Review Article

A Comparison of Observed Collegiate Female Cyclists to Elite Female Cyclists from a Meta-Analytic Review

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ABSTRACT

International Journal of Exercise Science 9(3): 368-375, 2016. The aim of this study was to evaluate the physiological characteristics of competitive, collegiate female cyclists (CFC) to data of elite female cyclists (EFC) obtained from a meta-analytic review. Eleven (n=11) CFC volunteered as subjects. Subjects signed a university approved informed consent. Means and standard deviation (± SD) were obtained from the following measurements: age (y), 22.5± 5.1; height (cm) 167.22 ± 6.2; body mass (kg) 63.78 ± 9.71; body fat (%) 22.9 ± 3.6. Subjects performed a maximal cycling ergometer test to volitional fatigue. Maximal oxygen consumption (VO_2 max, mL*kg^{-1}*min.$^{-1}$) was analyzed using a gas analyzer. VO_2 max, maximal blood lactate (mM), maximal power (W), lactate threshold (mM), ventilatory threshold (VT, % of maximal) and heart rate threshold (HRT, % of maximal) were used to compare the performance of CFC to the data of EFC. An independent samples t-Test compared measures of the CFC vs. EFC. Alpha was set *a priori* at $p \leq 0.05$. Results indicate comparisons between CFC vs. EFC, respectively: body fat %, 22.9 (3.6)* vs 15.2(3.3); VO_2 max (mL/kg/min), 58.07(6.94)* vs 52.5 (5.5); max power (W) 275.0(42.5) vs 450.7(256)* ;lactate threshold (mM) 3.74(0.79)* vs 2.8 (0.28); VT (%) 87.0(4.1)* vs 73.2 (9.8) and HRT (% max) 93.1(2.2)* vs 79.7. There were significant differences *($p \leq 0.05$) in the aforementioned measures. Results indicate differences between CFC vs. EFC. These differences were favorable in relation to performance with both CFC and EFC.

KEY WORDS: Competitive female cyclists, physiological measures, triathletes, female road cyclist.

INTRODUCTION

During the last decade, cycling has grown exponentially as a competitive and a recreational sport (5). Competitive cyclists require aerobic as well as anaerobic power during conditions of training or performance. Physiological characteristics serve in determining the fitness status and efficiency of a cyclist (11). Through investigation of several physiological characteristics, the inherent interactions of these characteristics may very well enhance performance levels of female cyclists (5).

Comparative norms have been utilized to apply a standard to fitness and performance in the general and athletic populations, respectively. Physiological measures and associated norms have been found to act as training tools as well as influence the prediction of an athlete's performance (2).

Among those measures closely associated with cycling performance are peak power output, ventilatory threshold and peak oxygen consumption (1, 2, 4, 12). Additionally, recent studies have shown maximum power as a potential predictor of athletic performance (4, 11).

There are numerous investigations of physiological characteristics related to male cyclists. However, few studies consider female cyclists. Professional women's cycling is a growing performance venue in respect to the number of participants and the number of women's cycling competitions (11). Yet there is very little data available regarding female physiological characteristics and the possible implications toward performance. Wyatt et al. performed a meta-analysis profiling elite level cyclists (16). The meta-analysis included twenty (20) studies selected for inclusion with a sum sample size of n=232. Through this analysis, several physiological measures were established providing a standard associated with elite level female cyclists. The values obtained from this analysis could be useful in establishing norm references for comparison with other demographic groups. Therefore, the purpose of this study is to investigate the physiological characteristics of collegiate, competitive female cyclists in comparison with data available from a meta-analysis of elite female cyclists (16). From the comparison of observed data (i.e., collegiate female cyclists) to those measures of a prior investigation (i.e., meta-analysis) the following hypotheses were established: 1) comparison analysis will indicate that the standard values established by the meta-analysis of elite female cyclists will be significantly greater than the collegiate female cyclists pertaining to the physiological variables of maximal oxygen consumption (VO_2 max), maximal power, lactate threshold, ventilatory threshold (VT, % of VO_2 max) and heart rate threshold (HRT, % of MHR); 2) comparison analysis will indicate that the standard values established by the meta-analysis of elite female cyclists will not be statistically different than the collegiate female cyclists pertaining to the anthropometric variables of height, weight and body fat percentage.

METHODS

Participants
Eleven (n=11) competitive, collegiate female cyclists volunteered as subjects. Participants were recruited from a regional collegiate cycling team. All subjects signed a university approved informed consent prior to testing and filled out a fitness-readiness health questionnaire (Par-Q & You). Demographic measures were the following: age (y); height (cm); body mass (kg); body fat (%). A three-site skin-fold protocol was utilized to establish body fat with measurements taken at the triceps, suprailiac and quadriceps utilizing a Harpenden™ skin-fold caliper**.** Subjects completed a maximal oxygen consumption test (max VO_2, $mL*kg^{-1}*min^{-1}$) on a Velotron™ cycle ergometer utilizing the Australian Institute of Sport (AIS) Protocol. This protocol begins at 125 watts (w) for five (5) minutes followed by 25 (w) increases each minute until volitional fatigue. Furthermore, preceding the exercise test, bike fit measurements from the subject's bike were taken and transferred to the Velotron™ cycle ergometer. The Velotron™ allows for high validity and replicable testing, with $\pm$ 1.5% accuracy, and $\pm$ 0.2%

repeatability. Obtained measurements from the ParVo Medics TrueMax 2400™ metabolic cart included the following: expired minute ventilation (V_E, L*min.$^{-1}$); oxygen consumption (VO_2, L*min.$^{-1}$); carbon dioxide production (VCO_2, L*min.$^{-1}$); respiratory exchange ratio (RER, VCO_2*VO_2^{-1}); and maximal oxygen uptake (VO_2 max, ml*kg^{-1}*min.$^{-1}$). A Polar RS800CX ™ heart rate monitor was used to measure heart rate (b*min.$^{-1}$) recorded during every minute of the cycling test. A Nova Biomedical Lactate Plus™ was used to obtain whole blood lactate by removing 10µl from a finger during the cycle ergometer test. Lactate was then determined by reflectance photometry at a wavelength of 657nm in a colorimetric lactate-oxidase mediator reaction.

Each subject was asked to abstain from food and caffeine three (3) hours prior to the test and to arrive for testing in a euhydrated state. Subjects were allowed to warm up ad libitum. The following measures were recorded during the cycle ergometer test: VO_2 max; maximal heart rate (MHR, b*min^{-1}); maximal power, watts (w); peak blood lactate, millimoles (mM); lactate threshold (3); heart rate threshold (15) and ventilatory threshold (6).

The selected variables for comparison were predicated on measures obtained in the meta-analytic review and the availability of apparatus for measures taken with the collegiate female cyclists. For example, age, height, weight, body fat percentage, VO_2 max, peak blood lactate, lactate threshold, heart rate threshold, ventilatory threshold and peak power were variables analyzed in the comparison between groups (i.e., meta-analysis vs. collegiate). While muscle fiber type was a variable noted in the meta-analysis, this procedure was not available within the collegiate female group. Additionally, the meta-analytic procedure is compiled mean data from several studies (i.e., 20). As such, the apparati utilized in these twenty (20) studies varied. This lack of control during protocols in meta-analytic procedures is common and may provide for spurious findings. However, statistical power is established through the previously noted enhanced sample size. Based on the sample size and alpha level for a two-tailed analysis in the current study, statistical power is calculated as greater than .95. Therefore, the enhanced power established through the large sample provided by the meta-analysis allows for greater probability of not committing a type II statistical error and correctly identifying differences between groups.

Statistical Analyses

Descriptive means and standard deviations (SD) were used to analyze group measures. Comparisons between groups (i.e., observed collegiate female cyclists vs. prior data from the meta-analysis) was established. Because comparisons were done on only two groups (i.e. meta-analysis elite vs. collegiate), an independent samples t-Test was used to determine differences among the group data obtained from the past meta-analysis (reference criteria) and the data obtained from the current tests of the collegiate female cyclists. All statistical procedures were done utilizing Statistica™ software. Statistical level of significance was determined *a priori* at $p \leq 0.05$.

Table 1. Comparative Measures between Collegiate Female Cyclists and the Meta-Analysis

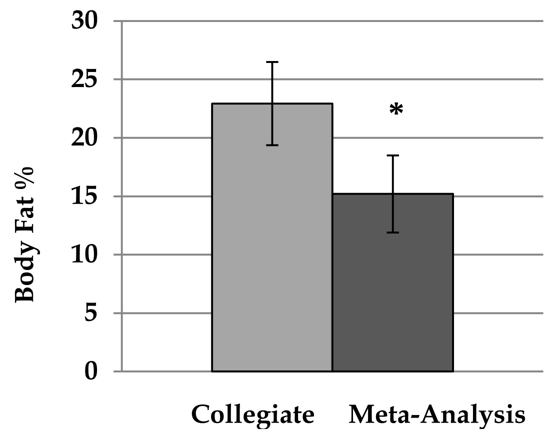
Variable	Mean (SD) Data (collegiate)	Reference (SD) (meta-analysis)	Alpha level
Age (y)	22 (5.1)	25 (4)	.08
Height (cm)	167.22 (6.2)	165.7 (3.4)	.45
Body mass (kg)	63.78 (9.71)	59.4 (2.9)	.17
Body Fat (%)	22.9 (3.6)	15.2 (3.3)*	.001
VO_2 Max ($ml*kg^{-1}*min.^{-1}$)	58.07 (6.94)	52.5 (5.5)*	.02
Peak Lactate (mM)	12.3 (2.5)	10.6 (2.1)	.09
Max Power (w)	275.0 (42.5)	450.7 (256)*	.001
Lactate Threshold (mM)	3.74 (.79)	2.8 (.28)*	.02
VT (% max)	87.0 (4.1)	73.2 (9.8) *	.001
HRT (% max)	93.1 (2.2)	79.7 (**)*	.001

*=statistical significance of p<0.05: **=no standard deviation because only one study was done.

RESULTS

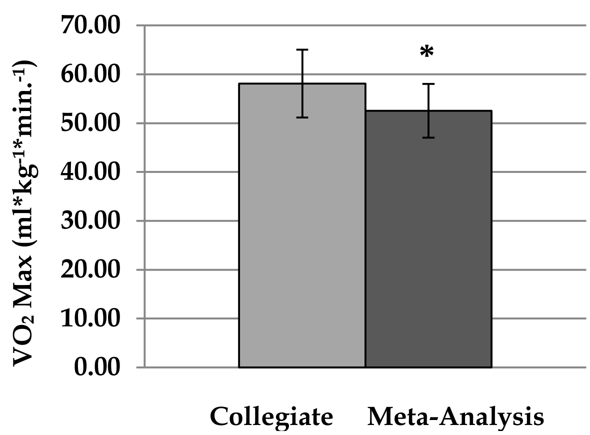
Results of the data showed that age (y), height (cm), body mass (kg) and blood lactate (mM) were not significantly different between the collegiate competitive female cyclist and the data obtained from the reference meta-analysis. However, body fat (%), VO2 max, maximal power, lactate threshold, VT (% of VO2 max) and HRT (% of MHR) were significantly different between the collegiate competitive female cyclist and the data obtained from the meta-analysis. Table 1 indicates the values of the data obtained from collegiate competitive female cyclist in comparison with the reference data obtained from the meta-analysis.

The following graphs represent the data of significant differences between the collegiate competitive female cyclist and that from the past meta-analysis. Figures 1-6 show comparisons between the collegiate female cyclists tested in the current study and the elite female cyclists from the meta-analytic review. Those variable comparisons are the following: body fat, VO_2 max, maximal power, lactate threshold, ventilatory threshold (% of VO_2 max), and heart rate threshold (% of maximal heart rate).



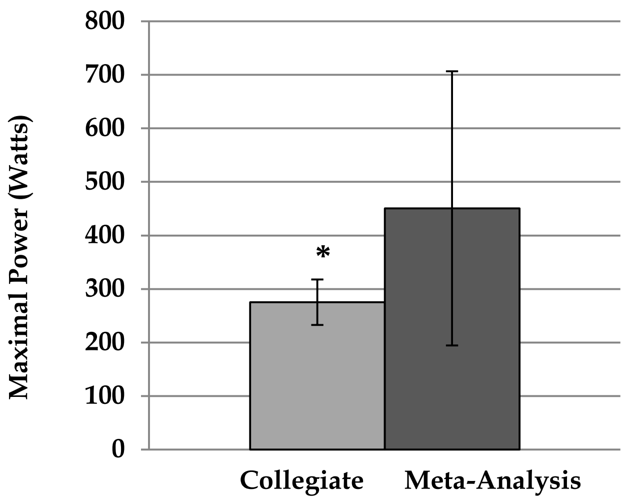
*Statistically significant at $p < 0.05$

Figure 1: Comparison of Body Fat between Collegiate Female Cyclists and the Meta-Analysis



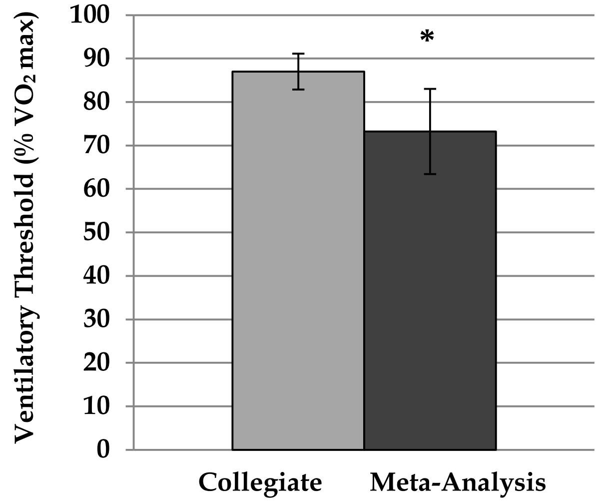
*Statistically significant at $p < 0.05$

Figure 2: Comparison of VO_2 Max between Collegiate Female Cyclists and the Meta-Analysis



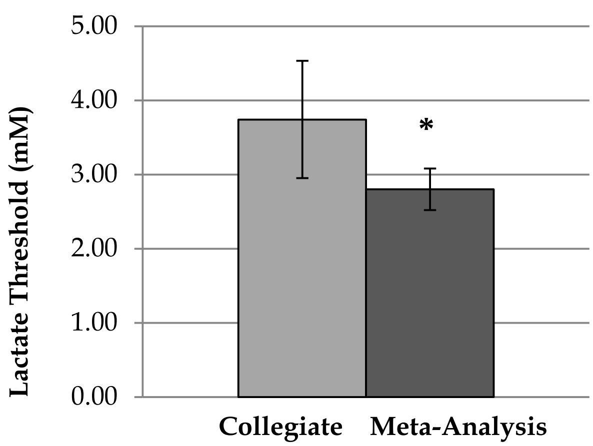
*Statistically significant at $p < 0.05$

Figure 3: Comparison of Maximal Power between Collegiate Female Cyclists and the Meta-Analysis



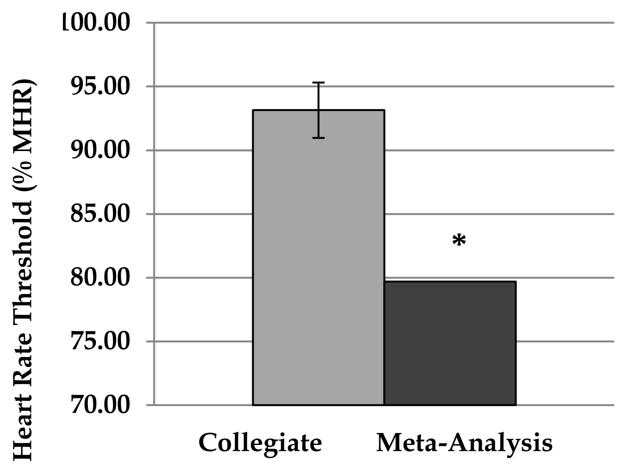
Statistically significant at $p < 0.05$

Figure 5: Comparison of Ventilatory Threshold between Collegiate Female Cyclists and the Meta-Analysis



*Statistically significant at $p < 0.05$

Figure 4: Comparison of Lactate Threshold between Collegiate Female Cyclists and the Meta-Analysis



* Statistically significant at $p < 0.05$

Figure 6: Comparison of Heart Rate Threshold between Collegiate Female Cyclists and the Meta-Analysis

DISCUSSION

Anthropometric and physiological characteristics can be used as outcome measures to scrutinize health parameters within the general public as well as the performance capabilities of athletes in sports. Knowledge of this data can help in the design of sport specific training programs and prediction of performance outcomes (2). In a case study investigating body fat and body mass of an elite female cyclist, manipulation of training variables and diet carries significant consequences (7). This is an example of utilizing data to provide interventions resulting in positive performance outcomes (7). The purpose of this study was to determine through Bayesian Analysis, if the physiological characteristics of competitive, collegiate female cyclists align with the physiological characteristics of elite female cyclists from data obtained through a past meta-analytic procedure. The results indicate the competitive, collegiate female cyclists were different from the elite female cyclists in the following measures: body fat %, maximal power output (w), maximal oxygen consumption ($ml*kg^{-1}*min.^{-1}$), lactate threshold (mM), ventilatory threshold (% VO_2 max) and heart rate threshold (% MHR). Moreover, the measures were mixed in relation to performance outcomes for female cyclists. Several measures favored the collegiate female cyclists in terms of performance outcomes. These include the following: VO_2 max, blood lactate threshold, ventilatory threshold and heart rate threshold. Yet, the group from the past meta-analysis showed favorable performance values over the collegiate female cyclists in the following: body fat percentage and maximal power. Comparisons of this nature should be taken with a cautionary note because of the lack of control in measurements and protocol as noted in the Methodology. This is alleviated when within-group differences (i.e., standard deviation) are reduced between the two groups allowing for statistical sphericity. For example: Figures 1, 2, 5 and 6 show minimal within group differences as seen in the standard deviation bars. With the aforementioned sample size, this reduced within-group difference allows for a greater degree of confidence in establishing true statistical differences between groups. Conversely, Figures 3 and 4 show considerable within-group differences and a lack of sphericity between groups. While the statistical findings may indicate differences between groups on these variables, caution should be taken with interpretation of these findings.

Literature comparing anthropometric and physiological characteristics to power output, body fat, hip to waist ratio, ground terrain and cyclists body position have been established (2, 4, 8, 9, 10). Results of the aforementioned studies were mixed allowing for physiological characteristics and their associations to performance. This is not surprising considering the multiple variables associated with cycling (i.e., type of race, terrain), the various venues inherent in cycling (i.e., road, mountain, track) and the body types of female cyclists. For example, specific characteristic are noted with those athletes proficient in sprinting vs. those adept at climbing. Additionally, track cyclists (i.e., velodrome) compared to mountain biking yields varying anthropometric and physiologic characteristics within the participants (2, 5, 10, 13). Yet a study by Wilber et al. found similar physiological characteristics in comparing elite female road cyclists to their mountain bike counterparts (14).

Past research from Brunkhorst and Kielstein compared the anthropometric characteristics of female tri-athletes and cyclists (2). They looked at the hip-waist ratio and lower limb length to determine associations with the specific sport types and performances with little significance in their findings. Of note pertaining to the current study was the wide variance between groups on power and within the meta-analytic group on power. One possibility for this broad variability is that the meta-analysis group was comprised of professional road cyclists as well as triathletes, while the collegiate female group was comprised of road cyclists only and therefore more homogeneous. Variability can also be explained through the multiple measures and varied protocols that may ultimately influence power. Hubenig et al. compared the effect of different body position on the power output in aerobically trained female cyclists (9). They found that position does not significantly alter the power out in cycling competitions. Impellizzeri et al. investigated the ground terrain and cycling performance (10). They compared level ground cyclists with uphill bike riders to identify the effect of terrain on cycling characteristics and ultimately, performance. They found that both the uphill bike riders and level ground cyclists had similar physiological characteristics. In contrast, a study by Ebert et al. concluded that power output was influenced primarily by the racing terrain (4). They compared the power output of elite female world cup athletes on flat and hilly terrain. The hilly terrain riders spent greater time on riding at the cadence of 80-90 (rpm) where those on the level ground spent more time on cadence greater than 100 rpm (4). Through these previous studies and the current study, it seems clear that multiple iterations of influence (i.e., physiological characteristics, venue of cycling, terrain) on cycling performance will yield inconclusive findings.

There are minimal resources allowing for established norms when investigating the physiological characteristics in competitive female cyclists. The aforementioned meta-analytic study utilized in the comparative analysis of this study provides a first step in establishing these normative values. The observed data of collegiate females in the current study was conducted with a very small sample size, and thus open for continued comparison to enhance statistical power. Conversely, the large sample size established through the meta-analysis allows for more confident statistical analysis. There were several noted measures of significant difference between the collegiate female cyclists and the elite female cyclists from the meta-analysis. Future research can build on the current study to establish greater validity in the establishment of physiological characteristics in female cyclists. Moreover, with greater samples sub-categories of "types" of cyclists (sprinters, climbers) can be included in the analysis.

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