apprehension. Moreover, where medical supervision is limited, sub-maximal protocols may also be safer as well as more practical.

Another key consideration in designing exercise programs for cancer survivors is as an accurate assessment of the individual’s cardiorespiratory capacity. The gold standard assessment of cardiorespiratory capacity is measured maximal oxygen uptake (VO_{2max}) (American College of Sports Medicine, 2013) utilizing ventilatory expired gases analyses at maximal effort. VO_{2max} is determined by measuring volumetric oxygen consumption, in open circuit spirometry with cardiac monitoring, during increasing workloads until oxygen consumption plateaus.

Maximal exercise testing is typically performed for cardiopulmonary diagnostic purposes such as in individuals with high risk for significant cardiopulmonary disease (American College of Sports Medicine, 2013) or for purposes for the need for precise accuracy of true VO_{2max} such as in testing for athletic programs (McArdle, Katch, and Katch, 2010). Maximal exercise testing may not be warranted for exercise programming for populations with high rates of comorbidity, with little or no previous exercise experience, or with other important factors that can make reaching a true VO_{2max} an unreasonable expectation (Hautala et al, 2013). Factors can include fear of the novel physical exertion experience, lack of motivation to reach true maximal effort, lack of medical supervision and participant individual physical limitations (e.g. orthopedic issues). Thus for many practical reasons, VO_{2max} is often estimated from submaximal exercise protocols (American College of Sports Medicine, 2013). Many protocols that estimate VO_{2max} from sub-maximal testing rely on heart rate responding linearly to increases in workload up to the point of anaerobic threshold (Coquart et al, 2009; Lambrick, Faulkner, Rowlands, and Eston, 2009). However, for those individuals taking medications that can alter cardiovascular responses to workload (e.g. beta-blockers), the accuracy of estimating VO_{2max} from sub-maximal protocols based on linear heart rate response can be called into question (Gauri et al, 2001), such as a blunted heart rate response from such medications that can result in an over-estimation of cardiorespiratory capacity (Tsai, Huang, Chen, and Ting, 2015). Alternative methods for estimating VO_{2max} in cancer survivors that do not rely specifically on linear increases in heart rate with increased workload therefore warrant further investigation. In this study we wanted to compare such an alternative method based on rating of perceived exertion with heart rate response in participants taking beta-blocker medications.

Beta-blockers are a commonly used class of medications that alter cardiovascular responses to changes in physical effort. They work by blocking norepinephrine and epinephrine from beta receptors on tissue. When these beta receptors are blocked, nerve impulses are affected, resulting in a reduced response to increasing workload demands. Most BB medications are classified as "cardioselective", indicating the selectivity to the myocardium; whereas, other BB medications are classified as non-selective affecting peripheral responses to the medication as well as the myocardium.

The Borg Rating of Perceived Exertion (RPE) scale is often used as an alternative to heart rate for measuring the intensity of physical activity (Borg, 1970). RPE, which has a linear relationship with oxygen uptake (Borg, 1982) is a validated measure for exercise intensity while assessing overall perceived physical and mental exertion from physical activity (Borg, 1998). This method has been validated in a variety of clinical populations such as: cardiac patients (Goss et al, 2011; Hautala et al, 2013; Tsai, Huang, Chen, and Ting, 2015); obese women (Coquart et al, 2009); as well as a variety of healthy populations (Lambrick, Faulkner, Rowlands, and Eston, 2009; Scherr et al, 2013), with correlations between VO_{2max} and RPE ranging from 0.67 to 0.97. In our study we wanted to compare use of heart rate (VO_2HR) and use of rating of perceived exertion (VO_2RPE) in sub-maximal GXT in 93 post-treatment endometrial cancer survivors.

To investigate this comparison between methods, we conducted a secondary analyses of physiological responses during a graded cycle sub-maximal exercise test (GXT) conducted at baseline for 93 post-treatment endometrial cancer survivors who agreed to participate in a six month exercise intervention testing determinants of exercise adherence (Basen-Engquist et al, 2011). Data from the sub-maximal GXT were stratified according to whether participants were taking beta-blockers (BB) medications or not (non-BB). The purpose of this study was to investigate an alternative method for estimating VO_{2max} in cancer survivors that does not rely specifically on linear increases in heart rate. We hypothesized that there would be no difference between VO_2HR and VO_2RPE estimates among participants in the non-BB group, but that estimated VO_2HR would be higher than estimated VO_2RPE for the BB group due to medically induced blunted heart rate response.

METHODS

We conducted a secondary analysis of baseline GXT data from a six-month exercise study for 100 previously sedentary post-treatment endometrial cancer survivors (Basen-Engquist et al, 2013). As part of baseline assessments, we conducted a submaximal graded cycle ergometer stress test with open circuit spirometry respiratory gas-exchange analysis for 93 of the 100 enrolled participants (detailed below). The primary goal of the parent study was concerned with how Social Cognitive Theory (Bandura, 1986) constructs relates to physical activity, so the GXT was designed to provide an exercise stimulus between cognitive tasks during the baseline assessment (Basen-Engquist et al, 2011). In addition, the GXT was used to provide an estimate of cardiorespiratory fitness while assessing individual exercise tolerance at intensity levels slightly higher than would be initially prescribed.

Participants

Participants were 100 previously sedentary women who had been diagnosed with stage I-IIIa endometrial cancer within the past 5 years and had been finished with treatment for at least 6 months with no evidence of current disease. Participants were excluded if they were physically active at moderate or greater intensity activity for at least 30 minutes on 5 or more days per week or vigorous intensity activity for at least 20 minutes on 3 or more days per week and had maintained that level of activity for 6 months or longer. Participants meeting this criteria were excluded as the primary objective of the parent study was to determine Social Cognitive Theory determinants of exercise adherence for sedentary endometrial cancer survivors for whom engaging in levels of physical activity meeting public health guidelines would be a novel behavior. Enrollment was contingent on a signed release from patients' physicians indicating that they were sufficiently healthy to participate in a home-based exercise program and had no absolute contraindications for exercise testing as defined by ACSM's Guidelines for Exercise Testing and Prescription (American College of Sports Medicine, 2009).

Participants were recruited from the gynecologic oncology clinic at The University of Texas MD Anderson Cancer Center ($n = 59$), MD Anderson's outreach sites ($n = 36$), and a private gynecologic oncology practice in Houston, Texas ($n = 5$). All participants received a gift card worth $40 for completing the baseline assessments. The MD Anderson Institutional Review Board (IRB) approved all study procedures prior to recruiting any participants. Participants who were able to perform the exercise stress test at an adequate intensity to enable estimation of VO_{2max} were split into two groups (beta-blocker and non-beta-blocker) according to whether or not they were taking any medication categorized as a beta-blocker.

GXT Procedures

Participants' height (cm), weight (kg), resting electrocardiogram (ECG), resting blood pressure (mmHg) and resting heart rate in beats per minute (bpm) were recorded. If the participant did not present with any contraindications to exercise testing (American College of Sports Medicine, 2009), she was asked to complete a graded submaximal cycle ergometer exercise test (GXT*)*. As this was the first exercise testing protocol initiated in a new facility and with the anticipated level of co-morbidity of our study population, cycle ergometry was chosen over a treadmill protocol to lessen participants' risk of falling, to facilitate12-lead ECG monitoring and to facilitate blood pressure monitoring.

Before participants were tested, they received a detailed explanation of the procedure for the GXT, including how to interpret the Borg RPE scale (Borg, 1998) mounted on a 12” x 18” framed scale on the wall in front of the participants. We used the 15-point Borg RPE scale, which ranges from 6 (“no exertion at all”) to 20 (“maximal exertion”). Each participant was shown how to signal if for any reason she wished to immediately stop the GXT.

During the duration of the GXT, participants were connected to a Cardiac Science Quinton Q5000+ (Bothell, WA) for continuous 12-lead ECG monitoring and a SunTech Medical Tango+ (Morrisville, NC) automated blood pressure cuff interfaced to the Quinton was used for measuring blood pressure. Participants were connected with open-circuit spirometry to a ParvoMedics TrueOne 2400 (Sandy, UT) metabolic measurement system for measuring breath-by-breath respiratory gas exchange and ventilatory responses. The ParvoMedics controlled the resistance on a Lode Corival (Groningen, The Netherlands) exercise cycle per a specifically developed protocol detailed below.

Each participant began by pedaling for 60 seconds at no resistance on the cycle. This was followed by a warm-up phase of pedaling for 120 seconds at 20 watts (W) of resistance. Then the exercise phase began with one W of resistance added every six seconds to the initial 20W. Participants were encouraged to maintain a cadence of 60 ± 5 RPM during the exercise phase. Heart rate signal from the Quinton Q5000+ was interfaced with the metabolic cart. Continuous respiratory gas exchange breath-by-breath analysis of the metabolic cart included heart rate, breath-by-breath measurements of VO_2 (mL/kg/min), VO_2 (L/min), VCO_2 (L/min), VE (L/min), VE/VO_2, VE/VCO_2, and Respiratory Exchange Ratio (RER) (VCO_2/VO_2) where VO_2 is volume of oxygen (L/min), VE is minute ventilation (L/min), and VCO_2 is volume of carbon dioxide (L/min). Blood pressure and RPE were recorded every 2 minutes. Resistance increased by one W every six seconds until the participant reached either: a sustained RER greater than 1.0; reached 85% of her age-predicted maximum heart rate; was unable to maintain the pedaling cadence of 60 RPM; presented with any abnormal blood pressure response or arrhythmia; or if the participant gave the signal that she wished to stop the test.

After reaching the exercise phase target point(s), resistance was dropped to 20W while the participant completed a “cool-down” recovery phase. Respiratory gas exchange, ventilatory response and heart rate continued to be monitored continuously while blood pressure and RPE were recorded every minute. Once the participant cooled down for a minimum of 2 minutes, the GXT was stopped and the equipment removed.

Statistical Analysis

We calculated VO_{2max}HR via ordinary least squares regression analysis using each participants’ respiratory gas exchange and ventilatory response test data. To smooth out the inherently noisy breath-by-breath data, 30-second average heart rate and VO_2 levels were used in the regression analysis. Heart rates were linearly regressed onto corresponding VO_2 (mlO_2/kg/min) levels during the period from the beginning of the exercise phase (resistance greater than 21 W) to the exercise phase end point. This regression generated the prediction equation of VO_2 level based on the linear relationship between VO_2 and heart rate in the exercise phase. This linear relationship was then extrapolated to each participant’s age-predicted maximum heart rate (220 – current age) (Fox, Naughton, and Haskell, 1971) to predict VO_{2max}HR (mlO_2/kg/min).

We used a similar linear regression procedure to calculate VO_{2max}RPE but RPE instead of HR was regressed onto corresponding VO_2 (mlO_2/kg/min) levels. As stated, RPE was collected every 2 minutes during the exercise phase. RPE was recorded into the Parvo metabolic cart each time participants identified their current RPE. Thus we paired the time the RPE was collected to the closest 30-second VO_2 (mlO_2/kg/min) average as indicated on the Parvo metabolic cart readout. A regression equation similar to one used for the VO_{2max}HR method, was created to regress the RPE level on VO_2 levels during the exercise phase. The RPE was then extrapolated to a "maximum" RPE of 19, and predicted VO_{2max} level for each participant was calculated on the basis of a linear relationship between VO_2 and RPE. We used an RPE of 19 instead of 20 as the maximum point of an RPE level of 19 has been suggested as a more realistic RPE level for maximal effort during exercise testing (Faulkner, Parfitt, and Eston, 2007).

Treatment of Data

Participants who were taking beta-blocker (BB) medications or not (non-BB) were compared for responses in heart rate, RPE, VO_2, RER and blood pressure during a GXT at start of the exercise phase (21W resistance), at 40W resistance, at 60W resistance and test termination criteria. The mean VO_{2max}HR was compared with the mean VO_{2max}RPE using paired-sample *t*-tests. The VO_{2max} data were calculated using Microsoft Excel (Redmon, WA). Bland-Altman plots were generated to assess the level of agreement between both methods of VO_{2max} estimates. Analyses of variables of interest were conducted using SPSS V 21.0 (Statistical Package for the Social Sciences), (SPSS, Inc., Chicago, Ill.).

RESULTS

Descriptive statistics for all 100 participants are shown in Table 1. Of the 100 participants, 7 were unable to perform the exercise stress test at an adequate intensity to enable estimation of VO_{2max}. Of the remaining 93 participants, 70 reported they were not taking beta-blockers (non-BB), and 23 reported they were taking beta blocker (BB) medications. In our study 21 of the 23 participants were taking cardioselective BB medication; results from the GXT for the other two participants that were taking non-cardioselective BB were compared and found not to differ and therefore were included in the results.

The mean age of the BB group was 59.74 years (range, 40–76 years), and the mean age of the non-BB group was 55.87 years (range, 25–78 years; $p = 0.149$). The mean BMIs for the BB group and the non-BB group were 35.53 kg/m^2 and 32.87 kg/m^2, respectively ($p = 0.191$). Both groups were similar in demographic characteristics.

Table 2 details the physiological responses for BB and non-BB groups as they completed the GXT. This includes at the start of the exercise phase (21W), approximately half way through (40W) closer to the end (60W) and end of exercise phase. The resultant predictions of VO2max are also shown. For the non-BB group, 70 participants were tested; for the BB group 23 participants were tested. The number of participants completing each level of intensity differed and so noted in the table. As expected, the resting heart rate for the BB group (64.5 bpm) was significantly lower than that for the non-BB group (72.5 bpm, $p < 0.001$). This difference in HR between the two groups remained significant (lower for BB group) at 21W, 40W, 60W and at the end of exercise phase. The mean maximum heart rate achieved during the exercise test for the BB group (112.2 bpm) was significantly lower than that for the non-BB group (130.9 bpm, $p < 0.001$). However, RPE was not different between groups at any level of intensity. The BB group difference in a lower VO2 peak than the non-BB group approached significance (11.4 mlO_2/kg/min versus 13.6 mlO_2/kg/min, p = 0.052). Also approaching significant difference, was the lower watt resistance achieved for the BB-group compared to the non-BB group, (68.2W versus 77.1W, $p = 0.075$). Thus, though there was no significant difference in VO2 peak estimation between groups as noted below, the BB group had significantly lower heart rate at all workloads.

Among non-BB participants, there was no difference between the mean VO_2HR and the mean VO_2RPE estimates of cardiorespiratory capacity (VO2max), (20.4 and 19.3, respectively; $p = 0.166$), (Table 2). Among BB participants, the mean VO_2HR approached significant difference from the mean VO_2RPE, (21.7 and 17.6, respectively; $p = .087$). To better assess these two methods, Bland-Altman plots were created, (Figures 1 and 2). The non-BB group indicated a proportional bias with a negative slope ($B = -.310$, p = 0.004; $B = -.423$, p < 0.001, respectively).

The bias seems to be greater where the mean for both methods is higher, i.e. where estimated VO2max max is higher. Bias was not evident in the BB group ($B = 0.045$, p = 0.868). An interpretation of these results is the use of HR for estimating VO2max for on BB medications may be a preferred method to using RPE, especially for those with greater cardiorespiratory capacity.

Exercise stage termination criteria is detailed in Table 3. There were similar percentage of participants in the BB group (56.5%) and the non-BB group (55.1%) that reached an RER ≥ 1.0 as the primary criteria for stopping the exercise stage. Eighteen (26.1%) of non-BB group participants reached 85% of age-predicted maximum HR; whereas, only two of the BB group participants did (8.7%). Three of the non-BB group participants reached both criteria of 85% HR and RER ≥ 1.0 whereas no BB-group participants did. As illustrated on Table 3, similar % of participants in both groups were unable to maintain cadence, were stopped due to high blood pressure, or indicated the desire to stop the test.

DISCUSSION

We examined physiological responses using continuous heart rate monitoring and breath: breath respiratory gas exchange analysis in sedentary (i.e. not moderately active ≥ 30 minutes on ≥ 5 days per week or vigorously active ≥ 20 minutes on ≥ 3 days per week) post-treatment endometrial cancer survivors performing a ramped sub-maximal cycle ergometry exercise stress test. Results were stratified according to beta blocker medications usage and we used the physiological response data to estimate VO_{2max} (mlO_2/kg/min) using two methods: heart rate response and RPE.

Resting heart rate and heart rate response during the GXT were different between groups. However, both groups self-reported no differences in levels of perceived exertion (RPE) during the GXT. The two methods of estimating VO_{2max} did not differ in the non-BB group (p = 0.166) and approached significant difference in the BB group (p = 0.087). We acknowledge that without participants performing a maximal stress test to reach a true VO_{2max}, it is not possible to determine which method (HR or RPE) is a more accurate method of estimating VO_{2max} from a sub-maximal GXT for participants taking BB medications. From a practical standpoint, however, there are indeed many instances where a maximal stress test is not the preferred option, (e.g. need for medical supervision) or justified in terms of participant risk and comfort.

Our results suggest that RPE can be used as a viable alternative method to heart rate response for assessing exercise tolerance when use of heart rate is not always possible to collect or not always as accurate in sub-maximal protocols as in the case of participants on BB medications where heart rate response is blunted.

Our argument is based on our GXT results that as exercise intensity increased both groups responded with similar RPE regardless/independent of beta blocker medications usage but presented with different heart rate responses. In the case of those on BB medications heart rate response during exercise is in fact blunted (American College of Sports Medicine, 2013; Eston and Connolly, 1996; Tang et al, 2016; Tsai, Huang, Chen, and Ting, 2015), which could result in an overestimation of cardiorespiratory capacity in sub-maximal protocols. Our results suggest that RPE may be a viable alternative approach for estimating cardiorespiratory capacity in sub-maximal protocols, as both our groups reported similar RPE values at all workloads but the BB-blocker group recorded lower heart rate responses at all workloads when compared to the non-BB blocker group.

Our results should be interpreted in light of several limitations. First, we performed a submaximal stress test with stopping points short of maximal effort. The comparison of the two methods would be more valid with a truly maximal stress test. This is an important area for future clinical research: comparing submaximal methods of estimating VO_{2max} with maximal testing specific for populations such as post-treatment cancer survivors. For our study we opted for submaximal testing as the main focus of the GXT was to provide a consistent, structured exercise stimulus between cognitive assessments. VO_{2max} was not the study's main endpoint and we had scheduling challenges to secure the necessary medical supervision for maximal testing of higher at-risk participants (American College of Sports Medicine, 2009). Thus, for our given circumstances and the overarching objectives of the parent study a sub-maximal protocol was the preferred choice. Other researchers and clinicians may face similar issues. Use of RPE versus heart rate to estimate cardiorespiratory capacity in these applications may be a viable alternative.

RPE is often used as additional information during submaximal and maximal exercise testing (American College of Sports Medicine, 2013; Coquart et al, 2014). RPE has been used as a guideline for exercise termination as well as exercise prescription in populations on BB medication (Eston and Connolly, 1996; Tang et al, 2016; Tsai, Huang, Chen, and Ting, 2015). Our results provide support for RPE as a preferred alternative for post-treatment endometrial cancer survivors on BB in assessing exercise tolerance and thus applicable in estimating cardiorespiratory capacity and subsequent exercise prescription.

We also acknowledge a limitation that this was the first exposure to the concept of RPE for almost all our participants. Therefore, our participants may not have been able to accurately anchor their level of exertion on the basis of the RPE scale. Finally, our participants had cardiorespiratory capacity in the lowest percentiles of published norms (American College of Sports Medicine, 2013), so they spent a relatively small amount of time in the exercise phase of the testing protocol (approximately 7–9 minutes). Therefore, we had fewer data collection points with which to generate a prediction regression equation.

However, despite these limitations our results do suggest that using RPE to assess exercise tolerance and estimate cardiorespiratory capacity is a viable alternative in sub-maximal exercise test protocols in endometrial cancer survivors using BB-medications. Further research evaluating the use of RPE as a criterion for maximal VO_{2max} testing for special populations such as post-treatment cancer survivors is warranted.

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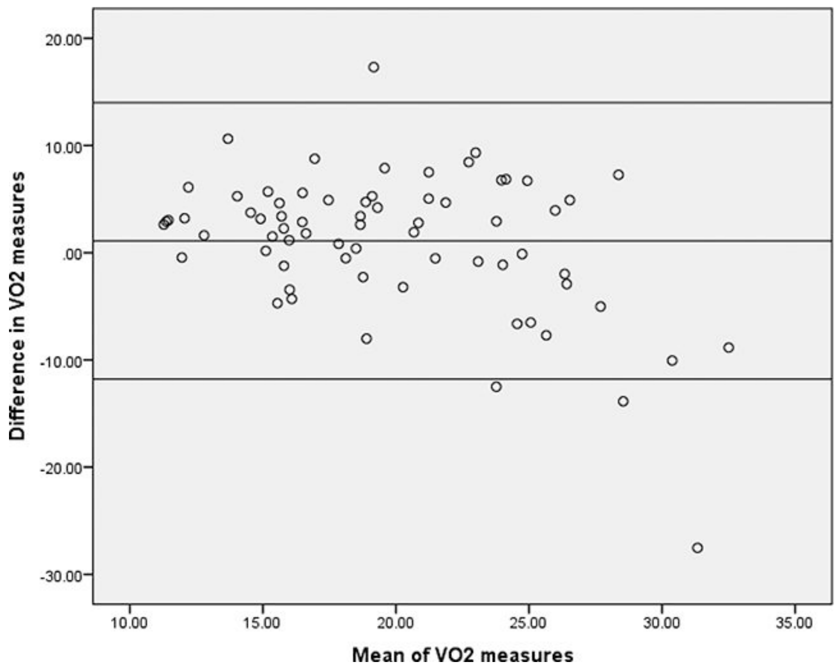

Figure 1. Bland-Altman plot non-BB group VO2maxHR & VO2maxRPE

Note: Mean difference = 1.11; standard deviation= 6.57;

95% confidence limits: upper = 13.99, lower = −11.78

Regression coefficient $B = -0.423$, $p < 0.001$.

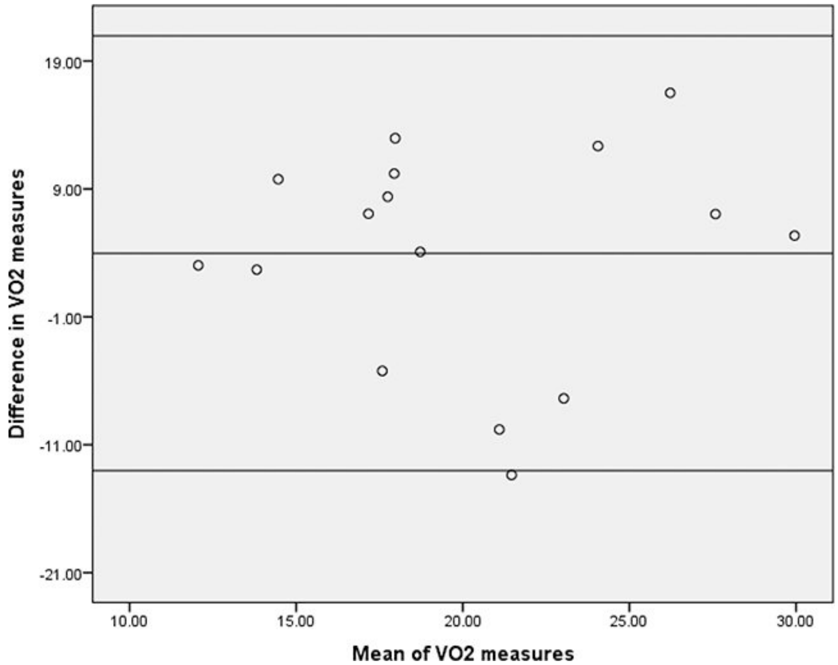

Figure 2. Bland-Altman plot BB group VO2maxHR & VO2maxRPE

Note: Mean difference = 3.98; standard deviation= 8.67;

95% confidence limits: upper = 20.97; lower = −13.02

Regression coefficient B= 0.045, p = 0.868.

Table 1.

Characteristics of Endometrial Cancer Survivors Enrolled in an Exercise Program (n = 100)

Characteristic	Percent
Ethnicity	
Hispanic	12
Non-Hispanic	86
Data Missing	2
Race	
White	84
African American	7
Asian	5
American Indian	1
Pacific Islander	0
Other	3
Age[a]	
40 y	8
40–49 y	12
50–59 y	34
60–69 y	35
≥ 70 y	11
Education	
Greater than bachelor's degree	17
4-year college degree	24
Some college	36
Technical/vocational degree	8
High school degree	13
Did not complete high school	2
BMI[b]	
< 25.0 kg/m^2 (normal weight)	15
25.0–29.9 kg/m^2 (overweight)	21
30.0–34.9 kg/m^2 (class I obese)	25
35.0–39.9 kg/m^2 (class II obese)	11
≥ 40.0 kg/m^2 (class III obese)	28

[a]Mean [SD], 57.1 [11.1] years; range, 25.0–76.0 years.

[b]Mean [SD], 34.3 [9.4] kg/m^2; range 18.7–53.2 kg/m^2.

Table 2.

Physiological Responses During Sub-Maximal Cycle Exercise Test

Variable	*Non-BB Mean (SD)*	*BB-Group Mean (SD)*	*p*
Age	**56.03 (11.6)**	**59.96 (8.11)**	**0.121**
BMI	33.53 (9.14)	36.70 (10.1)	0.146
Resting	n = 75	n = 23	
HR	72.48 (9.51)	64.48 (9.70)	<0.001
SBP	130.2 (18.2)	134.2 (19.4)	0.349
DBP	76.9 (8.44)	73.8 (12.0)	0.157
21W (Start Exercise Phase)	n = 70	n = 23	
HR	95.85 (20.2)	84.91 (14.0)	0.020
RPE	9.59 (2.15)	8.95 (1.70)	0.227
VO_2	7.95 (2.06)	7.27 (1.52)	0.161
SBP	145.8 (23.8)	151.6 (18.6)	0.317
DBP	77.8 (10.6)	75.8 (10.0)	0.452
RER	0.82 (0.07)	0.86 (0.11)	0.047
40 W	n = 68	n = 20	
HR	101.8 (19.6)	91.85 (14.9)	0.039
RPE	10.9 (2.28)	10.6 (2.21)	0.607
VO_2	9.12 (2.46)	8.09 (1.57)	0.075
SBP	153.6 (23.8)	152.6 (17.8)	0.859
DBP	76.1 (10.4)	77.8 (9.88)	0.505
RER	0.86 (0.07)	0.90 (0.11)	0.060
60 W	n = 53	n = 15	
HR	112.8 (14.2)	99.2 (20.7)	0.005
RPE	12.4 (2.22)	12.5 (2.20)	0.855
VO_2	11.2 (3.96)	10.2 (1.82)	0.345
SBP	162.9 (21.8)	162.5 (21.1)	0.943
DBP	78.6 (9.82)	76.9 (10.8)	0.571
RER	0.92 (0.07)	0.93 (0.11)	0.775
End of Testing Phase	n = 70	n = 23	
Wattage Achieved	77.1 (21.0)	68.2 (19.3)	0.075
HR	130.9 (19.4)	112.2 (20.6)	<0.001
RPE	13.5 (2.6)	13.2 (2.4)	0.619
VO_2peak	13.6 (5.2)	11.4 (3.5)	0.052
SBP	175.5 (22.4)	168.8 (34.6)	0.285
DBP	79.5 (12.0)	79.3 (12.8)	0.942
RER	1.03 (0.07)	1.02 (0.10)	0.836
Estimated VO_2max	n = 70	n=19	
VO_{2max}HR	20.4 (4.8)	21.7 (6.5)	0.308
VO_{2max}RPE	19.3 (7.3)	17.6 (6.2)	0.421

Note: BMI=Body Mass Index; HR = Heart Rate; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure RPE = Rating of Perceived Exertion; VO_2= volume of oxygen uptake mlO_2/kg/min; RER = Respiratory Exchange Ratio.

Table 3.

Test Termination Criteria Group Comparison

Variable	***Non-BB n = 70 n (%)***	***BB n = 23 n (%)***
Reached RER ≥ 1.0	38 (55.1)	13 (56.5)
Reached 85% of age predicted HR	18 (26.1)	2 (8.7)
Reached both RER & HR	3(4.3)	0 (0.0)
Unable to maintain cadence	4 (5.8)	2 (8.7)
High blood pressure response	4 (5.8)	2 (8.7)
Participant wanted to stop	2 (2.7)	1 (4.3)
Other		
(equipment malfunction)		1 (4.3)
(no supervision – test stopped at 70%)		1 (4.3)
(GXT test stopped early by tech)	1 (1.3)	1 (4.3)